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CONTENTS

Foreword	7
1. Beata ANDRZEJCZAK – Assessment of the effectiveness of selected logistics indicators of network enterprises in the SME sector in Poland in 2019-2022.....	9
2. Katarzyna BARTUSIK, Jolanta WALAS-TREBACZ – Effects of implementing ergonomic innovations – empirical research in organizations.....	23
3. Monika BOLEK, Burcu ZENGİN – ESG: the new currency of brand value	49
4. Marta CZERNECKI-WILCZYŃSKA – Quality management as a result of the development of human thought	75
5. Joanna ĆWIAKAŁA, Waldemar GAJDA, Michał ĆWIAKAŁA, Ernest GÓRKA, Dariusz BARAN, Gabriela WOJAK, Piotr MRZYGLÓD, Maciej FRASUNKIEWICZ, Piotr RĘCZAJSKI, Jan PIWNIK – The importance of emotional intelligence in leadership for building an effective team.....	89
6. Michał ĆWIAKAŁA, Julia WALTER, Dariusz BARAN, Gabriela WOJAK, Ernest GÓRKA, Piotr MRZYGLÓD, Maciej FRASUNKIEWICZ, Piotr RĘCZAJSKI, Jan PIWNIK – The impact of leadership styles on project efficiency.....	117
7. Irena DUDZIK-LEWICKA – "Silent seller" in business practice: preliminary research results based on the FMCG industry.....	137
8. Krzysztof GERLIC, Elżbieta RDZAWSKA-AUGUSTIN – Enhancing student learning through experimental research: traditional methods of constructing half-timbered walls	155
9. Szczepan GÓRTOWSKI – A data-driven framework for incremental supply chain optimization	169
10. Jolanta IGNAC-NOWICKA – Analysis of technical and technological solutions to support environmental management in a smart city	185
11. Olga JANIKOWSKA, Junaid AHMED – Comparative energy transformation management: Poland and Germany's path to sustainability.....	199
12. Ksenia JUSZCZAK-SZELĄGOWSKA, Weronika CZERWIŃSKA, Dawid OLEWNICKI, Tadeusz FILIPIAK – Polish consumers' preferences in vegetable consumption.....	223
13. Julia KARCZ-RYNDAK, Sandra ZAPATA-AGUIRRE – Theatre management in the context of the development of new generation technologies – management implications arising from the impact of technology on the shaping theatre functions ..	245
14. Tomasz KOĆ – Process orientation in project management in companies of the installation and assembly industry	265
15. Ewa KOPEĆ – The significance of economic innovation in the conditions of the pandemic crisis and related government actions	277

16. Karol KRÓL, Łukasz BAZARNIK, Arkadiusz NIEDZIÓŁKA, Łukasz DZIATKIEWICZ – Protecting and promoting Polish technological heritage with the tourist trail of digital cultural heritage: concept, criteria, and growth potential.....	291
17. Dominika LISIAK-FELICKA, Maciej SZMIT – Information security incident management and cybersecurity awareness in local government in Poland	315
18. Aneta MADYDA – Innovations in Polish enterprises in crisis conditions.....	335
19. Ewelina MARKOWSKA – The importance of personal income tax in the budgets of municipalities in Poland in 2019-2023	349
20. Rafał MATWIEJCZUK – Marketing concept revisited. market orientation as a basis for the marketing concept development.....	365
21. Ewa MAZUR-WIERZBICKA, Agnieszka RZEPKA, Julia BOIKO, Paweł BAŃKOWSKI – The role of leaders in establishing and maintaining interorganizational relationships	377
22. Katarzyna MAZUR-WŁODARCZYK, Katarzyna ŁUKANISZYN-DOMASZEWSKA – Empowering migrants through craft-based skills: social economy initiatives for integration and inclusion	391
23. Mariusz NIEKURZAK, Wojciech LEWICKI, Hasan Huseyin COBAN – The CAD tool in managing the design process of machinery and equipment as a road to Industry 4.0	425
24. Katarzyna OLEJNICZAK-SZUSTER – Ecology in the workplace: key value or redundant luxury?	437
25. Marcin PEŁKA, Aneta RYBICKA – Latent profile analysis of beer consumers with the application of R software	447
26. Sławomir PODKÓWKA, Jarosław KARPACZ – Tax consolidation: tool of creation relational rents, and interfirm performance	463
27. Agnieszka PRZYBYLSKA-MAZUR – Alternative method of fiscal stability assessment.....	483
28. Fabian SIEMIATOWSKI, Aleksandra SZULCZEWSKA-REMI – From knowledge to entrepreneurship: the concept of the utility factors model in economics and finance	503
29. Elżbieta SKRZYPEK, Piotr GRUDOWSKI – Conditions and consequences of quality development – from Quality 4.0 to 5.0.....	529
30. Anna SOŁTYSIK-PIORUNKIEWICZ, Witold CHMIELARZ, Patryk MORAWIEC, Marek ZBOROWSKI, Mesut ATASEVER – Awareness of knowledge and innovation of ehealth: similarities and differences in the assessment of ehealth portals and mhealth applications in students' perspective	547
31. Monika SZAFRAŃSKA – Price attributes of the image of cooperative banks.....	567
32. Katarzyna TOPOLSKA – Application of multi-criteria optimization for feature selection in machine learning based risk classification supporting supply chain management	581

33. Malgorzata ULEWICZ – Public procurement with environmental criteria in Polish construction: policy and practice implications.....	601
34. Krzysztof WALISZEWSKI, Sebastian ŁUKASZEWSKI – Quality of mortgage credit in Polish banks: the role of digitalisation.....	617
35. Tomasz WĘGRZYN, Bożena SZCZUCKA-LASOTA, Adam JUREK, Paweł PIOTROWICZ, Artur LABUS, Patrycja LASOTA – Economic aspects of of titanium alloy Ti-5Al-2.5Sn welding for aviation applications.....	639
36. Monika WODNICKA, Łukasz Jarosław KOZAR, Tomasz KARKOWSKI – Logistics services facing the challenges of a green economy: extraction of key green research areas	647
37. Aleksandra ZGÓRSKA, Robert HILDEBRANDT – Quantitative assessment of Sars-Cov-2 in municipal wastewater in comparison to daily epidemiological reports on the incidence of Covid-19 in the region.....	667
38. Wiktor ZYGOSZ – The internationalization of enterprises in the face of globalization – identification of key issues and models.....	683

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 38 papers.

The papers presented in the number concentrate on many topics connected with organization and management. There are in the number papers about: logistics, innovation management, quality management, leadership, supply chain management, smart city, energy transformation, consumption, public management, project management, economics, tourist management, safety management, marketing, leadership, Industry 4.0, ecology, entrepreneurship, Quality 4.0, knowledge management, finances, environmental management, digitalization, green economy, the impact of COVID-19 pandemic on management and internationalization.

Radosław Wolniak

ASSESSMENT OF THE EFFECTIVENESS OF SELECTED LOGISTICS INDICATORS OF NETWORK ENTERPRISES IN THE SME SECTOR IN POLAND IN 2019-2022

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Purpose: The aim of the article is to discuss the assessment of selected logistic indicators of network enterprises in the SME sector (micro, small and medium-sized enterprises) in Poland in 2019-2022 (with particular emphasis on the Łódź Voivodeship). The first part of the article presents the characteristics of the SME sector in Poland from a statistical perspective and the effectiveness of logistics activities in enterprises from a theoretical perspective. The second part of the article presents an analysis of selected logistics indicators of the SME sector based on author's own research.

Design/Methodology/Approach: The article was based, among others, on based on: literature on the subject, reports of the Polish Agency for Enterprise Development (PARP), practical knowledge about logistics presented by logistics companies on websites and own research, which was carried out in the form of surveys among enterprises in the SME sector in the Łódź Voivodeship.

Findings: The author's own research has shown that the analysed transport and logistics quality indicators are good enough for the companies of the SME sector in the Łódzkie Voivodeship, and this is due to: the share of logistics costs in the turnover of the company, which for the SMEs reached 32%, and for the manufacturing companies and service providers (outside the TSL industry) amounted to 24% (a very good result was recorded for micro and medium-sized companies, it amounted to 11% and 10%, respectively). Favorable results for the SME sector in the Łódź voivodeship in Poland were also achieved, among others in terms of the proportion of error-free transport documents to the number of total documents issued, the figure for TSL companies in the SME sector was 85%, and for the other companies included in the survey it was 80%.

Practical Implications: The research that was carried out in the counties of the Łódź Voivodeship (of which there are 23 in the Łódź Voivodeship together with the Łódź agglomeration with county rights) may provide valuable information for city offices and county offices in terms of supporting the SME sector in these areas. This support for the development of these enterprises may include, among others: in reports on urban regeneration.

Originality/Value: The research in the article was carried out on a sample of network enterprises from the SME sector and companies located in smaller towns and villages in the Łódź Voivodeship outside the Łódź agglomeration in Poland. which are not often analyzed in the literature on the subject.

Keywords: network enterprises, supply chain management.

JEL codes: D20, L20.

Paper type: Research paper.

1. Introduction

According to the report of the Polish Agency for Enterprise Development (Polish abbr. PARP), the number of enterprises in Poland is growing and it reached 2.3 million in 2020 (an increase of 0.1% compared to 2019). The SME sector is the most numerous group of non-financial enterprises (99.8%) operating in Poland in 2020. Size-wise the group is made up of micro enterprises (97% of all SME sector enterprises, 2.2 million, an increase of 0.1% compared to 2019), followed by small enterprises (2.2% of all enterprises from the SME sector, 49.5 thousand, an increase of 0.01% compared to 2019), and the third in this group were medium-sized enterprises (0.6% of all SMEs, 14.4 thousand, a decrease of 1% compared to 2019) (<https://www.parp.gov.pl/>, 2022, pp. 12-13; <https://www.parp.gov.pl/>, 2021, pp. 11-12).

From the point of view of the industry profile of the SME sector, the Polish SME market is dominated by companies from the service sector, accounting for 53% of companies, followed by enterprises from the construction sector (15.5%) and, coming third, manufacturing companies (10%) (Fig. 1).

Based on the above-presented statistics, we can see that micro-enterprises are the main force driving the development of the SME sector in Poland and have the largest share in GDP creation (30.6% of 2019), as well as in the total employment in this sector (6.8 million jobs in 2020, a slight increase compared to 2019 in micro-enterprises and in small enterprises, by 1.4% and 0.8% of jobs, respectively, and a decrease in medium-sized enterprises by 2.3% of jobs). Micro-enterprises also exhibit an upward trend. Between 2008 and 2020 (after a slight decrease of 0.1% in 2009), they grew by 23% compared to 2008 (<https://www.parp.gov.pl/>, 2022, pp. 19, 21-23, 61-62).

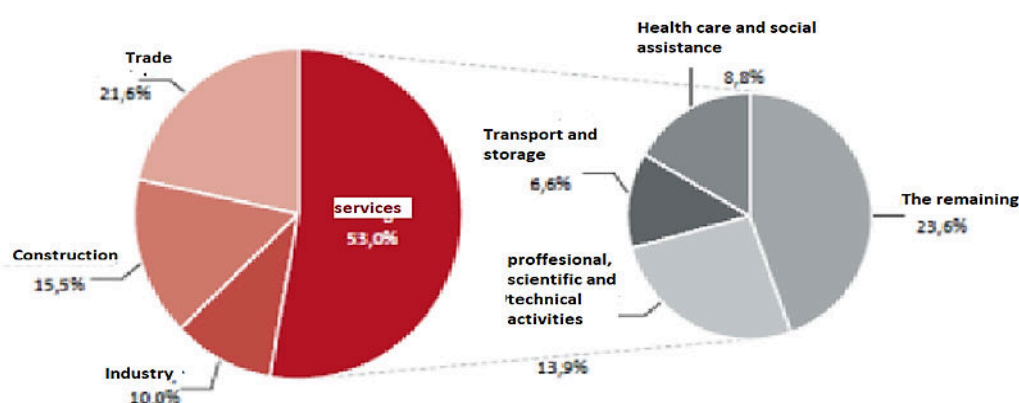


Figure 1. SME sector structure by industry.

Source: <https://www.parp.gov.pl/>, 2022, p. 15.

Most enterprises that agreed to take part in the survey were also micro-enterprises. However, the main research problem tackled by the article is to examine the efficiency of the SMEs in Poland in the years 2019-2022 (with particular focus on the Łódź Voivodeship) on the basis of selected logistic indicators.

However, the specific questions are whether the smaller the company, the more often it encounters greater problems and barriers to the development of its business during crises.

The research results presented in the article are important due to the lack of research on the issue of the effectiveness of logistics and transport indicators in the SME sector from the point of view of the network nature of these enterprises. Research on the effectiveness of selected logistic indicators of the SME sector conducted in the Łódź Voivodeship did not concern mainly the Łódź agglomeration, but the SME sector in smaller towns and villages of the Łódź Voivodeship. The article was based, among others, on based on: literature on the subject, reports of the Polish Agency for Enterprise Development (PARP), practical knowledge about logistics presented by logistics companies on websites and own research, which was carried out in the form of surveys among enterprises in the SME sector in the Łódź Voivodeship.

2. Efficiency Profile of Logistics Operations of Enterprises: a Theoretical Approach

The efficiency of logistical processes is of increasing importance from the point of view of enhancing the competitive and cooperative capacity of companies (Twaróg, 2003, p. 5). The aforesaid also applies to the search for value creation and partnerships in logistics networks of the SME sector.

The strategic objectives of logistics companies and companies for which logistics is one of the links in the supply chain are to achieve a smoothly operating supply service, through appropriate metrics for its implementation, and logistics systems, which will be analysed for effectiveness and efficiency of operation in the company. In turn, the setting of the company's strategic objectives will contribute to the establishment and setting of specific objectives through logistics metrics, which may include, for example, optimal production and sales planning, reduction of the costs of transport, materials, inventories (in all links of the supply chain) and finished goods for the final recipient/customer. Based on these measures, it will be possible to modify logistics if necessary and to monitor the economic development of the company.

In the literature, there is a wide variety of classifications of logistics indicators used to assess or obtain information on corporate performance. These indicators can be used to:

- evaluate a company's operating system by considering indicators such as:
 - effectiveness- measuring to what extent the system achieves what the company has planned,
 - efficiency - the ratio of the planned consumption of resources to the resources actually consumed,
 - quality - the degree to which customer requirements are met,
 - profitability - financial standing of the company,
 - productivity - the ratio of goods produced to inputs of factors of production,
 - quality of working conditions - how workers respond to the socio-technical working conditions in the company,
 - innovation - launching a new or upgraded product, materials, etc. (Slowinski, 2008, p. 68),
- assess the internal as well as external environment in which the company operates. The analysis of internal supply chain management addresses issues such as the evaluation of customer service levels and service quality, efficiency of capital use and logistics processes in company management. In turn, the analysis of the external metrics used to manage logistics processes will have a significant impact on, among other things, the comparison of the company's activities in comparison to the competition. (Twaróg, 2003, p. 28);
- measure business efficiency and management through logistics controlling for manufacturing enterprises to show the relationship between costs and logistics activities along the supply chain. In addition, logistics controlling should perform the following functions in this type of enterprise:
 - a) operational – setting objectives to be achieved,
 - b) incentive - to identify and control the solvency of the implementation of changes in the company,
 - c) advisory - to identify critical logistics indicators for the company,
 - d) steering and ongoing (to identify deviations from the planned management of the company's logistics processes) (Twaróg, 2003, p. 32).

Logistics costs also play a significant role in the selection of logistics indicators and metrics for assessing the efficient functioning of a supply chain or network, because with the help of selected logistics indicators it is possible to find the so-called optimum between rational costs across the entire supply chain and the appropriate level of delivered products and service to the final customer (Twaróg, 2003, p. 106; Blaik, 2010, p. 370). The manifestations of this rational approach to logistics exhibited by companies can be found in Table 1.

Logistics costs are defined in the literature in various ways, e.g., from the point of view of the scope and the structural breakdown of logistics costs, although defining them is rather problematic due to the interpretation of the concept. P. Blaik draws attention to, inter alia: the absence of adequate reference of the concept of logistics costs to the actual functions of logistics and logistics processes, or the lack of a comprehensive approach to the definition of logistics costs (Blaik, 2010, pp. 373-374).

Table 1.

Rationalisation of logistics operations

Cost reduction strategies in logistics		Customer value maximisation strategies
<ul style="list-style-type: none"> • Reduction of logistics costs through internal rationalisation within a company. • Cost reduction through a comprehensive adjustment (alignment) of the flows of materials and goods across the supply chain. • Cost reduction achieved by using (considering) logistics in the long-term decision-making in the company 	<ul style="list-style-type: none"> • Cost reduction and customer value maximisation through mutual adjustments (alignments) between partners across the supply chain in the field of the market, purchases, and sales. • Developing long-term cooperation models (between systems) 	<ul style="list-style-type: none"> • Increasing the flexibility of supplies (with regard to the time, type, and quantity). • Improving the reliability of supplies (quality of service). • Reduction of transaction costs at the customer end

Source: Blaik, 2010, p. 371.

Certainly, an important element in the definition of logistics costs is the inclusion of monetary consumption of company assets, which, according to M. Kufel's definition, is caused by *...planning, implementation and control of non-technological (non-production) movements of material goods, goods and information* (Nowak, Piechota, Wierzbinski, 2004, pp. 199-200; Stępień, Łęgowik-Świącik, Skibińska, Turek, 2016, p. 491). In contrast, the logistic cost function is characterised by complexity, as logistics costs, e.g., costs of transport are not only dependent on the quantity of goods and the length of the route, but also on the type of means of transport, the way the drivers drive, etc. (Pfohl, 1998, pp. 217-218).

An important element in assessing the effectiveness of a company is also the use of an appropriate breakdown of indicators to measure and assess the effectiveness of the logistics subsystems engaged in logistics operations along the supply chain, which include: (customer) order handling, warehouse management or logistics management. Therefore, the article analyses selected logistics indicators for SMEs related to supply chain management. The logistics indicators selected for analysis in this paper are those that are applicable to both TSL and non-TSL companies¹.

The main research question in the article is: what is the assessment of the effectiveness of the SME sector's business performance on the basis of selected logistics indicators in the Łódź Voivodeship in the years 2019-2022. In turn, the specific research question reads as follows: does the size of the surveyed enterprises matter for achieving good results in times of crisis?

¹ Logistics indicators used in the paper are presented in the next section.

Based on these research questions, two research hypotheses were formulated. The first one argues that the analysed indicators of transport and logistics quality for companies in the SME sector in the Łódzkie Voivodeship are very positive. The second research hypothesis reads: the smaller the size of the company, the more likely it is to achieve good results in times of crisis.

3. Methodology

The surveys used in the article to examine the effectiveness of logistics indicators in the SME sector were conducted online between 2019 and 2022, with most of the surveys analysed conducted during the COVID-19 pandemic. The research technique was an original proprietary questionnaire, which was distributed to 56 companies, of which 55 were qualified for the study. Most of the surveyed companies were not located in the Łódź agglomeration, but had their headquarters in other smaller towns and villages located in the Łódź Voivodeship, due to the existing numerous studies on the effectiveness of selected logistics indicators of Łódź enterprises. The selection of the sample for the survey research was carried out using a non-random technique in a convenient and random manner and was determined in accordance with the definition of SME sector companies applicable in the EU.

4. Analysis of Own Research Based on Surveys Concerning the Effectiveness of Logistics Indicators of Companies from the SME Sector in Poland with Particular Emphasis on the Łódzkie Voivodeship

Most of the companies participating in the study (84%) were based in the Łódzkie Voivodeship, with the remaining ones originating from the Mazowieckie, Śląskie, Opolskie and Dolnośląskie Voivodeships.

Tables 2 and 3 present the characteristics of the SME enterprises surveyed, which include information on:

- industry analysed. In order to carry out a proper analysis of the selected logistics indicators, different areas of activity of the SME sector were included in the research, (LOG.Mail No. 36). Half of the SMEs participating in the study (28 companies) belong to the TSL industry, while the other half (28 companies) are related with the manufacturing and service sector (outside the TSL industry);

- the division of companies from the SME sector. The majority of companies participating in the survey are micro-enterprises (with < 10 employees), both on the side of TSL companies (17 companies) and manufacturing and service companies (outside the TSL industry), (13 companies) (<http://publications.europa.eu/>, 2015). The second largest group among surveyed companies are small enterprises rendering TSL services and medium-sized manufacturing and service companies (non-TSL). The groups of medium-sized enterprises representing TSL service providers, as well as manufacturing and service companies (non-TSL) consisted of three companies each;
- date when SMEs participating in the study were established. The majority of the surveyed companies have been active in the market for a long time, (they were established between 2010 and 2020) and this can be said about 18 TSL companies and 18 non-TSL manufacturing and service companies;
- the majority of the companies surveyed are network companies.

The selection of transport and logistics quality indicators for assessing the efficiency of SME enterprises in the survey was based on subject-matter literature and an interview with full-time and part-time students of Management, Major in Logistics over the period 2019-2022.

An important element of the class discussion was the experience of part-time students who work in TSL service companies or in companies where logistics plays a significant role. Accordingly, the students presented those logistics indicators to which companies pay particular attention when they assess their logistics performance.

Table 2.

Characteristics of SMEs involved in questionnaire-based studies for TSL

Industry	Transport-shipment-logistics		
	Micro-enterprises	Small-enterprises	Medium-sized enterprises
Based in	Krośnica, Żarnów, Smardzewice, Wola Moszczenicka, Łódź, Opoczno, Zalesie, Teodozjów, Brudzewice-Kolonie, Tomaszów Mazowiecki (4), Opole, Świerczów, Budków, Guzów	Piotrków Trybunalski, Łazisko, Zaosie, Lubochnia, Tomaszów Mazowiecki (3)	Ujazd, Wolbórz, Tomaszów Mazowiecki
Date of launching operations:			
1990-2000	2	2	1
2001-2010	7	4	2
2010-2019	8	1	
Business profile	transport (10), retail and wholesale trade-transport, transport-tourism (Travel agency), passenger transport, forwarding services-transport, road transport, logistics, logistics-transport	transport (3), transport-forwarding services, transport-retail and wholesale trade, transport-forwarding services	International transport, contractual logistics, transport
Total	17	7	3

* One micro-enterprise included in the survey did not give the date of its establishment.

Source: author's own research.

Tables 4 and 5 present selected transport and logistics quality indicators for companies in the TSL sector and manufacturers and service providers (non-TSL) (Table 5).

The author's own research has shown that the analysed transport and logistics quality indicators are good enough for the companies of the SME sector in the Łódzkie Voivodeship, and this is due to: the share of logistics costs in the turnover of the company, which for the SMEs reached 32%, and for the manufacturing companies and service providers (outside the TSL industry) amounted to 24% (a very good result was recorded for micro and medium-sized companies, it amounted to 11% and 10%, respectively). This assessment is based on the opinion of selected authors of publications, who claim that logistics costs in relation to company turnover should be in the range of 10-40%, (Kowalska, Rubik, Skibińska, 2020, p. 23; Englon, Salakivi, Töyli, Ojala, 2022, pp. 29-35).

Higher logistics costs in relation to company turnover for companies in the TSL sector compared to logistics costs in relation to company turnover of companies for the manufacturing industry and service providers (outside the TSL industry) are due to the specificities of companies in the TSL sector and include:

- high operating costs (mainly fuel costs - 40 %), vehicle maintenance (costs related to regular technical inspections, purchase of high-quality spare parts), tolls, taxes, insurance, increasing staff salaries (mainly truck drivers' salaries);

Table 3.

Characteristics of SMEs involved in questionnaire-based studies for other industries that consider logistics in their strategies

Industry	Other industries that consider logistics in their strategies		
Size of firms from the SME sector	Micro-enterprises	Small-enterprises	Medium-sized enterprises
Based in	Tomaszów Mazowiecki (4), Wolbórz, Koluszki, Złoczew, Łódź (2), Inowłódz, Borowa, Żyrardów, Huta Będowska	Inowłódz, Łódź, Skierniewice	Tomaszów Mazowiecki, Ujazd, Łódź, Dąbrowa Górnicza (2), Warszawa Opoczno, Teresin Aleksandrów Łódzki, Poznań Warszawa
Date of launching operations:			
1990-2000	6	2	6
2001-2010	2		3
2010-2019	5	1	2
Business profile	beauty sector (2), recycling, Xerox-copying services, clothes-toys, sawmill services, wholesaler of cosmetics, medicine, carpentry, electronic services, wholesaler of bicycles, manufacturing and sales, fruit and vegetable wholesaler	manufacturing, curtains, steel framework structures for construction; personal hygiene products wholesaler of persons; marketing-advertising	construction-manufacturing-trade sector, trade-construction-agriculture sector, housing construction, recycling, tools manufacturing, ceramic tiles wholesale and retail, packaging-manufacturing, textile fibre wholesale and retail, office supplies manufacturing, wholesale and retail of beauty accessories
Total	13	3	11

Source: author's own research.

- and a number of miscellaneous difficulties related to the efficiency of TSL companies caused by the delayed collection of receivables (according to the BIG InfoMonitor debtor register, at the end of May 2023, the overdue debt of transport companies amounted to PLN 2.79 billion) and the lack of clarity in the terms of commercial contracts (<https://www.logistyka.net.pl/>).

Other measures of transport and logistics quality for the TSL sector and manufacturing and service companies (non-TSL) are as follows:

- The share of transport and cargo handling costs in relation to company turnover for companies in the TSL sector is also higher than for companies involved in manufacturing and the provision of services (non-TSL) and in the surveys it amounted to 37% and 26% respectively. Transport costs are related to the delivery, distribution and movement of goods. An important component of transport costs is, inter alia, transport time (i.e., the shorter the transport time, the higher the transport cost), the size and type of cargo, the distance from the place of loading to the place of unloading (cost of 1 km travelled). Such costs are most often contractual between the principal and the contractor;

Table 4.

Effectiveness assessment for selected measures of transport and logistics quality for TSL companies

Definition of an indicator of transport and logistics quality and its formula (in %)	SMEs from the TSL sector			
	Micro enterprises	Small enterprises	Medium-sized enterprises	Total
1. Share of logistics costs in the turnover $\frac{\text{Total costs of logistics}}{\text{Turnover}} \times 100\%$	27%	35%*	35%	32%
2. Share of transport and handling costs to total turnover $\frac{\text{Transport and handling costs}}{\text{Turnover}} \times 100\%$	47%	35%	30%	37%
3. Share of storage cost (cost of own storage or warehouse services) to company turnover $\frac{\text{Cost of storage}}{\text{Turnover}} \times 100\%$	8%	13%	42%	21%
4. Share of inventory cost to company turnover $\frac{\text{Cost of inventory}}{\text{Turnover}} \times 100\%$	8%	4%	5%**	6%
5. Share of administrative costs of Logistics to company turnover $\frac{\text{Administrative costs}}{\text{Turnover}} \times 100\%$	11%	16%	27%	18%
6. Share of error-free transport documents $\frac{\text{No. of error-free transport documents}}{\text{No. of issued transport documents}} \times 100\%$	78%	91%	86%	85%

*one company failed to provide data,

** one of the companies decided that a question from the survey did not apply to them.

Source: author's own research.

- The higher share of storage costs (costs of in-house warehouse or warehouse services) in relation to company turnover for TSL companies (21%) compared to these costs for manufacturing and service companies (outside the TSL sector), (11%), is a result, among other things, of the activities of TSL companies within contract logistics services. The level of costs is also related to infrastructure, equipment and personnel costs. On the other hand, the relatively low ratio of the cost of storage in relation to company turnover for manufacturing and service companies (outside the TSL sector) testifies to proper warehouse management by maximising the use of resources, while minimising costs and applying an appropriate logistics strategy for the SME sector, which (depending on financial and organisational possibilities) does not execute more than 50 orders per day. This strategy also includes: an appropriate layout of the company's warehouse, the introduction of logistics management methods, such as cross-docking or lean management (saving on stock management, increasing quality), multitasking of employees (involved in various warehouse operations: cargo collection, packaging, etc.), and picking carried out in stages (<https://www.mecalux.pl/>).

Table 5.

Effectiveness assessment for selected measures of transport and logistics quality for manufacturing and service companies outside of TSL sector

Definition of an indicator of transport and logistics quality and its formula (in %)	Non-TSL manufacturing companies and service providers from the SME sector			
	Microenterprises	Small enterprises	Medium-sized enterprises	Total
1. Share of logistics costs in the turnover $\frac{\text{Total costs of logistics}}{\text{Turnover}} \times 100\%$	11%	50%	10%	24%
2. Share of transport and handling costs to total turnover $\frac{\text{Transport and handling costs}}{\text{Turnover}} \times 100\%$	11%*	55%	12%	26%
3. Share of storage cost (cost of own storage or warehouse services) to company turnover $\frac{\text{Cost of storage}}{\text{Turnover}} \times 100\%$	3%**	20%	11%	11%
4. Share of inventory cost to company turnover $\frac{\text{Cost of inventory}}{\text{Turnover}} \times 100\%$	12%*	23%	5%	15%
5. Share of administrative costs of Logistics to company turnover $\frac{\text{Administrative costs}}{\text{Turnover}} \times 100\%$	17%**	18%	3%	13%
6. Share of error-free transport documents $\frac{\text{No. of error-free transport documents}}{\text{No. of issued transport documents}} \times 100\%$	58%	93%	89%	80%

* two companies did not answer the question,

** one company did not answer the question.

Source: author's own research.

- The low cost of inventories, particularly for companies in the TSL sector (6%) and slightly higher for manufacturing and service enterprises (outside the TSL sector), (15%), is the result, among other things, of proper inventory management, inventory monitoring to compare actual figures (with the balance of inventory), in theoretical terms, and the adaptation of inventories to the needs and specificities of the company at a minimum cost (generated by frozen capital) and acceptable risk (related, for example, to the inability to meet demand or the instability of production due to lack of materials) (<https://entra-group.eu/>);
- the ratio of logistic administrative costs to company turnover is favourable both for companies in the TSL sector (18%) and for manufacturing and service companies (outside the TSL sector), (13%). Company's administrative costs most often consist of personnel costs, office operating costs and advertising activities. Reducing costs in a company is an extremely difficult task, as, for example, abandoning training or courses for employees, or reducing costs for advertising, can contribute to lower quality of services and restrictions on reaching out to new customers, (<https://dziennikbankowy.pl/>);
- in terms of the proportion of error-free transport documents to the number of total documents issued, the figure for TSL companies in the SME sector was 85%, and for the other companies included in the survey it was 80%.

In the research analysis attention should also be drawn to the rather high ratios for small manufacturing and service companies (outside the TSL industry) of logistics costs and transport costs in relation to the company's turnover, which amounted to 50% and 55% respectively in the period under study. An index above 40% was also recorded for micro-firms in the TSL sector. This was caused by the Covid-19 pandemic crisis, the growing energy problem and the negative impact of the war in Ukraine on business in Poland. (<https://www.europarl.europa.eu/RegData/etudes/>). Despite being two separate crises, the pandemic and the war have global impacts, including disruptions to foreign trade and global supply chains. According to the report of the Polish Economic Institute released in June 2022, small companies suffered from deteriorating financial liquidity. Only 43% of the representatives of these companies declared that they had sufficient financial resources to run their business for more than 3 months. Manufacturing companies had the biggest liquidity problems. In contrast, the situation was better for TSL companies. Only 49% of manufacturing companies claimed that they had the resources to run their business for longer than 3 months, while in the case of TSL companies, it was just over 50% (<https://pie.net.pl/>, <https://gtlaw.com/en-gb/>).

5. Conclusion

Transport and logistics indicators should serve as a basis for company decisions, and as sources of relevant data that allow SMEs to improve their competitiveness. Higher competitiveness can be achieved by, e.g.: shortening the distance between the goods (across the entire supply chain) and the final customer, reduction of stocks in warehouse management, maintaining a high level of customer service and quality of logistic services for efficient transfer of goods to the final customer (Twaróg, 2003, p. 35).

Our research confirmed the hypothesis according to which, the analysed indicators of transport and logistics quality for SMEs in the Łódzkie Voivodeship are satisfactory. And that occurred despite the fact that in 2022 only 19% of enterprises were positive about the economic situation, compared to 2019, when the percentage of positive opinions among surveyed companies increased to 27%. The average assessment of the current Polish economic situation depends on the size of the company. Micro businesses saw the economic situation the least positive (score 2.30), while small companies (2.41) and medium-sized companies (2.57) were slightly more positive (<https://www.parp.gov.pl>, 2023, pp.73-74). On the other hand, despite the Covid-19 pandemic, the decline in Poland's GDP was relatively small at -1.7 per cent and -2.7 per cent in Q3 and Q4 2020, respectively, compared to the same quarters of 2019. In view of the crisis caused by the Covid-19 pandemic in 2020, the government launched a number of tools to support businesses including, among others, a crisis shield (<https://www.oecd-ilibrary.org/>, <https://www.worldbank.org/>, <https://comsision.europa.eu/>). The second hypothesis arguing that the smaller the company, the more often it encounters greater problems and barriers to the development of its business during crises, was confirmed only in the case of slightly higher indicators for the manufacturing and trade (non-TSL) industries, for the share of, e.g., logistics and transport costs in company turnover, which were 50% and 55% respectively.

The increase in business efficiency will depend on various indicators related to marketing, customer service or business profitability, as well as motives (e.g., innovative concepts and solutions for logistics development) and barriers to the development of logistics in the SME sector (including, among others, lack of adequate IT support for logistics activities, lack of qualified staff, etc.) (<https://www.manpowergroup.pl/>). Therefore, managers in the framework of improving the functioning of their SME sector enterprises should focus and pay attention to the digitalization of their processes in the SME sector. However, the barriers to the development of logistics in the SME sector should be solved through, among others: resources from European funds (such as eurogrants implemented under the European Funds for a Modern Economy program). The selection of appropriate indicators to assess the performance of a company will contribute to the assessment of the achievement of both strategic and

operational goals of companies. A reliable analysis conducted in companies will certainly provide answers.

At the moment the research carried out in the article cannot be reduced to research on this topic, both regarding the networking of enterprises in the SME sector in Łódź and in other voivodeships, due to limitations in the literature on the subject.

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EFFECTS OF IMPLEMENTING ERGONOMIC INNOVATIONS – EMPIRICAL RESEARCH IN ORGANIZATIONS

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Purpose: The purpose of this article is to present the results of research on the most commonly implemented types of ergonomic innovations in organizations and their impact on employees and organizational functioning. It also highlights key benefits and barriers associated with their implementation.

Design/methodology/approach: The study was based on an analysis of surveys conducted among 357 organizations. The questionnaire included questions about the types of ergonomic innovations implemented, their impact on organizational activities, the most common results achieved, and the implementation barriers encountered. Data were collected using the CAWI technique. Respondents were managers and specialists with knowledge and experience in implementing ergonomic solutions in their organizations.

Findings: The research results indicate that the implementation of ergonomic innovations contributes to increased employee productivity and improved comfort and safety at work. Organizations that effectively implement such solutions also report increased employee engagement and improved task quality. The main barriers to introducing ergonomic innovations include limited financial resources and lack of time for implementation.

Research limitations/implications: The main limitations of the study concern the relatively small number of organizations surveyed, which may affect the weaker ability to generalize the results. Additionally, the analysis is based on subjective assessments by respondents, which may lead to some measurement errors.

Practical implications: The research results provide practical guidelines for managers and ergonomics specialists, emphasizing the importance of implementing ergonomic innovations. Their implementation promotes improved comfort and quality of work, increases employee safety, and contributes to increased productivity and better organizational outcomes.

Originality/value: The article adds new value to the literature on ergonomic innovations by combining theoretical perspective with empirical analysis of their implementation effects. The obtained results can inspire further research and support practical actions to more effectively implement ergonomic innovations in organizations.

Keywords: ergonomic, ergonomic innovations, types of ergonomic innovations, benefits of implementing ergonomic innovations, barriers of the implementation of ergonomic innovations.

Category of the paper: Research paper.

1. Introduction

Modern organizations operate in a dynamic environment where ergonomic innovations play a crucial role in shaping working conditions, process efficiency, and employee well-being (Hovanec et al., 2024). Ergonomic innovations are used in every sector of the economy (Shorrocks, Williams, 2016). On one hand, their search and application are highly risky and unpredictable, but on the other hand, they offer an opportunity for businesses to maintain or even strengthen their market position. The growing interest in ergonomic innovations in organizations stems from the belief in their positive impact on efficiency and quality of work life (Duplakova et al., 2022; Dewicka-Olszewska, 2023). Ergonomic innovations are applied in design processes, diagnostic research, and managerial actions in enterprises (Górska, 2021; Czernecka, 2022). Implementing modern ergonomic solutions, which include both technologies and work organization methods, contributes to increased work comfort, reduced physical and mental strain, and improved overall business productivity (Grossi, 2017; Drăghici et al., 2017; Sosa et al., 2018; Loup-Escande, Loup, 2021). The specificity and innovation of ergonomics lie in synthesizing knowledge from various fields and using methods to assess human needs and expectations to create safe, useful, and comfortable environments, products, and services. This is also a way to improve physical, cognitive, sensory, and emotional experiences (Wilson, Sharples, 2015).

In this article, attention is focused on analyzing the effects resulting from the implementation of ergonomic innovations in organizations. Both the motivations for implementing ergonomic innovations, the types of benefits achieved, and potential challenges or difficulties associated with implementing ergonomic solutions in organizations are presented. Identified research gaps based on a literature review allowed for defining the research goal and problems. The paper presents the results of empirical research on identifying ergonomic innovations implemented in organizations operating in various sectors of the economy.

The article consists of four sections, an introduction, and a conclusion. Section 1 is theoretical and includes a literature review on types of ergonomic innovations in organizations and benefits and barriers to implementing ergonomic innovations. Additionally, this section presents the problem undertaken. The next section of the article is empirical and contains research methodology, research results, and their limitations. Section three includes conclusions and practical recommendations, while section four presents directions for future research. The article provides valuable information for decision-makers shaping work ergonomics policy.

2. Theoretical background

2.1. Types of ergonomic innovations in organizations

Ergonomic innovations refer to novel solutions related to the economy and human interaction with objects. They can be defined as the process of introducing "new solutions" into production and use by combining anthropocentric, social, biotic, and technical elements, leading to changes in the parameters of objects and products in terms of size, quality, modernity, and efficiency (Harris, 2016; Dewicka-Olszewska, 2021). Ergonomic innovations can be treated as the implementation of new solutions within the industrial process and new solutions in the areas of technology, economics, and human interaction with products (Hoff, Öberg, 2014). Ergonomic innovations are new or improved methods, technologies, tools, or workplace designs that, by considering human capabilities and limitations, lead to improved working conditions, employee well-being, and productivity, while minimizing the risk of injuries and health problems (Marková, Lestyáška Škurková, 2023). Therefore, ergonomic innovations in businesses involve adapting technology, technology, and the work environment to human psychophysical capabilities, using anthropocentric, social, biotic, and technical knowledge. Their task is to adapt the parameters of objects or products in terms of safety, quality, modernity, and efficiency (Dewicka-Olszewska, 2023).

The goal of ergonomic innovations is to meet the requirements of local and international communities, which expect formalization, expansion, and adherence to standards for the safety of products and services produced and offered under conditions of high safety and hygiene at work, along with respect for the natural environment (Faludi, 2022).

Based on the analysis of literary sources, the following types of ergonomic innovations can be distinguished:

1. Product (technological) innovations. These involve designing ergonomic tools and devices, using new intelligent materials, integrating intelligent technologies, and incorporating digital solutions into ergonomic products, which improves their functionality and adaptation to user needs (Ferenčíková, 2014; Lawrence, 2021; Spreafico, Sutrisno, 2023; Gempur Santoso, 2023; Dewicka-Olszewska, 2023; Hovanec et al., 2023; Michel, 2023).
2. Process (organizational/non-technological) innovations. These concern optimizing (designing) workstations according to ergonomic principles, implementing ergonomic principles in processes, creating procedures and instructions that consider ergonomic aspects, conducting ergonomics training for employees, and developing systems for monitoring working conditions (Alhadeff et al., 2012; Alexander, Paul, 2014; Claeys et al., 2022; Dewicka-Olszewska, 2023).

3. Marketing innovations. These involve conducting effective promotions of products and services that improve ergonomics. They are crucial for increasing awareness and demand for these products, and informational campaigns can educate consumers about the benefits of ergonomics (Alexander, Paul, 2014; Chodźko, Szymczyk, 2023).
4. Innovations in business models. These involve offering advisory services and personalizing solutions (Wierzbński, 2017; Dewicka-Olszewska, 2023).

Ergonomic innovations utilize scientific achievements in ergonomics to improve and organize work, as well as methodologies for creating new and correcting existing technical-organizational solutions. Practical examples include innovative solutions in work processes, work organization, work methods, work tools, physical work environment, enhancing work qualifications, and managerial procedures (Górska, 2021; Dewicka-Olszewska, 2023).

It is important that ergonomic innovations facilitate work and reduce the burden on employees. The synergy between technological and non-technological innovations is crucial, for example, introducing advanced work tools should be combined with appropriate training and workstation optimization (Desbarats, 2005; Hovanec et al., 2023; Bortolini et al., 2023; Mehta et al., 2024).

2.2. Benefits and barriers of implementing ergonomic innovations in organizations

The motivations for implementing ergonomic innovations in organizations are various factors of economic, social, and regulatory nature (Alexander, Paul, 2014; Dewicka-Olszewska, 2021; Spreafico, Sutrisno, 2023; Murani, 2024). Implementing ergonomic solutions has significant importance for both the organization and its employees. Research results indicate that the benefits achieved from ergonomics include the following aspects:

1. Increased efficiency and productivity. Ergonomic workstations contribute to increased productivity because employees working in comfortable conditions are more focused and engaged (Kushwaha, Kane, 2016; Hovanec et al., 2023; Mehta et al., 2024).
2. Improved workplace safety, reduced accidents and occupational diseases. The implementation of ergonomic solutions reduces the number of accidents and injuries related to working conditions, contributing to improved employee health and reduced absenteeism (Quiroz-Flores et al., 2023; Amit, 2024; Korkmaz, Unver, 2024).
3. Increased employee well-being. Ergonomic solutions reduce the number of medical leave days and medical care costs (Wilson, Sharples, 2015; Marková, Lestyáška Škurková, 2023).
4. Boosted morale and employee satisfaction. Investing in ergonomic solutions shows employees that the organization cares about their comfort and health, which strengthens their engagement and loyalty to the company (Mazzoni et al., 2019; Heidarimoghadam et al., 2020).

5. Achieving long-term economic benefits. Investments in ergonomics allow for reducing labor costs, such as absenteeism and medical care costs, while improving productivity. Organizations can also gain prestige and attractiveness as employers. Well-designed work environments also contribute to better company performance (Mishra et al., 2021; Duplakova et al., 2022; Hovanec et al., 2023; Quiroz-Flores et al., 2023; Mehta et al., 2024).
6. Improved work quality. Ergonomic workstations reduce errors and improve the quality of tasks performed (Thun et al., 2011; Hasanain, 2024).

Ergonomic innovations also bring intangible business benefits, such as improving the well-being of employees and users (increased motivation), interest in work and tasks, adaptation to work and tolerance of mental stress, and reducing interpersonal conflicts. Additionally, innovative ergonomic solutions include mechanization and automation of work, which improve work posture, better organize work time, and streamline information reception and transmission (Dewicka-Olszewska, 2023).

Despite numerous benefits, many organizations face difficulties in implementing ergonomic innovations. The main barriers include:

1. Lack of management support. Insufficient engagement from management can result in a lack of resources for implementing ergonomic innovations (Yazdani, Wells, 2018; Neves et al., 2023).
2. Limited financial resources. The costs of purchasing new equipment, modifying existing workstations, and training employees often pose a barrier (Karsh et al., 2013; Cyran, 2016).
3. Employee resistance. Lack of awareness of the benefits of ergonomic solutions and fear of change can hinder implementation (Rothmore et al., 2015; Mooren-van der Meer et al., 2024).
4. Deficiencies in research and development infrastructure. Limited technical facilities can delay the implementation of innovations (Riel, Imada, 2010).
5. Insufficient knowledge of ergonomics. Both employees and managers may not be aware of available solutions and their advantages, resulting in a one-sided, narrow view of developing and implementing ergonomic innovations (Karsh et al., 2013; Yazdani, Welles, 2018).
6. Lack or insufficient training. Inadequate preparation of employees to apply ergonomic practices can hinder the implementation of changes (Karsh et al., 2013; Mooren-van der Meer et al., 2024).
7. Communication problems. Lack of information about implemented ergonomic solutions can lead to misunderstandings and lack of employee engagement (Driessen et al., 2010; Kumar, Kashyap, 2023).
8. Bureaucracy. The process of obtaining funds for implementing ergonomic innovations can be complicated and time-consuming (Koma et al., 2019).

9. Complexity of implementations. They require cooperation between many departments, which can be difficult to achieve (Mooren-van der Meer et al., 2024).
10. Complex legal regulations. Regulations can hinder rapid implementation, and there is also a problem with standardizing the norms used in a specific organization (Glimskär, Lundberg, 2013).
11. Prioritizing other needs. Organizations often focus on production and productivity, marginalizing ergonomics (Mooren-van der Meer et al., 2024).

Ergonomic innovations are an important element of organizational development. They require a holistic approach, considering technical, organizational, marketing, and business aspects. Despite the barriers, investing in ergonomics leads to increased productivity, improved work quality, and gaining a competitive advantage.

2.3. Legal regulations in the field of ergonomics

The modern work environment increasingly appreciates the importance of ergonomics, which plays a crucial role in improving employee safety, health, and productivity. Ergonomic innovations are supported by legal regulations worldwide. In the European Union, for example, directives concerning machinery and work with display screen equipment specify minimum safety and health requirements (Guide to Application..., 2024). In Poland, the Regulation of the Minister of Labor and Social Policy imposes an obligation on employers to ensure ergonomic working conditions, including at workstations with screen monitors (The Journal of Laws of the Republic of Poland 2023, item 2367). At the international level, ISO standards, such as ISO 9241, provide guidelines for ergonomic design of workstations, interfaces, and work systems (*ISO 9241-20:2021(E)*).

The most important, selected initiatives undertaken recently in the EU in the field of occupational safety and health include (EU Strategic Framework..., 2025; Eurofound, 2024a):

- Treaty on the Functioning of the European Union (TFEU) (art.: 91, 114, 115, 151, 153 and 352).
- EU Strategic Framework on Health and Safety at Work 2021-2027.
- Update of Council Regulation (EC) 1994/2062 establishing the European Agency for Safety and Health at Work (EU-OSHA) and its tasks (Regulation (EU) 2019/126 of the European Parliament and of the Council of January 16, 2019).

In 2025, according to information published by EU-OSHA, safety regulations will undergo changes to reflect global trends, including technological innovations (the development of automation, robotics, and intelligent technologies), remote and hybrid work models (Moreno, 2025). It is also worth noting that aspects related to the use of artificial intelligence, particularly during the implementation of ergonomic innovations, lack unified legal regulations despite ongoing efforts. This is due to the complexity of systems (Ziakkas, Henneberry, 2024) and the dynamic development of technology (ERA Industrial..., 2024).

2.4. Context of the problem addressed

Ergonomic innovations, due to their diversity, require conducting extensive research, methodological analyses, and workshops. The need for these arises both before implementing new solutions such as machines, systems, or technologies and in situations where the number of injuries and occupational diseases increases, negatively affecting working conditions (Dewicka-Olszewska, 2023). The results of ergonomic research and analysis allow companies to meet legal requirements, adhere to safety and hygiene standards, and effectively improve employee comfort and health. An analysis of the literature on ergonomic innovations has identified several key research gaps:

1. Insufficient scope of research on evaluating the effectiveness of implementing ergonomic Innovations.
2. Lack of evidence showing the impact of ergonomic innovations on productivity, health, and working conditions.
3. Lack of detailed analyses on the economic aspects of implementing ergonomic innovations.
4. Lack of in-depth research on adapting ergonomics to new technologies.
5. Few studies showcasing the practical use of different methods at the stage of implementing ergonomic innovations.
6. Lack of research integrating different approaches to create a coherent model for implementing ergonomic innovations.
7. Limited scope of research on the impact of ergonomic innovations on safety culture.
8. Concentration of research mainly on standard solutions, overlooking the diversity of needs of different user groups, including people with disabilities.

Identifying these gaps indicates the need for further research in the area of ergonomic innovations, which can contribute to better adapting the work environment to employee needs and increasing organizational efficiency (Kim, 2015). An important aspect that should be studied and compared is the ability to identify types of implemented ergonomic innovations and the effects achieved by organizations after their implementation.

3. Empirical studies

3.1. Methodology

The adopted research methodology is consistent with the approaches presented in the literature and used in management science research (Matejun, 2021). This methodology allows for achieving the set goal, was chosen appropriately for the topic, and includes several stages. The first stage was a review of Polish and foreign literature in four publicly available databases:

EBSCO, Scopus, Web of Science, and Emerald. The analysis covered two main research areas: types of ergonomic innovations and benefits and barriers associated with their implementation. The literature review allowed for identifying research gaps in the area of ergonomic innovations. In the next stage, the research objective was defined (Stańczyk-Hugiet, 2021).

The main objective was to identify current challenges related to the implementation of ergonomic innovations in organizations, determine their types, and identify the benefits and barriers during their implementation. The practical objective of the study was to develop conclusions and recommendations that management staff in organizations can use to more effectively and quickly implement ergonomic innovations that improve employee productivity and safety.

To conduct the research, four research hypotheses were formulated:

- H1: The ergonomic innovations implemented in organizations most often focus on improving the workstation and work organization.
- H2: The primary goals set by organizations implementing ergonomic innovations are to increase work productivity and improve work safety.
- H3: The most commonly achieved benefits of implementing ergonomic innovations in organizations are improved work comfort and improved work quality.
- H4: Financial and time constraints on implementing changes are the main barriers to implementing ergonomic innovations in organizations.

In the study, a diagnostic survey method was used, allowing for the collection of information about the phenomenon under investigation, analysis of respondents' views and beliefs, and assessment of their state of knowledge (Dźwigoł, 2015; Czakon, 2021). A questionnaire was used to collect data (Matejun, 2021). The developed questionnaire consisted of a metadata section and detailed questions, serving to conduct quantitative research (Czakon, 2021). The study was conducted from October 2024 to January 2025 using the CAWI method. The research sample was selected purposefully, and the questionnaire was addressed to management and specialists who have knowledge about the ergonomic innovations implemented in their organizations. The questions were closed-ended. The type and size of the organization were not significant – the study included manufacturing, service, and trade organizations operating in Poland. Based on the collected data, an analysis of the results was performed (Baran, 2021), and conclusions were formulated in relation to the research hypotheses (Flick, 2020). The obtained results also enabled the proposal of recommendations for organization managers and the indication of directions for future empirical research in this area (Lenart-Gansiniec, 2021).

3.2. Research results

The overall goal of the empirical research conducted in organizations operating in Poland was to identify the types of ergonomic innovations being implemented and the benefits and barriers encountered during the implementation of ergonomic innovations. The presented results constitute a part of broader research conducted using a questionnaire survey. The study involved 357 organizations. Table 1 contains data on the characteristics of the surveyed organizations.

Among the surveyed organizations, the largest percentage consisted of: organizations with over 20 years of experience in the market (28.3%), employing up to 49 employees (41.5%); having good financial condition (41.7%); providing services (54.1%); conducting sales on the domestic market (33.6%); operating based on domestic capital (40.3%), and functioning in industries such as food (30.7%), IT and telecommunications (13.2%), construction (8.4%), clothing (7.8%), and machinery (6.7%).

Table 1.
Characteristics of the surveyed organizations (% share)

1. Experience on the market			
under 5 years (28.9)	6-10 years (20.7)	11-20 years (22.1)	over 20 years (28.3)
2. Number of employees			
10-49 (41.5)	50-249 (30.8)	250-499 (10.1)	over 500 (17.6)
3. Financial condition			
very good (14.0)	good (41.7)	average (33.6)	weak (10.7)
4. Scope of core activities			
component production (9.5)	manufacturing of products (24.9)	services (54.1)	commerce (23.5)
5. Sales markets			
regional (20.8)	national (33.6)	international (29.7)	global (12.9)
6. Foreign capital share			
0% (40.3)	1-50% (37.8)	51-75% (15.7)	over 75% (6.2)

Source: own study based on research results.

Types of ergonomic innovations implemented in the surveyed organizations

Most respondents considered ergonomic innovations to be the process of introducing new solutions using the collaboration of humanities and technical and organizational sciences to adapt the work environment to the needs and expectations of workers, thereby improving their safety and hygiene at work, which increases their productivity and enhances organizational efficiency. Respondents were asked to indicate the areas where ergonomic innovations were implemented over the past three years in their organizations. Figure 1 shows the share of the most frequently mentioned types of ergonomic innovations implemented in the surveyed organizations.

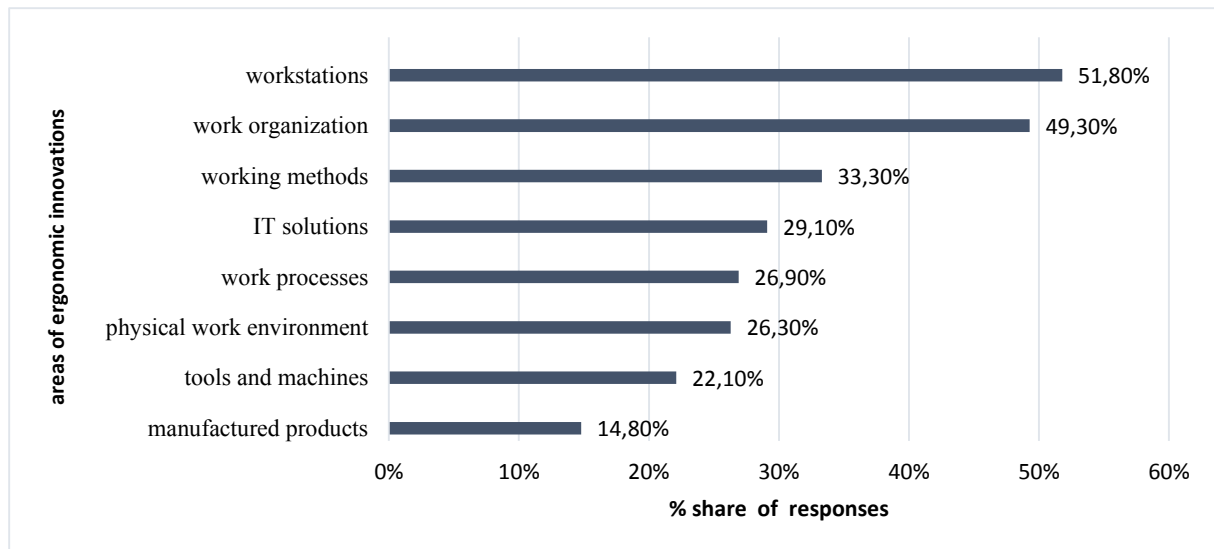


Figure 1. Share of the most frequently mentioned types of ergonomic innovations implemented in the surveyed organizations.

Source: Own elaboration based on survey research results.

The greatest emphasis in the surveyed organizations is placed on implementing ergonomic innovations at workstations (51.80%) and work organization (49.30%), as well as work methods (33.30%), which may result from their direct impact on improving employee comfort and productivity. The surveyed organizations most often invest in improving working conditions by changing the organization of processes and adapting workstations to meet employee needs. In contrast, less attention in the surveyed organizations was devoted to implementing ergonomic innovations in manufactured products (14.8%) and tools and machines used (22.1%), suggesting that innovations in these areas may be less of a priority or more difficult to implement.

Objectives and benefits of implementing ergonomic innovations

In the next question, respondents were asked to assess the objectives impacted by the ergonomic innovations implemented in their organizations. They were able to use a scale from 1 to 5 (1 - completely insignificant impact; 2 - slightly significant impact; 3 - average impact; 4 - significant impact; 5 - extremely significant impact). Among several proposed objectives (5 out of 11), respondents indicated that the ergonomic innovations implemented in their organizations had the greatest impact on: increasing productivity (3.96), achieving better results from business activities (3.92), improving workplace safety (3.86), better meeting consumer needs (3.57), adapting to legal standards (3.54), and enhancing the company's image (3.51).

In the following question, respondents were asked to evaluate the benefits that ergonomic innovations brought to their organizations over the past three years. Table 2 presents the results of responses provided by respondents from the surveyed organizations.

Table 2.*Types of benefits achieved in surveyed organizations*

Benefits	1	2	3	4	5	Average
work efficiency	37	19	88	149	74	3.66
product/service quality	19	31	128	128	62	3.61
quality of work	24	22	80	169	74	3.79
frequency of accidents at work	19	30	151	112	59	3.57
severity of work accidents	25	21	155	101	68	3.57
number of workplace accidents	21	28	150	100	70	3.58
potentially accidental events	21	31	134	19	59	2.40
sickness absence	22	29	175	99	38	3.34
labor costs	22	45	135	124	38	3.37
employee turnover	25	44	146	112	36	3.30
direct supervision	24	44	154	101	39	3.29
costs of repairs of machines and equipment	24	49	145	109	39	3.33
caring for equipment and tools	25	27	142	128	43	3.45
work comfortable	19	27	66	168	86	3.85
employee satisfaction level	22	27	81	162	73	3.73
customer satisfaction level	21	27	121	125	71	3.62
organizational image	16	25	100	145	77	3.73
work safety	18	23	117	142	65	3.66
self-control	26	25	146	125	40	3.40

Scale used: 1 - significant deterioration; 2 - deterioration; 3 - almost the same benefits; 4 - improvement; 5 - significant improvement.

Source: Own elaboration based on survey research results.

From the data in Table 2, it appears that the surveyed organizations achieved the greatest benefits in terms of improving work comfort (3.85), improving work quality (3.79), and increasing employee satisfaction (3.73), suggesting that ergonomic actions focus primarily on improving employment conditions. The implemented innovations also had a positive impact on enhancing the organization's image (3.73) and improving safety, which is reflected in the reduction of accidents and improvement in the overall safety level within organizations. Economic and organizational benefits, such as a decrease in absenteeism, labor costs, or employee turnover, are visible but not as strongly noticeable, which may indicate that their effects are more long-term. However, the least noticeable benefit concerns the elimination of potentially hazardous situations (2.40), which may suggest that organizations focus on specific accidents rather than preventive actions reducing risks.

Barriers to implementing of ergonomic innovations

In the next question, respondents were asked to select the 5 most important barriers from 10 proposed options that hinder the implementation of ergonomic innovations in their organizations. Figure 2 shows the percentage share of the most significant obstacles indicated by the respondents.



Figure 2. Largest share of barriers to implementing ergonomic innovations.

Source: Own elaboration based on survey research results.

From the data presented in Figure 2, it appears that respondents considered the following as key barriers to implementing ergonomic innovations in the surveyed organizations: (1) limited financial resources (65.00%); (2) lack of time to implement changes (39.20%); (3) insufficient employee education (32.80%); (4) short-term thinking (32.50%); (5) spatial and organizational constraints (30.50%); (6) costly technological solutions (30.00%); (7) lack of tools and resources (29.40%) supporting ergonomic innovations; (8) lack of management support and engagement (27.20%); (9) employee resistance to change (25.50%).

Identifying these potential barriers allows for continuous monitoring and management of the risk associated with implementing ergonomic innovations, which can prevent unforeseen problems.

3.3. Research limitations

This study encounters limitations associated with the quantitative research paradigm. The study was limited to a selected period (time frame), which did not allow for determining the dynamics of changes in implementing ergonomic innovations and achieving effects by the surveyed organizations. Empirical research conducted using a questionnaire survey has certain limitations, including:

1. Subjectivity of responses. Respondents evaluated the effects of implemented innovations based on their own assessments, which may lead to distortion of the results.
2. Limited knowledge of respondents. Specialists and management of the surveyed organizations may not have had full knowledge about the effects of ergonomic innovations, which could affect the quality of the collected data.
3. Small scale of empirical research. This may have influenced the representativeness of the results and limited the possibilities for generalization.

4. Lack of in-depth understanding. There was no possibility of gaining a deep understanding of the causes and mechanisms behind the effects of ergonomic innovations over time.
5. Potential misinterpretation of questions: Respondents may have misinterpreted questions, leading to incorrect answers and incorrect conclusions.
6. Providing only cross-sectional data. The study provides data at a specific point in time, while the effects of ergonomic innovations may only become apparent after a longer period.

Future research should be conducted on a larger sample and should be more contextually diverse (in different countries, in different sectors), which can contribute to a deeper analysis of the problem. Additionally, conducting research in different countries will allow for comparisons, drawing conclusions, and increasing the possibilities for generalization. Using mixed research methods, which combine quantitative survey data with qualitative interviews or case studies, may allow for a better understanding of the impact of various ergonomic innovations on organizational outcomes.

4. Conclusions and recommendations

Organizations implement ergonomic innovations to improve working conditions, increase work productivity, and reduce the risk of injuries (Gašová et al., 2017). These innovations include actions aimed at humanizing the living and working environment to make it user-friendly for the psycho-physical needs of users, providing them with numerous benefits (Butlewski et al., 2015). The ergonomic innovations implemented in the surveyed organizations relate to technical solutions (adapting workstations and methods to meet employee needs) and organizational solutions (aimed at improving quality of life and safety at work).

The analyzed results from the conducted research unequivocally confirm the four adopted hypotheses:

- Ergonomic innovations in the surveyed organizations most often focus on improving workstations (51.80%) and work organization (49.30%) (H1).
- The primary goals set by the surveyed organizations implementing ergonomic innovations are to increase work productivity (3.96) and improve work safety (3.86) (H2).
- The most commonly achieved benefits of implementing ergonomic innovations in organizations are improved work comfort (3.85) and improved work quality (3.79) (H3).
- The main barriers to implementing ergonomic innovations in organizations are financial constraints (65%) and time constraints (39.2%) for implementing changes (H4).

Contemporary ergonomic innovations also encompass forms of work, including the use of remote work (Kamala et al., 2024), the utilization of digitalization, and automation based on artificial intelligence (Marková, Lestyáská Škurková, 2023). To optimize human-machine-environment interaction, it is crucial to leverage the synergy between technological progress and workplace ergonomic needs, particularly digitalization (Laudante, 2017) and artificial intelligence (Priyanka, Subashini, 2024). Digitalization can improve work ergonomics in production facilities, minimizing risks and increasing efficiency (Duplakova et al., 2022), although it can also lead to "digital Taylorism," limiting autonomy and increasing employee control (Lager et al., 2021), as well as increasing cognitive load and deepening dependence on modern technology, which may contribute to problems in case of failures or lack of access to this technology (Mehta et al., 2024; Milea, Cioca, 2024).

From the analysis of literature and empirical research, it appears that to meet challenges and effectively implement ergonomic innovations in organizations, several best practices should be employed. Below are the most important ones:

1. Increasing management engagement. Enhancing the involvement of management staff (Dewicka-Olszewska, 2023).
2. Employee participation. Encouraging employee involvement in creating and implementing pro-ergonomic projects (Cervai, Polo, 2018; Rostami et al., 2021; Czernecka, 2022; Zhang, Lin, 2023).
3. Expanding work on implementing ergonomic innovations in products and tools. Increasing efforts to implement ergonomic innovations in manufactured products and tools used (Bortolini et al., 2023; Proia et al., 2025).
4. Introducing flexible workspaces and ergonomics training. Providing flexible workspaces, offering ergonomics training for employees, and promoting a safety culture (Quiroz-Flores et al., 2023; Korkmaz, Unver, 2024).
5. Universal design. Incorporating diverse user needs into design (Tosi, Pistolesi, 2018; Vujica Herzog et al., 2019; Mehta et al., 2024).
6. Designing workstations with lean manufacturing and ergonomics principles. Integrating lean manufacturing and ergonomics principles in workstation design (Herwanto, Suziant, 2023).
7. Better recognition of organizational capabilities. Often, there are differences between designed and implemented solutions (Jacobo-Galicia et al., 2021; Motamedimoghadam et al., 2024).
8. Leveraging advanced technologies. Used of automatization, Robotic Process Automation (Ziemianin, 2023), AI (Marková, Lestyáská Škurková, 2023; Bortolini et al., 2023; Hovanec et al., 2024), digitalization (Duplakova et al., 2022).
9. Developing and applying diverse criteria for evaluating ergonomic innovation effects. establishing varied criteria for assessing the effects of ergonomic innovation implementation (Gualtieri et al., 2020; Dewicka-Olszewska, 2023).

10. Integrating ergonomic innovations with other processes. Integrating ergonomic innovations with other organizational processes (Moreira da Silva, 2015; Hovanec et al., 2023).
11. Limiting the impact of existing financial and time barriers. Obtaining different funding sources for implementing ergonomic innovations (Dewicka-Olszewska, 2023) e.g., EU funds (Horizon Europe), application of prioritization strategies for ergonomic projects, phased implementation of ergonomic innovations, division of complex innovative projects into subprojects, cooperation with specialized institutions, involving employees in the process of designing and implementing ergonomic innovations (Zhang, Lin, 2023), use of remote work (Kamala et al., 2024), partnership with technology suppliers (Hoque et al., 2022).

Understanding and effectively managing these challenges is crucial for companies to ensure workplace efficiency and employee well-being across different cultures and locations. New technologies have opened up new opportunities for managing ergonomic challenges, offering innovative, efficient, and consistent solutions. They help companies provide a safe and comfortable work environment for all employees, regardless of their geographical location.

5. Directions for future research

In the future, research on ergonomic innovations in organizations should focus on several key areas to effectively address the changing needs of employees and workplace challenges. Below are the main areas that deserve detailed investigation:

1. Technology and intelligent solutions. The increasing use of technologies such as implementing artificial intelligence (AI), smart workwear, and wearable robotics requires research on their impact on employee health and productivity. Studies should include the effectiveness of these solutions in reducing injuries and improving work comfort (Colim et al., 2020; Alpala et al., 2022; Leśniewicz, 2024; Proia et al., 2025).
2. Personalization of workstations. Understanding how the diversity of employee needs affects the design of ergonomic workstations. Research should focus on developing solutions tailored to individual requirements, which can increase comfort and efficiency (Mayer et al., 2021; Priyanka, Subashini, 2024; Eurofound, 2024b; Firescu, 2025).
3. Ergonomics in remote work context: The growing popularity of remote work poses new ergonomic challenges. Research should address the design of ergonomic home workspaces and the impact of such solutions on employees' mental and physical health (Alsafran, 2024).

4. Impact of work environment on mental health. Investigating the relationship between ergonomics and employees' mental health. Research may focus on the impact of ergonomic solutions, such as lighting or acoustics, on well-being and productivity (Dewicka-Olszewska, 2023).
5. Economic aspects of ergonomic innovations. Analyzing the economic benefits resulting from the implementation of ergonomic innovations, including savings from fewer injuries and increased productivity. Research should also evaluate the long-term effects of investing in ergonomics for organizations (Gupta, 2024).
6. Sustainable development and ergonomics. Researching how sustainable development principles can be integrated with ergonomic innovations to create more environmentally friendly workplaces. This approach may include using eco-friendly materials and designing spaces that promote energy efficiency (Hasanain, 2024).
7. Utilizing diverse methods for analyzing and evaluating implemented ergonomic innovations. Using various methods to analyze and evaluate ergonomic innovations in different organizations (Magally, Wilfredo, 2022; Czernecka, 2022).

These research directions can contribute to further analysis and study of various areas where ergonomic innovations will be developed and implemented in organizations, improving working conditions, health, and well-being of employees, as well as enhancing organizational productivity and efficiency.

6. Summary

The purpose of this study was to identify the types of ergonomic innovations implemented in organizations and the benefits and barriers encountered during their implementation. It was conducted based on an analysis of the results of survey research carried out among 357 organizations. The empirical data indicate that various types of ergonomic innovations are implemented in the surveyed organizations, particularly in the areas of workstations and work organization. The ergonomic innovations introduced in organizations primarily contribute to increasing work productivity, achieving better results from business activities, and improving workplace safety and hygiene. In terms of benefits achieved, respondents most often pointed to improved work comfort and quality. Financial and time constraints were identified as the most significant barriers to implementing innovations.

Identified research gaps and empirical research enabled the identification of directions for further research and the provision of recommendations in key areas related to implementing ergonomic innovations, allowing organizations to achieve better outcomes (Carayon, 2019; Dul, Neumann, 2020). Cultures promoting openness, continuous learning, and employee engagement are better prepared for the effective development and implementation of ergonomic

innovations, which is also confirmed by research conducted in European countries (Eurofound, 2024a). For Poland and other countries, a priority should be to address barriers that hinder innovation and create conditions that stimulate the introduction of ergonomic innovations in enterprises (Growth and competitiveness ..., 2025). Meanwhile, for businesses, priority should be given to actions that potentially stimulate the implementation of innovative ergonomic solutions in various areas, including workstation design, work organization, tool design and selection, creation of the physical work environment, enhancement of work qualifications, creation of managerial procedures, and design of manufactured products or services provided (Laudante, 2017). Ergonomic innovations should be one of the key elements of ESG (Environmental, Social, Governance) strategies. Research in this area allows companies to improve working conditions, which is an important aspect of sustainable development.

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ESG: THE NEW CURRENCY OF BRAND VALUE

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Purpose: This study aims to assess the impact of ESG (Environmental, Social and Governance) performance on the determination of brand value, considering both its aggregate influence and the effects of its individual subdimensions.

Design/methodology/approach: The hypothesis that environmental, social, and governance practices enhance brand value is tested. The study uses regression and correlation analyses to evaluate the relationship between Brandfinance Global 500 brand values, S&P Global ESG scores, financial variables, and enterprise value over the period 2013-2023.

Findings: The results of multiple regression analyses indicate that assets and enterprise value positively influence brand value, while, contrary to expectations, the overall ESG score exerts a negative effect. The analysis of ESG subdimensions reveals varying impacts: the environmental dimension positively correlates with brand value, the governance dimension exhibits a negative relationship, and the social dimension shows no statistically significant relationship.

Practical implications: The findings emphasize the need for a more nuanced and critical approach to ESG evaluation. Stakeholders should focus on the quality and authenticity of ESG practices, rather than simply relying on aggregate scores. This research encourages a shift towards a more sustainable and responsible business environment.

Social implications: The research highlights the disconnect between perceived ESG performance and actual brand value, raising concerns about the authenticity and effectiveness of current ESG practices. This has far-reaching social implications, impacting investor behavior, corporate governance, consumer expectations, and regulatory policies.

Originality/value: This study is expected to add to the scarce research that examines the connection between brand value and ESG performance. By elucidating the relationships within the brand value-firm value-ESG score framework, the findings are expected to significantly influence the strategic decisions of corporate, brand and financial managers.

Keywords: ESG, performance, brand value.

Category of the paper: Research paper.

1. Introduction

A brand, defined as a symbol that differentiates or defines the product or service (Kotler, 2000), adds value to the company in many ways. Brand value is a concept that refers to the additional value that a brand gives to a product or service. The value added to companies can be considered from many perspectives. A strong brand gives a company a competitive advantage (Gupta et al., 2020; Melo, Galan, 2011, p. 424), making it harder for new players to enter the market. A strong brand helps to find cheaper and more continuous resources (Michell et al., 2001, p. 416), reduce risk, attract investors' attention (Rahman et al., 2023, p. 329), and increase customer loyalty (Dam, Dam, 2021, p. 586). In this way, we are expected to reach the same conclusions, even with different mechanisms. Companies with strong brands and with high growth potential are believed to be able to significantly increase firm value in the future (Kumar et al., 2021, p. 2; Kirk, 2013, p. 488; Yeung, Ramasamy, 2008, p. 331). According to traditional shareholder theory, which advocates that shareholders' interest should be the primary priority (Friedman, 1970), the focus should be on the value created by the brand and the benefits to shareholders. This theory is increasingly being challenged in the face of sustainability and ESG strategies that are beginning to play an increasingly important role in economics.

It is known that brands contribute to shareholder value even if they do not appear on company balance sheets. Brand value consists of tangible components, such as benefits resulting from physical features, as well as intangible and difficult-to-measure components, such as brand associations and consumer perceptions (Kamakura, Russell, 1993, p. 19; Kirk, 2013, p. 488). Brand value, represented as market-based assets, has traditionally been the basis for long-term, sustainable customer value. By creating brand value, firms contribute to the value-generating capacity of their physical assets and benefit from developing their organisational networks (Tiwari, 2010, p. 423; Srivastava et al., 1998, p. 6). In this manner, the brand value aims to increase shareholder value with a customer-focused approach such as increasing customer loyalty, decreasing flexibility against price increases, and increasing trade partnerships and licencing opportunities (Keller, 1997). Today, brand value is viewed not only in terms of shareholder value, but also from the perspective of "stakeholder theory", which considers the interests of all stakeholders (shareholders, customers, suppliers, investors, and the state). Researchers who support this theory state, contrary to the idea that firm value is only related to shareholder value, that a firm should create value for all stakeholders. Stakeholder theory argues that the firm is obligated to the members of its network (legally, contractually, and morally) (Jones, 2005, p. 12). This approach aims to manage and integrate the relationships and interests of shareholders, employees, customers, suppliers, communities, and other groups in a way that will ensure the long-term success of the company (Freeman, 1984; Freeman, McVea, 2001). To increase the brand value that will create firm value, it is important to make

strategic decisions by making an evaluation based on the trade-off between shareholder and stakeholder theories.

Although the goal of increasing brand value seems easily achievable, it requires a difficult process to evaluate due to the abstract components of the brand concept. For the evaluation to be sound, the brand value must be assessed. However, measuring brand value is a complex process that requires various methods. There is no single universal indicator that will provide a definitive determination of brand value. The most commonly used methods are market research, measuring brand awareness, customer preferences, loyalty, understanding the emotional connection between customers and the brand, and neuromarketing research on analysing the brain's response to brand-related stimuli (Bong Na et al., 1999, p. 170; Pina, Dias, 2021, p. 106; Gurgu et al., 2020, p. 212). Financial methods developed to evaluate brand value can be listed as the replacement cost method (estimating the cost of rebuilding the brand from scratch), the residual income method (calculating the brand value according to the additional income generated by the brand) and the real options method (estimating the cash flows that the brand will create in the future) (Salinas, Ambler, 2009, p. 45; Bagna et al., 2017, p. 5866; Winzar, 2017, p. 642; Trigeorgis et al., 2021, p. 523). ESG scores, which affect the firm value by making an assessment of the company in terms of environmental, social, and governance during the determination of brand value, are thought to be important. There are many studies that indicate that ESG disclosures change the value of the firm positively or negatively. Researchers who think that ESG will positively affect company value argue that with a high ESG score, consumer loyalty will increase, risk perception will decrease, capital costs will decrease with increased credibility, and financial performance will increase (Chen et al., 2023, p. 11; Velte, 2017, p. 170; Zhou et al., 2022, p. 3376; Chelawat, Trivedi, 2016, p. 195; Aydogmus et al., 2022, p. 120; Alareeni, Hamdan, 2020, p. 1409; Puriwat, Tripopsakul, 2023, p. 2). However, researchers who state that there is no statistically significant correlation or negative correlation between ESG and company value evaluate the situation with shareholder theory. They argue that activities that distance the priority of shareholder value will reduce efficiency and increase costs, negatively affecting the company value (Mikołajek-Gocejna, 2024, p. 144; Behl et al., 2022, p. 245; Saygili et al., 2022, p. 527; Han et al., 2016, p. 61; Kim, 2018, p. 1097; Duque-Grisales, Aquilera-Caracuel, 2021, p. 326). Research that examines the brand value effects of ESG on a global scale differs from the literature at this point. The relationship with brand value is a relatively new field of study. This research aims to contribute to the topic of the newly formed literature.

In the research, the impact of ESG activities on brand value was addressed together with environmental, social and governance dimensions, and its subdimensions were examined separately. In this way, the impact of possibility that the ESG on brand value may differ holistically and specifically for its components was not ignored. With the help of a large data set, this research article evaluates the relationship between brand value and ESG, which has

an important place in company valuation, and aims to provide practical recommendations to researchers and companies.

The paper is organised as follows. Literature studies are examined in Section 1. The theoretical background is presented in Section 2. The research methodology is stated in Section 3. The findings of the research are presented in Section 4. The discussion of the research is presented in Section 5. The conclusions of the research and recommendations for companies and researchers are shown in Section 6.

2. Literature

The relationship between ESG rating and company value is complex and has been the subject of numerous scientific studies, the results of which are not always unambiguous. However, there are not many studies that focus on the impact of ESG disclosure on brand value, especially from a financial perspective. The issue of how transparency in ESG reporting, especially including environmental, social, and governance issues, affects the brand value of companies, still needs to be explained. The main topic addressed in the articles is how ESG rankings translate into company value, including brand value. Some researchers indicate a positive impact of good ESG results on company value, while others argue that this correlation is statistically insignificant or even negative. Factors that may affect this relationship, such as industry, geography, and time, have also been examined. Many articles emphasise the importance of considering different dimensions of ESG, not just the overall ranking, as these can have different effects on company value. They also state that more research is needed to better understand this complex relationship.

The vast majority of studies in the literature point to the positive impact of ESG on brand value. A study conducted by Alcaide González et al. (2020) indicates a positive relationship between companies' transparency in CSR reporting and the credit rating awarded by rating agencies, especially Moody's. This means that companies that clearly and transparently report on their ESG activities are perceived as more credible and solvent. Cowan and Guzman (2020) argue that positive CSR signals increase brand value, especially for companies from countries with an average level of sustainability reputation (COSR). Agus Harjoto and Salas (2017) found that a company's strategic (proactive) approach to stakeholder management, through strong CSR, is positively related to the level of brand value. Ajour El Zein et al. (2020) found that ESG factors are crucial for stakeholders because they increase brand value, increasing the competitive advantage of branded companies over generic ones. Loh and Tan (2020) presented findings that support stakeholder theory. Despite the positive correlation between sustainability reporting and brand value, the study shows that one fifth of 100 leading brands in Singapore do not participate in sustainability practices. The researchers emphasised that investor decisions

may be negatively affected if brand managers and sustainability practitioners do not meet stakeholder expectations. Kim et al. (2021) argue that ESG initiatives confer a competitive advantage to companies. Specifically, environmental ESG activities enhance corporate image and brand reputation, thereby contributing to competitive advantage. Furthermore, practices that emphasise strong employee relations and diversity are linked to improved business performance and increased brand value. However, it was found that corporate involvement in product quality initiatives does not have a strong connection to brand value.

On the contrary, some authors in the literature argue that ESG has no clear correlation with, or may even negatively impact, brand value. Yang and Basile (2019) demonstrated that diversity and governance-related corporate social responsibility (CSR) positively influence brand equity, while employee-related CSR has a negative impact. Their findings were based on a panel data set of 78 firms that span the period 2000 to 2014. Flores-Hernández et al. (2020) found no direct relationship between CSR and the creation of sustainable financial value in Peru, a developing economy. They noted that the link between CSR and firm value can only be established through the enhancement of brand value, particularly in terms of corporate reputation and brand image. Similarly, Zampone et al. (2021) found no significant link between CSR and governance disclosure. The research indicated that brand value is shaped by several company-specific factors, such as size, market performance, financial performance, and financial leverage. Pope and Kim (2021) highlight the methodological diversity between different organisations and question the accuracy of ESG ratings, pointing out that some ratings may favour companies with substantial resources or those aware of the ranking process, potentially leading to biased results.

Although numerous studies explore the relationship between brand equity, the value of a brand from the consumer's perspective, and Governance) factors, research examining the connection between ESG and brand value, which focusses on the brand's financial worth, remains scarce. This study aims to fill that gap and contribute to the existing literature.

The theoretical basis of this study, which comprehensively explains the relationship between ESG and brand value, is shaped by the theoretical foundations of the relationship between ESG and firm value. The relationship between ESG and brand value can be understood through two theoretical lenses.

Shareholder Primacy Theory approach is based on the theory that the company is responsible only to its shareholders and that the company will gain value only by increasing shareholder interest. The company does not have any social responsibility in terms of environmental, social, and governance (Friedman, 1970). Therefore, it is argued that ESG scores, which show that companies fulfil their social responsibilities, will not positively affect firm value and brand value. On the contrary, the agency cost (Jensen, Meckling, 1976) that will occur as a result of the disagreement between the company's shareholders and managers will negatively affect the value of the company.

This approach suggests that when companies incur unnecessary costs to achieve high ESG scores, costs that do not enhance shareholder value, it can have a negative impact on the firm's overall value. Investors may view such spending as a sign of poor management, leading to an increased perception of risk associated with the firm. Additionally, efforts to adhere to stringent ESG regulations can reduce the firm's flexibility, limiting its ability to respond swiftly in a crisis. This loss of efficiency could, in turn, harm financial performance indicators. This theory can also be applied to the relationship between brand value and ESG. The perceived loss of flexibility, the increased risk in the eyes of investors, and the decline in financial performance due to an ineffective financial strategy can negatively impact brand value. According to the agency cost theory, neglecting the interests of shareholders in favour of other concerns can ultimately reduce the firm's brand value (Barnea, Rubin, 2010).

Stakeholder theory posits a positive relationship between ESG performance and firm value. According to this view, ESG scores reflect a management approach that considers the interests of all stakeholders (Freeman, 1984) by addressing environmental, social, and governance dimensions within corporate governance. Stakeholder theory emphasises the importance of ESG scores in accounting for the various sensitivities of different stakeholder groups in various dimensions. ESG scores influence stakeholders' perceptions, commitments, risk assessments, portfolio choices, financial performance expectations, and ultimately their expectations of the brand value. Even when stakeholders lack a strong social responsibility orientation, they can still factor ESG scores into their assessment of the company's value, anticipating that high ESG performance will improve the firm's overall worth.

ESG ratings will provide an accurate idea about the company's environmental, social and governance stakeholder evaluation (Signori et al., 2021, p. 2). This approach can examine the relationship between ESG scores and brand value from different points of view. It is thought that ESG scores will attract the attention of investors, increase consumers' loyalty to the brand, change risk perceptions positively, increase price flexibility, reduce resource costs, expand the reliability of companies, positively affect their financial performance, and, with the effect of all these, increase brand value.

The basic hypothesis is formulated within the context of this theoretical framework to examine the relationship between ESG and brand value.

H1. ESG has a positive impact on brand value

Pro-ecological activities have an increasing impact on brand value, and this trend is expected to intensify in the future. Consumers are increasingly aware of the impact of their choices on the environment and prefer brands that share their values and take action to protect the environment. Proecological activities create a trust relationship between the brand and the consumer (Nugroho et al., 2024, p. 19; Duan et al., 2023, p. 6). A company with a high ESG score is considered a sign that it is socially responsible and cares about future generations. In this era of saturated markets, where differentiation is important to gain competitive

advantage, features that increase emotional benefit have become important (Barrena, Sanchez, 2009, p. 1001). Proecological activities increase emotional benefits, allowing us to stand out from the competition and create a unique position in the market. Brands perceived as environmentally friendly are more attractive to investors, business partners, and employees. Pro-ecological activities can help reduce the risk associated with climate change, legal regulations, and social expectations. Within the framework of the management approach compatible with stakeholders in stakeholder theory, brand strategies aimed at reducing these risks can be achieved by interacting with customers (Khan et al., 2023, p. 204).

It is known that customers who care about environmentally friendly values are more loyal to brands that care about them (Puriwat, Tripopsakul, 2023, p. 2; Gamlath, 2020, p. 3). In addition, it is expected that pro-ecological activities generally lead to process optimisation and cost reduction, thus translating into better financial results (Henisz et al., 2019, p. 3; Chen et al., 2023, p. 2). Although studies generally find results consistent with stakeholder theory, some researchers have reached results that support shareholder primacy theory. Accordingly, some researchers emphasise that such activities are an additional expense that reduces the profitability of the business. Contrary to shareholder primacy theory that suggests that such activities are an additional expense that reduces profitability for the business, according to the Porter hypothesis, strict environmental regulations encourage companies to innovate in technology or management, thus providing cost reductions in the future (Saini et al., 2023, p. 666). Although studies generally find results consistent with the stakeholder theory, some researchers have reached results that support shareholder primacy theory. Accordingly, some researchers emphasize that such activities are an additional expense that reduces the profitability for the business.

Specific examples of pro-ecological activities that have a positive impact on brand value include reducing carbon footprint by reducing greenhouse gas emissions, using renewable energy. Ecofriendly packaging is related to using biodegradable materials, reducing the amount of plastic. Sustainable production using recycled raw materials aims to minimise waste and support environmental protection initiatives, and promote a sustainable lifestyle. To sum up, pro-ecological activities are an investment in the future of the brand. They help build a positive image, increase customer loyalty, and attract new customers. In the long term, they can bring significant financial and nonfinancial benefits. Based on these arguments, the following hypothesis is proposed to evaluate the relationship between the environmental dimension of ESG and the value of the brand.

H2. Environmental ESG has a positive impact on brand value

A similar explanation can be provided for the social component of ESG, which indicates the company's social activities. It is argued that high ESG ratings, which are considered an indicator of the company's fulfilment of its social responsibilities, positively affect firm value following the stakeholder theory (Fatemi et al., 2018, p. 48; Becchetti et al., 2022; Uyar et al.,

2022, p. 7). Some researchers have argued that investors who do not attach enough attention to social activities (Abdi et al., 2020, p. 17; Bakri et al., 2022, p. 219) negatively affect firm value because they perceive them only as a cost element. The effects of these two approaches on brand value will also be evaluated. The approach that suggests that a company's social activities positively affect brand value attributes this to not only financial but also non-financial value increase. Consequently, when a company engages in activities for society, the environment or other important causes, it creates a strong and positive reputation (Melinda, Wardhani, 2020; Uyar et al., 2022, p. 2). This results in many benefits. Consumers increasingly prefer products and services from companies that act responsibly. They feel connected to such brands and become more loyal (Nugroho et al., 2024, p. 2; Puriwat, Tripopsakul, 2023, p. 2). Social activities help create a positive image of the company (Koh et al., 2022, p. 2), which is associated with values such as responsibility, honesty, and caring for others. Customers who appreciate social values are more likely to try the products or services of a company that participates in social activities. Employees who work in a company that is involved in society feel more satisfied and motivated. This means greater productivity and loyalty to the company (Henisz et al., 2019, p. 6; Tunio et al., 2021, p. 10664). Investors are increasingly paying attention to the social and environmental aspects of company operations. Companies that operate in a socially responsible manner are perceived as more attractive investments. Investor interest in ESG investing can be explained by the fact that ethical investment practices are actively promoted and improve portfolio performance, increase returns, and reduce portfolio risk (Broadstock et al., 2021, p. 2). Socially responsible activities can help minimise the risk associated with negative events such as scandals or image crises.

Specific examples of socially responsible activities include supporting local communities: e.g. organising volunteering, sponsoring local events, protecting the environment: e.g. reducing carbon footprint, using environmentally friendly packaging, supporting education: e.g. funding scholarships, running training programmes, equality and diversity: e.g. promoting gender equality, creating an inclusive work environment. Prosocial activities, which many researchers view as an investment in a company's long-term success, help build a strong brand that is valued by customers, employees, and investors. The following hypothesis is proposed to evaluate the relationship between the social dimension of ESG and brand value.

H3. Social ESG has a positive impact on brand value

The governance dimension of ESG indicates whether companies implement good corporate governance elements. At this point, while examining the governance dimension, which is generally observed to have a more positive effect on company value compared to other dimensions, several possible reasons for this effect have been considered. The implementation of high governance standards is attributed to legal frameworks and regulatory oversight and monitoring by national and international institutions (Holder-Webb et al., 2008, p. 19). Unlike environmental and social dimensions, which are voluntary and often difficult to verify,

the mandatory nature of governance regulations increases the positive perception of this dimension among stakeholders (Fatemi et al., 2018, p. 57).

Corporate governance is designed to protect the interests of shareholders (Tang, 2022, p. 2), but in some cases it can have a negative effect on the value of the brand. This effect needs to be considered in terms of the dimensions of shareholder primacy and agency cost theories. The lack of board independence is one of the reasons, and if board members are aligned with management or have their own interests, they may not act in the best interests of the company. This can lead to decisions that damage the reputation of the company and reduce its value. Conflicts of interest are another issue. When board members have their own interests that may conflict with the interests of the company, this can lead to decisions that benefit themselves rather than the company (Espinosa-Méndez et al., 2023, p. 2). In addition, the competence, independence, and qualifications of the board of directors (Arayssi et al., 2019, p. 137) are also important in this conflict of interest. If board members do not have the necessary competence, they cannot effectively oversee the company's operations. This can lead to bad decisions and financial losses. An excessive focus on short-term results is a problem in management today. If the board of directors focusses only on short-term financial results, this can lead to decisions that will harm the long-term value of the company (Nekhili et al., 2021, p. 3061). Lack of transparency in the activities of the audit board can raise doubts about the honesty and integrity of the company's management. Overly complicated procedures and excessive bureaucracy in the audit board can slow down the decision-making process and reduce the company's efficiency. If the audit board fails to detect or prevent a corporate scandal, it can seriously damage the company's reputation and reduce its value (Arif et al., 2021, p. 500).

The consequences of the negative impact of corporate governance on brand value can be problematic. Investors lose confidence in companies with inconsistent ESG performance and weak corporate governance (Uyar et al., 2022, p. 2). This can lead to a decrease in the value of their stocks and difficulties in raising capital. Companies with corporate governance problems may have difficulty attracting and retaining customers, may be held legally liable, and may have difficulty retaining employees (Karwowski, Raulinajtys-Grzybek, 2021, p. 1279; Liu, Nemoto, 2021, p. 21). In short, corporate governance plays an important role in shaping brand value. Weak corporate governance can lead to the loss of trust from investors, customers, and employees, and can lead to serious financial and legal problems. That is why it is so important for companies to have strong, independent boards of directors. Based on these arguments, the following hypothesis is proposed to evaluate the relationship between the governance dimension of ESG and the value of the brand.

H4. Governance ESG has a positive impact on brand value

Based on the literature review, four hypotheses were formulated, which will be verified in the following sections.

3. Data and Methods

The relationship between ESG ratings and is brand value is complex and not easily understood. To accurately explain this relationship, the research's theoretical framework was developed to address ESG in a holistic manner, encompassing its subdimensions (environmental, social and governance). The econometric model was subsequently designed to align with this framework.

To explore the relationship between brand value and ESG disclosure, the analysis uses two distinct sources. The primary source is the S&P Global ESG Scores database, which assesses companies on sustainability-related factors, such as availability, quality, relevance, and performance, on a scale of 0-100. This database, designed to evaluate ESG risks, opportunities and impacts, is compiled using company disclosures, media and stakeholder analysis, modelling approaches, and the S&P Global Corporate Sustainability Assessment (CSA).

S&P Global ESG scoring provides a quantitative assessment of a company's sustainability performance, derived primarily from their Corporate Sustainability Assessment (CSA). This scoring system evaluates companies across a spectrum of environmental, social, and governance criteria, utilizing a double materiality approach to capture both the company's impact on the world and the impact of ESG factors on its financial health. Scores are presented on a scale of 0 to 100, reflecting how well a company manages its ESG risks and opportunities relative to its industry peers.

For the brand value analysis, the Brandfinance database was used as our second source. Specifically, data from the Brandfinance Global 500 (<https://www.spglobal.com/...>) brand ranking was utilised for the years 2013-2023. Brandfinance, which evaluates 6000 brands across 31 sectors in 41 countries annually, aims to establish a connection between brand value and financial value. This objective aligns with the research question of examining the significance of ESG in the global firm-brand value relationship. The latest data from the Brandfinance Global 500 brand ranking was obtained with special permission after discussions with Brandfinance representatives. It was necessary to match brands with their corresponding companies to analyse these brand values alongside S&P Global ESG scores and other company variables. For this purpose, brand websites, corporate websites, and Google searches were used to identify brand owners.

The analysis sample, which was created using the S&P Global and Brandfinance databases, was reduced due to missing data. Our final sample contains data from 307 firms, which leads to 3377 firm-year observations.

Following the approach of similar studies that investigate the relationship between brand value and ESG performance (Alcaide González et al., 2020; Cowan, Guzman, 2020; Agus Harjoto, Salas, 2017; Kim, Wang, 2021; Flores-Hernández et al., 2020; Zampone, 2021; Pope,

Kim, 2021), the brand value was designated as the dependent variable. The brand value data was sourced from Brandfinance's Global 500 reports, which are determined using the royalty relief method. The 2023 report, representing the most recent data prepared for the Global 500, served as the basis for selecting the brands included in the analysis. Brandfinance calculates the brand value using the royalty relief method, which estimates the amount consumers are willing to pay for a brand. Research based on market value figures enhances the realism of brand valuation.

It is important to note that, despite extensive literature on their differences (Tiwari, 2010; Raggio, Leone, 2009), brand value and brand equity are not entirely distinct concepts. Brand value inherently includes brand equity, which reflects consumers' perceptions of the brand. Therefore, in cases where the true market value cannot be directly ascertained, brand strength, taking into account brand equity, and estimated brand-specific revenues, derived from historical revenue trends, equity analyst estimates, and economic growth rates, are utilised to calculate brand value.

To investigate the relationship between ESG and brand value, the central focus of this study, ESG scores were selected as the primary explanatory variable, with data obtained from S&P Global. Four distinct regression analyses were conducted to assess the impact of ESG both in aggregate and through its individual subdimensions. This approach aims to offer detailed strategic recommendations by separately evaluating the environmental, social, and governance components.

This study is different from previous research by incorporating enterprise value, return on assets (ROA), and total assets as control variables. Enterprise value data, derived from BrandFinance, is used to represent the comprehensive valuation of a company, which differs fundamentally from brand value. For example, in the case of Meta, the enterprise value reflects the total valuation of the Meta corporation, while the values associated with Facebook or Instagram represent their respective brand values (Brandfinance Report, 2023, 2024). It is commonly observed that companies pursuing sector dominance through mergers and acquisitions typically manage multiple brands (Warf, 2003, p. 332). The value of each of these brands does not equate to the enterprise value; similarly, the enterprise value of Meta is distinct from the individual brand values of Facebook or Instagram. Additionally, the analysis incorporates the return on assets (ROA), a widely recognised profitability metric in the literature, and asset size, an indicator of the company scale, as control variables.

The aim of multiple regression is to quantify the relationships between many independent (explanatory) variables and the dependent (criterion, explained) variable. The classic linear regression model with many independent variables (so-called multiple regression) is defined by the equation:

$$Y = b_0 + b_1 x_1 + b_2 x_2 + \dots + b_k x_k + \varepsilon, \quad (1)$$

where:

x_i – empirical values of the independent variable X ,

b_i – model parameters (partial regression coefficients) describing the influence of i – this variable,

ε – random component (S_e).

Model verification involves checking whether the model assumptions are met:

- significance of linear regression,
- significance of partial regression coefficients,
- lack of multicollinearity (redundancy) between independent variables,
- assumption of homoscedasticity, which means that the variance of the random component is the same for all observations,
- no autocorrelation of residuals,
- normality of the distribution of residuals,
- the random component (residuals i) has an expected value equal to 0 with a period.

Table 1 presents the descriptive statistics characterizing the studied population of companies.

Table 1.
Descriptive Statistics

Variable	Average	Mediana	S.D.	Minimum	Maksimum
BV – Brand Value	13 300 000	7 630 000	197 000 000	899	355 000 000
EV – Enterprise Value	79 300 000	4 640 000	126 000 000	12 700 000	2 300 000 000
ESG Score	54,5	53,0	19,9	2,00	95,0
E- Ecology Score	57,1	59,0	24,0	2,00	100,
S – Social Score	50,8	49,0	21,5	2,00	97,0
G – Governance Score	55,9	55,0	18,9	3,00	97,0
ROA – Return on Assets	3.14%	2.06%	22.1%	-9.28%	42.0%
A – Assets	274 000 000	700 000 000	577 000 000	0,0560	5 740 000 000

Source: own study.

The descriptive statistics reveal a highly diverse sample of companies, characterized by significant variations in size, valuation, profitability, and ESG performance. Brand value, enterprise value, and likely assets demonstrate right-skewed distributions, indicating the presence of a few exceptionally large entities that significantly influence the mean. This is further supported by the substantial standard deviations observed across these variables. ESG scores, along with their environmental, social, and governance components, exhibit moderate variability and relatively symmetrical distributions, reflecting a broad range of sustainability practices. Notably, return on assets (ROA) displays considerable dispersion, suggesting substantial differences in profitability among the companies. A data anomaly was observed with the average and median asset values likely being switched. Overall, the data underscores the heterogeneous nature of the sample, highlighting the need for analyses that account for these variations.

4. Results

The results of the correlation analysis between the brand value and its explanatory variables are presented in Table 2.

Table 2.

Brand Value and its Explanatory Variables Correlation Analysis

BV	EV	ESG	E	S	G	ROA	A
Correlation	0,8056	-0,0559	0,0147	-0,0540	-0,1064	0,0118	0,1604
p-value	0,0000	0,0010	0,3858	0,0015	0,0000	0,4203	0,0000

Source: own study.

Brand value is significantly and positively correlated with the value of the company and its assets. The correlation with ESG factors, including social and corporate governance components, is significantly negative. The correlation with enterprise value is very strong, indicating that brand value is an important factor in valuation.

First, the parameters of the heteroskedasticity-corrected regression model were estimated, in which the company's BV was explained, in addition to control variables such as company value, asset size and their profitability, also by assessing ESG activities. The estimation results are presented in Table 3.

Table 3.

OLS model heteroskedasticity corrected with BV as a descriptive variable and ESG (n = 3377)

	Coefficient	Std. Error	t-ratio	p-value	
Const	3,11587	0,127395	24,46	<0,0001	***
I EV	0,563354	0,0104313	54,01	<0,0001	***
ROA	-0,306031	0,175295	-1,746	0,0809	*
I ESG	-0,0308523	0,0162346	-1,900	0,0575	*
Sum squared resid	10420,68		S.E. of regression		1,757680
R-squared	0,465023		Adjusted R-squared		0,464547
F(2, 89)	977,3152		P-value(F)		0,000000

Source: own study.

The estimation results presented in Table 3 show a significant and positive impact of the enterprise value and the return on assets on the value of the brand. The ESG score has a negative impact in global terms, which means that this activity does not build brand value.

In the next step, it was checked how the brand value is affected by the company's social activity, and the results are presented in Table 4.

Table 4.

The heteroskedasticity of the OLS model corrected with BV as a descriptive variable and S (n = 3387)

	Coefficient	Std. Error	t-ratio	p-value	
Const	3,01089	0,123954	24,29	<0,0001	***
l EV	0,566498	0,0104264	54,33	<0,0001	***
ROA	-0,271025	0,178393	-1,519	0,1288	
l S	-0,0132006	0,0153665	-0,8591	0,3904	
Sum squared resid	10545,14		S.E. of regression		1,765530
R-squared	0,466984		Adjusted R-squared		0,466511
F(2, 89)	987,9659		P-value(F)		0,000000

Source: own study.

The social activity of the companies does not have a significant impact on the value of the brand, as shown by the results of the study presented in Table 4. This is a surprising result in the context of the activity of companies in this area.

The impact of ecological activities on the value of the brand was examined, and the results are presented in Table 5.

Table 5.

OLS model heteroskedasticity corrected with BV as a descriptive variable and E (n = 3387)

	Coefficient	Std. Error	t-ratio	p-value	
Const	2,86369	0,121627	23,54	<0,0001	***
l EV	0,560950	0,0103165	54,37	<0,0001	***
ROA	-0,160466	0,175237	-0,9157	0,3599	
l E	0,0388496	0,0136976	2,836	0,0046	***
Sum squared resid	10238,90		S.E. of regression		1,739705
R-squared	0,468440		Adjusted R-squared		0,467969
F(2, 89)	993,7630		P-value(F)		0,000000

Source: own study.

The results of the model parameter estimation show that pro-ecological activity has a positive and significant impact on the value of the company. The last variable examined was corporate governance, and the results of the analysis of its impact on brand value are presented in Table 6.

Table 6.

The heteroskedasticity of the OLS model corrected with BV as a descriptive variable and G (n = 3387)

	Coefficient	Std. Error	t-ratio	p-value	
Const	3,40503	0,131691	25,86	<0,0001	***
l EnterpriseValueM	0,565388	0,0103497	54,63	<0,0001	***
ROA1	-0,333634	0,171350	-1,947	0,0516	*
l G	-0,108577	0,0179735	-6,041	<0,0001	***
Sum squared resid	10612,17		S.E. of regression		1,771133
R-squared	0,473462		Adjusted R-squared		0,472995
F(2, 89)	1013,994		P-value(F)		0,000000

Source: own study.

The results presented in Table 6 show that corporate governance has a significant and negative impact on brand value in the companies surveyed. Investor skepticism could arise if high governance scores are perceived as signaling excessive caution or risk aversion, hindering innovation and growth, which are often vital components of strong brand value. Alternatively, stringent governance structures might lead to bureaucratic inefficiencies, slowing down decision-making and preventing companies from capitalizing on market opportunities, thereby negatively impacting brand perception. Furthermore, investors might interpret high governance scores as a sign of management focusing excessively on compliance rather than strategic brand development or customer engagement. It's also possible that the market perceives these high scores as an indicator of internal problems, suggesting the need for strict controls due to past or anticipated issues.

5. Discussion

Environmental, social, and governance (ESG) criteria are increasingly integrated into the evaluation process when assessing company brands. It is assumed that companies adhering to their ESG responsibilities –reflected in their ESG scores—are likely to have higher brand values. This perspective is widely discussed in the literature, particularly through the lens of stakeholder theory, with numerous empirical studies supporting the positive relationship between ESG performance and brand value. However, there is also a body of research presenting contrary findings, suggesting either a negative relationship or no significant connection between ESG and brand value. These studies often align with shareholder theory, which traditionally emphasises financial metrics over broader stakeholder considerations. In the literature, the value of the firm is typically measured using financial metrics alone. However, brand value—though more challenging to quantify financially – encompasses perceptions held by various stakeholders, including consumers, investors, and suppliers. Recent financial studies indicate that brand value significantly influences a company's financial performance and overall firm value. Consequently, research that elucidates the relationship between ESG scores, brand value, and firm value would offer a valuable contribution to the literature.

In addition to divergence from existing literature that predominantly focusses on firm value, this study makes several noteworthy contributions to academic discourse. First, it evaluates brand value by focussing on a sample of 500 companies recognised globally for their strong brands. These companies, identified by Brand Finance's Global 500 list, are considered the most representative of brand value. This approach enables a comprehensive analysis of the relationship between brand value and ESG performance, using a robust, global dataset. Furthermore, by incorporating S&P Global's ESG data from S&P Global for the period 2013-

2023, the study offers a realistic and current assessment, grounded in the most recent available data.

Another significant contribution of this study lies in its findings, which diverge from the prevailing literature. Numerous researchers, such as Cowan and Guzman (2020), Ajour El Zein et al. (2020), and Kim et al., (2021), have posited a positive relationship between brand value and ESG performance. They argue that companies with high ESG scores experience increased brand value due to improved customer loyalty, mitigation of future social, environmental, and governance risks, improved credibility, and the resultant improvements in financial statements. It is commonly believed that by maintaining high ESG scores, companies not only elevate their brand value, but also enhance overall firm value through better financial performance and investor perception. However, our study presents findings that challenge this perspective, particularly when considering the ESG score as a whole through the lens of stakeholder theory (Freeman, 1984). Contrary to the prevailing view, our results indicate that a holistic approach to ESG can reduce brand value. This outcome aligns with the shareholder primacy theory (Friedman, 1970), suggesting that prioritising stakeholders over shareholders can lead to increased agency costs, which outweigh the potential benefits. ESG practices that prioritise stakeholder interests, rather than enhancing brand value, can divert the company from its core business, reduce operational efficiency, and ultimately alienate investors. The perception that ESG practices are merely additional costs, rather than value-adding investments, may lead stakeholders to view these initiatives unfavourably, thus diminishing their positive impact on brand value. These findings are consistent with the results of Yang and Basile (2019), Flores-Hernández et al. (2020), and Zampone et al., (2021).

This study examines the relationship between the ESG score, its subcomponents and brand value, focusing on the distinct channels through which these factors interact. The relationship between brand value and the dimensions of ESG is inherently complex, as both concepts encompass multiple dimensions that vary according to their interactions. Each dimension of ESG (Environmental, Social, Governance) influences different aspects of a company's operations and is perceived uniquely by various stakeholders, including consumers, investors, and others. This variation arises because stakeholders prioritise ESG factors differently, and the impact of these dimensions may evolve. To unravel the complexities reflected in the study findings, it is essential to consider each dimension of ESG separately. Therefore, the analysis distinguishes between the overall ESG score and its dimensions to provide a clearer interpretation of the results.

The study confirms that positive environmental practices, such as reducing harmful emissions, conserving natural resources, lowering the carbon footprint, utilising renewable energy, and producing environmentally friendly products, effectively mitigate environmental risks, capture the attention of investors and consumers, enhance brand loyalty and commitment, improve financial performance and, consequently, elevate brand value. The findings reveal a positive relationship between environmental ESG and brand value, supporting this assertion.

In alignment with stakeholder theory, improvements that benefit all stakeholders positively influence both firm value and brand value. There are many possible reasons for this positive relationship. Consumers who prioritise ecological values may base their purchasing decisions on the company's favourable environmental reputation. A positive brand image can increase the company's attractiveness to investors by providing protection against potential crises. Companies with increasing market values can access cheaper and more stable resources due to enhanced financial credibility (Henisz et al., 2019; Chen et al., 2023). Improved efficiency in energy or raw material use can lead to lower production costs; and companies that invest in ecological technologies tend to be more innovative, enabling them to better adapt to changing market conditions.

The study also explored the relationship between socially responsible and employee-focused activities and brand value, revealing varying results in this area of research. While some scholars have identified a positive relationship between these factors, others have observed either a negative or non-existent relationship (Abdi et al., 2020; Bakri et al., 2022). Similarly, this study did not find a statistically significant relationship between social ESG and brand value. Several factors may explain this outcome. Social initiatives, which are less directly related to financial performance, may affect firm value and brand value differently than other ESG components. The inherently complex nature of social issues means that their influence on brand value is not as straightforward. Social aspects of ESG, such as employee well-being, community participation, and diversity, are generally less tangible and more challenging to quantify compared to environmental or governance factors. As a result, these activities may not significantly influence the value of the brand due to their limited visibility in the perceptions of consumers and investors. Although environmental initiatives can yield immediate benefits for branding, the positive effects of social improvements may manifest over the long term and may not be immediately apparent. Consequently, the analyses may not capture a discernible impact on brand value. This outcome could be attributed to the dispersed effects of social initiatives, which impact a broad range of stakeholders rather than a specific group, thus diluting their influence on brand perception. Additionally, because many businesses engage in similar socially beneficial activities, it becomes difficult for any company to distinguish itself within the industry or to gain a competitive advantage through these initiatives.

Corporate governance, defined as the set of rules, mechanisms, and processes that regulate a company's operations and govern the relationships among its organs, shareholders, and other stakeholders, was analysed under the governance component of ESG. Interestingly, the study found that corporate governance negatively impacts brand value. Although corporate governance aims to ensure transparency, accountability, and operational efficiency, its relationship with brand value was expected to be positive; however, the findings suggest otherwise. Several factors may explain this unexpected outcome. Although strong ESG governance frameworks may appear beneficial on the surface, there are instances where investors and customers may lose trust if they suspect that a company is withholding or

distorting information about its activities. For example, financial scandals or the concealment of negative environmental impacts can lead to significant trust deficits. In addition, when short-term objectives dominate and boards of directors or audit committees prioritise immediate profits over the long-term sustainability of the company and its stakeholders, risky decisions can be made that ultimately diminish company value. Conflicts of interest also pose a risk; if members of the board or audit committee have personal interests that conflict with the company's interests, they can make decisions that are detrimental to the company and its shareholders (Espinosa-Méndez et al., 2023; Arayssi et al., 2019). Additionally, the absence of effective internal control systems can result in fraud, inefficiency, and financial losses. A lack of diversity within management and audit committees can limit the range of perspectives and ideas, leading to suboptimal decision making. Furthermore, governance efforts, unlike environmental or social initiatives, may be perceived primarily as internal controls rather than value-adding activities. For brand equity, environmental initiatives are often more visible and easier to market, whereas governance practices might be viewed as necessary but not directly contributing to brand image. This perception could explain the negative relationship between corporate governance and brand value.

This research is significant for its analysis of the ESG-brand value relationship, a relatively new area in the literature. However, the inherent complexity of the concepts of brand value and ESG, along with the varying measurement approaches employed by different institutions, poses challenges for analysing this relationship. In this study, S&P Global's ESG data from S&P Global and Brand Finance Global 500 were used. A key limitation of the research is the methodologies adopted by these companies, which may influence the findings. Different results could likely be obtained if the study was replicated using data from companies employing alternative methodologies. Future research should consider this issue and compare different methodologies to gain a more complete understanding. Additionally, it would be valuable to perform analyses with varying lag lengths, as the impact of ESG components on brand value can evolve over time.

6. Conclusions

Brand value is not only an abstract concept but also a tangible asset that offers numerous advantages to a company. Accurate measurement of brand value allows a clearer understanding of its market position and facilitates the implementation of effective marketing strategies. It is widely recognised as one of the most critical factors that influence the overall value of a company. Building a strong brand is a long-term strategic investment that accounts for the tangible benefits to all stakeholders. In today's environment, stakeholders, including consumers, investors, employees, and governments, are increasingly aware of the environmental, social,

and governance (ESG) improvements that companies undertake, and they shape their perceptions of a brand accordingly. ESG is known to improve financial performance, elevate company value, and contribute to brand equity.

This study investigates the impact of ESG on brand value, both holistically and through its dimensions, using data from Brand Finance Global 500 companies and S&P Global ESG scores for the period 2013-2023. The research contributes to the existing literature with its nuanced findings and comprehensive analysis. The results reveal a complex relationship. Although a company's overall ESG score negatively correlates with brand value, the relationships within the individual dimensions vary. Specifically, a positive relationship was found between environmental ESG and brand value, while governance ESG exhibited a negative relationship. No statistically significant relationship was identified between social ESG and brand value.

This study's findings carry significant social and practical implications. Socially, they highlight the potential for misleading ESG reporting and the need for greater public scrutiny of corporate sustainability claims, potentially fostering a more discerning consumer base and driving demand for authentic ESG practices. Practically, corporations are urged to re-evaluate their ESG strategies, focusing on transparency and genuine impact, particularly in governance, while investors should exercise due diligence beyond aggregate ESG scores and advocate for improved metrics. Regulatory bodies are prompted to strengthen ESG reporting standards and oversight, ensuring that market incentives align with genuine sustainable development rather than superficial brand enhancement.

These findings, which enrich the emerging literature, can be attributed to the differential perceptions stakeholders have about each ESG dimension, the evolving impact of these factors over time, and their varying levels of visibility and measurability. The study results can be further interpreted through the lens of shareholder theory, stakeholder theory, and agency cost theory. This research not only contributes to academic discourse but also offers valuable insights for ESG practitioners, financial managers, and brand managers. Understanding the differentiated effects of ESG dimensions on brand value - particularly in the areas of environmental, social, and governance factors - will be crucial in guiding companies on which social responsibility projects to prioritise.

To strengthen the reliability and effectiveness of ESG evaluations, governing bodies and rating organizations need to emphasize consistency and openness. Establishing uniform reporting standards and requiring precise, sector-specific performance indicators would facilitate meaningful comparisons and minimize misleading sustainability claims. Trust and responsibility can be fostered by demanding that rating organizations reveal their assessment procedures, including where they obtain their information and how they prioritize different factors. Rigorous third-party reviews and confirmation of ESG data, along with governmental supervision and enforcement, are crucial for preserving the accuracy of the information. Additionally, making data easily accessible through public platforms and providing educational resources for both investors and businesses regarding ESG principles will enable more

informed choices. By placing importance on these critical elements, regulators and rating agencies can cultivate a more dependable and impactful ESG environment.

Future research, expanding on the obtained results, will focus on the differences between continents in terms of the impact of ESG on brand value. The authors believe that market and cultural conditions may generate differences in the strength and direction of the examined relationships.

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QUALITY MANAGEMENT AS A RESULT OF THE DEVELOPMENT OF HUMAN THOUGHT

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Purpose: The aim of this article is to systematise the view of the human being from antiquity to modern times, to consider how anthropological philosophy can influence the discipline of quality management sciences in companies, and to demonstrate that the mentioned disciplines of sciences directly influence each other and how the human being is an important factor in the quality management process.

Design/methodology/approach: The human being can be considered as a common point of reference for philosophy and quality management science. The paper is a literature review of the achievements of philosophy regarding the human being and an attempt to link the quality management sciences with philosophy (philosophical anthropology).

Findings: Thanks to the development of philosophy, man is no longer treated merely as an element of a larger, complex whole or mechanism in which he acts as a mode. He is an individual, endowed with unique predispositions which, if properly managed, can bring enormous benefits not only to himself, but also to the working environment in which he functions and in his private life.

Originality/value: Considering quality and quality management in the context of a philosophy changes the perspective of how people are perceived in the work environment. The combination of quality management science and philosophy can allow a completely different dimension of business management to be discovered.

Keywords: management, quality, employee, human being, philosophy.

Category of the paper: Viewpoint.

1. Introduction

The concept of quality can be encountered as far back as ancient times. Since ancient times, man has followed quality, but the first mention of quality was made by Plato. He used the word *poiotes* - quality is the degree of perfection that things achieve. In doing so, Plato juxtaposed the concept of quality and beauty, which assesses the value of things (Mroczko, 2012). The definition of quality as such is difficult to grasp, since it usually refers to subjective feelings

and can change depending on, among other things, the stages of development of civilization or the awareness that a company acquires with the education of management and employees (Bielawa, 2011). However, if one were to look at what most affects quality, it is undoubtedly the human factor. Looking at the human being, whose sense of existence has been pondered by philosophers since antiquity, is an extremely important aspect in building the good name of enterprises. Therefore, there is no doubt that the discipline of management sciences (including quality) can be combined with philosophy and anthropology as sciences in which a key role is played by man as such, along with his emotions, thoughts, biological and psychophysical conditions. The question to be answered is, who is man? This question, which is strictly philosophical in nature, can prove to be the key to understanding the employee as a human being, which in turn can help understand how to manage people and processes so that the company's profit is as high as possible. The close combination of anthropological philosophy and quality management science in the available literature is rare. There are many sources in which the human being is placed at the center as a determinant of corporate success. In the modern world, companies are paying more and more attention to the employee as a human being, but this tendency is not often linked to the achievements of philosophers over many centuries. This topic was chosen because it enables a whole new discovery of both disciplines and makes it possible to merge aspects of the human being, his existence, even the meaning of life and noodynamics with economics and quality in a broad sense.

It should be remembered that the definition of profit is not limited to obtaining benefits only in the form of company revenues, but also includes intangible benefits, such as employee satisfaction with the workplace and the company's good reputation in the domestic and international markets. Understanding human beings in industry has many perspectives to consider when considering a company's operations (Grybauskas, Cardenas-Rubio, 2024), especially in an era of technological developments where people communicate with artificial intelligence or are completely replaced by automation and robotisation of processes (Frey, Osborne, 2017).

2. Literature review

The following part of the article will cover an attempt to clarify the definition of a human being. It should be borne in mind that there is no single, specific definition of man. Over the centuries, many philosophers have looked at man from different perspectives, which has resulted in a whole base of different meanings that define man's existence in the world. To begin with, it is important to realize that for the believer, the Bible is the first Book that explains the existence of man. It explains that man is someone created by God in the process of creating the world. Man is connected to God because he has a soul. On the pages of the Bible one can

encounter the evolution of thoughts about the soul of man, which in the Old Testament is referred to as *ruah* (almost divine spirit), and then *nephesh* (individual soul - psyche), while man is seen as a general whole that cannot be divided (Stachowiak, 1974). The New Testament, on the other hand, is a more broadly developed definition of man, where *nephesh* is switched to *pneuma* (that is, the spirit that directs man from within). *Pneuma* is inextricably linked to Christ and his actions.

The definition of man was dealt with by philosophers as far back as antiquity. Taking up the challenge of philosophically explaining what a human being is, in a time spanning antiquity, Socrates stated that the most valuable knowledge is self-knowledge (Olafson, 1995). According to Plato, the two elements that make up a human being are the body and the soul, while the soul has a threefold meaning. It can be sensually driven, sensually desirous and rational - the latter is characteristic only of man (Faggin, 1954). The soul makes the body live. *This is the only clue we have, indeed, that if any one of us desires when to know something in a pure way, he must liberate himself from the body and view reality with the soul alone(...)* (Plato, 2005) - Plato believed that the soul was responsible for man's cognition of the world. Another philosopher who pondered the theory of man was Aristotle. The soul cannot exist outside the body and is an *eidos*, i.e., a Form that performs its tasks through organs (i.e., through the body). Aristotle is the author of the phrase: *pantes anthropoi tou eid eidenai oregontai physei*, which translated means that *humans by nature desire knowledge* (Gogacz, 1969) and that cognition and knowledge come from the soul. The first humanists in antiquity were the sophists, the most famous of whom is Protagoras. He uttered the postulate, which reads as follows: *Antropos metros ton panton* (man is the measure of all things). What man sees or feels is an individual truth for each individual. Included in this sentence is the relativism of man's perception of the world.

In the 19th century, the German philosopher Martin Heidegger, in his work *Sein und Zeit*, tried to explain that who man is today has been shaped by history, and he called man's existence *Seiende*, or being also referred to as *Dasein*. According to Heidegger: *Diese Seiende (...) fassen wir terminologisch als Dasein* (Heidegger, 1984).

In 1913, Max Scheler, a German philosopher, published a paper entitled *Zur Phaenomenologie und Theorie der Sympathiegefuhle*. In his publication, he presents the view that man is only able to know what he has previously loved. Love is the bridge between man and the world, and man's ability to love opens up new possibilities for him (Scheler, 1913). Only man has the ability to love, and because of this he is able to connect with nature, with knowledge of the world, and this is something that distinguishes him from other beings living on Earth.

Man can also be called by the term *rational animal* (Krapiec, 1991). The characteristic is that man is responsible for the development of technology, but he would not be able to do this if he were not a herd creature. It is the presence of other people that allows the individual to develop in a dynamic way. An example is the research that was done in the post-World War II

period on newborns by physician Rene A. Spitz. He observed the development of a group of newborns who, although fed and washed, were deprived of contact with their mothers. It turned out that the lack of affection and maternal warmth wreaked havoc on the nervous system in such young children. After three months of separation from their mothers, the children became increasingly apathetic, the brain did not develop properly, weight began to drop, and the toddlers' contact with the environment was very limited. After five months, Rene A. Spitz observed the children taking on a so-called waxy face and limiting their movements to a minimum involving finger movements. Almost 40% of children treated in this way did not live to the age of two (Brzeziński, 2013). From the first days of life, a human being needs contact with his mother and with another human being in order to develop properly. The quality of life of a man who has been loved from infancy, in the subsequent stages until old age, allows him to fulfill his life to the fullest.

Man, in addition to being a rational and herd creature, can create art, culture and also uses symbols. Accordingly, man can be called by the term *animal symbolicum* (Cassirer, 1944). He is capable of abstract thought and of creating a reality in which he can contemplate. There is also an evolutionary-naturalistic theory of man. One can quote the words of J. Huxley, an English biologist. According to him, before man existed, progress was a rare and capricious by-product of evolution. Man has the ability to turn it into the main feature of his future evolution and to direct its course in accordance with its intended purpose (Huxley, 1947). It is through the process of thinking that man is able to manage not only himself, but also the enterprise, and it is on him that the quality of work in the enterprise depends. Management can make the workplace a *second home* for the employee or a place to which he does not want to return or perform his duties under a lot of stress, which in turn will affect the productivity of work and the quality of services provided. An interesting view on human spirituality is presented by Teilhard de Chardin, who uses the definition of noosphere to mean *a certain tension of consciousness on the surface of the Earth*. Teilhard de Chardin, as a philosopher and theologian, combined science and religion in his works and proved that these spheres of life not only are not mutually exclusive, but also complement each other, and that Christ *radiates to the entire universe as the highest, completely sovereign consciousness* (Teilhard de Chardin, 1984). He also operates a definition of human morality, which can be static or dynamic. Static morality, simply put, is the observance of moral principles. Dynamic morality strives for spiritual development. It is the presence of spirituality that characterizes man and distinguishes him from other creatures on Earth. Thanks to the development of morality, the development of civilization and industry is possible.

3. Research methods

An analysis of the available literature sources has been carried out to attempt a theoretical link between the two scientific disciplines - philosophical anthropology and management and quality sciences. Research regarding the 'measurement of the human being' in the context of philosophy and quality at the same time is limited, because the variables are difficult to define unambiguously in this case, nevertheless the common ground is the human being, who can be understood multifacetedly. A review of the literature regarding the eras that philosophy has lived through from ancient times to the present day has been carried out and, in this connection, an attempt has been made to trace the evolution of thought and concepts of human existence and to link these concepts to quality in its widest sense.

Mankind has known about quality since the earliest times. The first definition of quality was introduced by Plato, then Aristotle placed quality as one of the elements of reality, which also includes place and time (Hamrol, Mantura, 2002).

In ancient Rome, King Cicero introduced the concept of *qualitas*, which was later translated into other languages, including English - quality. Quality can be defined as:

- issue, which is *determined by the ability to satisfy customers and the intended and unintended impact on relevant interested parties. The quality of products and services includes not only their intended function and performance, but also their perceived value and benefit to the customer* (ISO 9000:2015);
- *perfection that cannot be achieved, but to which one must persistently strive* (Hamrol, Mantura, 2002);
- *fit for purpose* (Lock, 2002);
- *ability to satisfy stated and potential needs (of the customer)* (Griffin, 1998);
- *providing the customer with what he needs today, at a price he is willing to pay, at a cost we can sustain, uninterruptedly again and again, and providing him with something even better tomorrow. Quality is the degree of congruence between expectation and realization. (...) Quality is: invisible when it is good, impossible not to notice when it is bad(...)* (Lock, 2002).

It is important to keep in mind that the concept of quality and quality management systems are closely related to human beings. Quality has no right to exist without human beings. Many organizations are following the recommendations of ISO 9001, because quality management systems make a company gain a good reputation internationally (Gremyr et al., 2021). Quality management is regarded as a philosophy based on three pillars: techniques, principles and practice (Dean, Bowen, 1994).

Quality management systems are in close connection with people's commitment, implementation strategy, maturity of quality management (Poksinska, 2010). Also, the attitude of management has an impact on quality management systems in the enterprise (Coffey et al.,

2011). Involvement of employees and management in the continuous improvement of the enterprise is, in addition to the analysis of the organization's strengths and weaknesses, business vision or processes, necessary for effective management of quality systems (Maguad, 2006). Proper quality management affects the mental health and functioning of employees and employers (Levine, Toffel, 2010).

Quality management has experienced several stages of development in its history. Quality Inspection (QI), whose era began in the early 20th century, consisted only of a technical look at the quality of products, i.e., sorting, finding sources of nonconformity, possible recovery and corrective action. The next stage in the development of quality management systems took place in the 1920s, when other aspects of quality began to be recognized (Rajkiewicz, Mikulski, 2016). The procedure for inspecting the skills of employees began, quality books and process supervision activities (so-called control cards) appeared. In the 1950s, the approach to quality management changed. Attempts to prevent defects and errors, instead of detecting them, began. Self-control processes began to play a large role, and the first enterprise quality plans, audits and certifications appeared.

Since the 1980s, quality management has become an indispensable part of running businesses, with leadership playing a significant role (Kaplan, 2001). According to Total Quality Management: the most important thing is the customer, and it is the customer's needs that should be the focus of quality management systems. The pursuit of quality is complicated by the fact that it can never be fully achieved, so standards have been created to guide companies to continuously improve their quality. The first standard was created in 1959 and was the US military standard MIL-Q-9858, reworked a few years later into the AQAP standard. The creation of subsequent standards led to the issuance of the ISO standardization that is popular today, the first standard of which was ISO 8402, which includes terminology, making it the basis for all ISO 9000 standards. Important standards in the ISO 9000 series include ISO 9001 (which contains requirements related to quality management systems) and ISO 9004 (which contains information and guidance on continuous improvement of the organization and the company's quality management systems).

Quality management should also not be limited to the human working environment. It is important to strive to improve the quality of life so that the employee is able to do his job properly. Quality of life consists of:

- Social quality of life (it can be internal and concern, among other things, views and beliefs, and external including family and other social groups).
- Professional quality (concerning qualifications, skills, material status and occupation).
- Quality of health (includes sports, other physical activities, mental health and nutrition).
- Quality of education and upbringing (concerning interests and personal development) (Goranczewski, Puciato, 2010).

Thus, quality management should be viewed from a broader perspective, encompassing not only the professional sphere, but also the private sphere of the employee. A decline in the quality of any of the components of quality of life can result in the deterioration of a person's functioning not only on the job, but also in society. The literature resources on philosophy and quality management sciences are rich in valuable items, but it is difficult to find measures or indicators to measure the degree to which the two scientific disciplines are linked (e.g. in the context of human functioning in the work environment).

4. Results

4.1. Antiquity

In ancient times, philosophers focused more on how the world was created than on man's being. They assumed that to understand man, one must first understand the world. The Pythagoreans believed that the human soul was immortal and believed in metempsychosis. Heraclitus of Ephesus made what is known as the humanist breakthrough involving the idea that man acquires wisdom by attempting to understand the logos derived from the gods and the cosmos (Wesoły, 1989). According to Parmenides of Elea, being is called that which exists and man can only think about what is, and truth can only be discovered by reason (Wesoły, 1992). Only the sophists (as the first humanists) turned their attention to human being in the most practical sense of its existence. They tried to answer the question, what makes a person successful in his life? One of the more famous sophists is Protagoras, who said that *man is the measure of all things, existing that they exist, and non-existing that they do not exist* (Niebrój, 2000). Referring to Protagoras' maxim - man is proof that in the world things can exist or not. Can this thought be applied to man's work environment? Can it be said that through an employee, an event at the workplace may or may not occur? Following this line of reasoning, one can come to a conclusion that seems obvious - if an employee has an accident, or if he avoids an accident, the event or lack thereof is directly related to the employee's behavior at the workplace. One can imagine a press on the shop floor turned on and a worker trying to repair or maintain it without first turning off the machine. In such a case, it is known with certainty that a tragic accident will occur because this worker failed to exercise caution. The lack of caution may be the result of a lack of proper training or a routine into which the worker has fallen. However, it is the employee's direct behavior in the performance of his duties that is the cause of the accident (or lack thereof). According to Plato, *experience allows one to direct one's life according to the rules of art, inexperience throws one into the play of fate* (Kuziak et al., 2004). The experience available to a company is the result of mistakes made by employees, but it is through these mistakes that safety management systems can be put in place to avoid further

accidents in the future. Without being aware of the consequences of one's actions, which is related to inexperience, a person is much more vulnerable to potentially accidental situations - an example of this is the brash driving behavior of some young drivers. For Socrates, human virtue (arete) is the highest good, which is not given to man from birth, but he acquires it in the course of his life. The good is useful (Kuziak et al., 2004). If virtue were understood as knowledge, which is a good, it could be inferred that ignorance is an evil. Often, poor quality of manufactured products or poor management of human resources is the result of ignorance.

4.2. Middle ages

Credo ut intelligam; intelligo ut credam (Kuziak et al., 2004) - I believe in order to know, I know in order to believe. At first glance, which is true, the words of St. Augustine can be adapted to the general existence of man in a world in which God's presence is strongly felt. Does this mean that this sentence can be considered in relation to jobs? For people who believe in God, who feel His presence, the answer will be simple. God is present in every moment of human life. He is also present in the performance of work. An attempt can be made to analyse a completely mundane situation, e.g. regarding training in occupational health and safety. Until a person experiences first-hand how important on-the-job training is, he will feel deep down that it is necessary, but only when he experiences certain situations in their living form will he come to the conclusion that he wants to prevent such situations. A person must get to know potentially accidental situations with their senses to believe that health and safety training is not only an invention of modern times. Another thing is that such training should not be a boring duty, but become an inspiration for each employee individually, which means that the employer should get to know his employees in a human way to ensure that each of them receives well-completed training. St. Augustine also said the sentence: *Si enim fallor, sum*, which translated into Polish means *If I am wrong, then I am*. What would health and safety training be if it were not for human error? In the case of an accident rate of zero, the safety function would be inherently unnecessary. It is thanks to the mistakes made by people over the years, at various workplaces, that it is possible to develop on-the-job training and training in the field of occupational safety in forms that are interesting for the recipients, not necessarily multimedia presentations, which are not as attractive as all kinds of games or other activities activating employees in this area.

4.3. Modern times

Running a business cannot take place without the application of certain moral and legal norms. Otherwise, the operation of such a workplace may cause a lot of harm to employees. Immanuel Kant, in his work entitled *Critique of Practical Reason*, says: *Two things fill my heart with ever new and ever-growing admiration and respect, the more often and persistently I reflect on them: the starry sky above me, the moral law within me* (Kant, 1984). It is the moral

law in people that makes the look at the employee take on a new dimension. It is obvious that good treatment of an employee by management will not eliminate human error during work, but it has a huge impact on the quality of manufactured products or services provided due to the well-being of people in the workplace. It should be borne in mind that although the accident rate cannot be completely eliminated at all, the number of accidents should be reduced to a minimum. As Arthur Schopenhauer said, *although every misfortune separately seems to be an exception, misfortune as such is the rule* (Kuziak et al., 2004). Accidents at the workplace should also be treated in this way. Each accident confirms a certain rule, but at the same time it should be considered individually for each injured party. Most accidents at work are caused by human error, but each one is a separate case, considered separately. Only by looking at the problem in both an individual and a "global" way can we understand it more deeply. A rational approach to the problem of accidents allows us to achieve a kind of freedom, the highest form of which is responsibility for another person. In this way, the words of Gottfried W. Leibniz can be applied to the work environment, who believed that *the more we are guided by reason in our actions, the more free we are – and enslaved, the more we succumb to passions* (Kuziak et al., 2004). Therefore, it is possible to imagine what the working environment of a man would look like if he was guided by his drives instead of reason. It is worth asking yourself whether it would be safe in such an environment? Would the quality and efficiency of work be greater or less? Or would the quality of the services provided be exactly the same as if the employee was guided by reason? If the last question were answered in the affirmative, there would be fewer accidents at work in each industry, and health and safety training would be unnecessary. The following scenario can be considered: the situation takes place on the assembly line of a car of a well-known brand. Each employee has a certain amount of time to perform their task, e.g. install a wiper, adjust the glass to the door opening, or tighten door handles. If even one employee started to function according to his whims, the car could leave the assembly line with a huge delay or not leave at all. This, in turn, would have disastrous consequences for the quality and good name of the company. Both on-the-job training and occupational health and safety training are aimed at organizing the employee's knowledge of how to behave in the workplace to avoid an accident. *Progress always remains a simple development of order* (Kuziak et al., 2004) - the words of Auguste Comte perfectly reflect the role of order in quality management systems. Thanks to proper organization and health and safety training, it is possible to implement safety and progress of the company, also in the quality of services or products. Organizing the rules of safe behavior at the workplace is tantamount to organizing the employee's knowledge on topics related to maintaining safety while performing professional activities, which in turn will translate into the efficiency of his or her work.

4.4. Present times

Each philosophical epoch is characterized by new thoughts about man. The human being, who is in the center of interest not only in philosophy or anthropology, but also in the field of quality management, is a component of the company's structure, thanks to which it can constantly develop on the domestic and foreign markets. It depends on the skills of a human how a given product will be produced, even if production is automated, because a human is also responsible for starting the devices. According to Ludwig Wittgenstein, *ambition kills thought* (Wittgenstein, 2000). How can this sentence be applied to the environment in which a person fulfills himself professionally? You can imagine a corporation in which only the results achieved by employees matter, at the expense of their mental and physical health. It is not difficult to guess that in the long run, employees will be laid off, which will result in lower profits for the company. Ambition and the desire for profit at all costs kill the thought of the employee as a human being. The employee becomes a machine to perform his work within certain standards and when he is not able to work out the standard, he will become useless to the company. This, in turn, will affect the good name of the company. An employee, feeling unfairly treated, may cause other potential employees to resign from participating in recruitment. *Every exact and especially scientific cognition is based on the obvious* (Krokos, 1984) – the words of Edmund Husserl can be quoted when returning to the thought of safety as an element determining the quality of work and the services provided or products manufactured in the company. What would health and safety training be if it were not for knowing what hazards exist in the plant? For example, a chemical laboratory worker working with carcinogenic and highly toxic substances will not need a demonstration on the hazards of the car assembly line, but on prevention or action if the substance gets into the eyes or on the skin. The person organizing the OHS training must first identify the hazards for a specific position. It is obvious, but thanks to such knowledge you can delve deeper into security issues, e.g. when working with hazardous substances.

5. Discussion

The contemporary view of man would not be the same if it were not for the influence of philosophy on the perception of the human being in subsequent epochs. Nowadays, society is increasingly paying attention to the role of humans in the work environment. It should be kept in mind that the development of industry and technology is associated with ever-increasing demands on human beings, such as a sense of purpose to be achieved (d'Alañon, 1994). The human being in the era of Industry 4.0 is beginning to be viewed differently in terms of the success of the company. Great attention is being paid, among other things, to the role of

leadership in the company (Gunasekaran, 2019). A human view of employees, and thus the creation of a friendly work environment, enables the development of professional competences of each employee in the workplace, and thus the quality of work improves. The quality of private life also improves due to the reduction of stress and the well-being of the employee, who is willing to return to work and function better at home. Increasingly, employers are using the term wellbeing to organize events to help employees take care of their mental health. Well-being is closely related to the quality of working life (including occupational health and safety) and has a significant impact on the productivity not only of the individual but also of the whole enterprise (Schulte, Vainio, 2010). There are many theories of how to define or measure human wellbeing, as well as concepts of how to obtain a state of wellbeing, but there is no doubt that wellbeing should be pursued (Sollis et al., 2022).

At the present time, it is impossible to measure by any method the extent to which anthropological philosophy can be combined with quality management science (human resources), but there is a common point between them, which is the human being. There are methods of measuring human capital in an organization. These include qualitative or financial methods of measurement, which use a variety of indicators, relating, for example, to age of retirement or salary levels (Lev, Schwarz, 1971). Perhaps in the future, the combination of philosophy and quality management will make it possible to discover new indicators or measures relating to philosophical or even transcendental issues linking human beings to quality in order to improve the quality of human functioning in society and the enterprise.

6. Conclusions

Mental health (meaning the proper care of the employee's mental comfort by the employer) is one of the most important, if not the most important, aspect affecting the quality of manufactured products or services. It is very important for companies to implement the idea of TQM and to consider more than just economic or technical aspects in their operations (Weckenmann et al., 2015). People and their specific needs are important (Wilkinson, Brown, 2007). Thanks to the development of philosophy, man is not treated only as an element of a larger, complex whole or a mechanism in which he plays the role of a cog. He is an individual, endowed with unique predispositions, which, if properly managed, can bring great benefits not only to himself, but also to the work environment in which he functions and in his private life. Quality management sciences can be combined with philosophy by human factor. It is important to remember that humans are complicated beings, so inventing the right measure or measures in this area can be complicated, but at the same time bring many benefits for the human comfort of the company, and therefore the organization in the future.

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THE IMPORTANCE OF EMOTIONAL INTELLIGENCE IN LEADERSHIP FOR BUILDING AN EFFECTIVE TEAM

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Purpose: This study investigates the role of emotional intelligence (EI) in leadership and its impact on building effective teams. It explores how EI competencies influence team collaboration, motivation, and conflict resolution within organizations.

Design/methodology/approach: A survey of 100 professionals assessed leadership traits and EI impact on teams. Statistical analysis identified key correlations.

Findings: Leaders with high EI are more empathetic, ethical, and effective in motivating teams. Strong correlations were found between EI, social competence, and leadership success.

Research limitations/implications: The study is limited to a specific demographic. Future research should explore diverse industries and cultural contexts.

Practical implications: Developing EI in leadership training enhances team cohesion, reduces conflicts, and improves motivation.

Social implications: EI-driven leadership fosters healthier workplace cultures, reducing stress and enhancing job satisfaction.

Originality/value: This study provides empirical insights into EI's role in leadership, filling gaps in research by linking EI with leadership effectiveness.

Keywords: Emotional intelligence, leadership, team performance.

Category of the paper: research paper.

1. Introduction

In today's fast-evolving business landscape, leadership is no longer defined solely by technical expertise or strategic decision-making. The ability to manage emotions, build strong interpersonal relationships, and foster a positive team environment has become essential for effective leadership. Emotional intelligence (EI), which encompasses self-awareness, self-regulation, motivation, empathy, and social skills, has gained significant recognition as a key determinant of leadership success.

The modern workplace presents numerous challenges, including managing diverse teams, navigating organizational change, and resolving conflicts efficiently. Leaders who exhibit high EI are better equipped to handle these complexities by understanding their own emotions and those of their colleagues. This capacity allows them to build trust, communicate effectively, and inspire team members to achieve common goals. Research has demonstrated that leaders with strong EI create environments where employees feel valued, motivated, and engaged, ultimately leading to higher productivity and organizational success.

Traditional leadership models often prioritized authority, control, and decision-making prowess. However, contemporary perspectives emphasize the importance of interpersonal effectiveness and emotional intelligence in fostering a resilient and adaptive workforce. Leaders with high EI can navigate crises with composure, encourage innovation by fostering psychological safety, and strengthen workplace relationships through empathy and emotional awareness. These factors contribute to a more cohesive, motivated, and high-performing team.

Additionally, emotional intelligence plays a crucial role in conflict resolution. Workplaces are often prone to misunderstandings, differing perspectives, and interpersonal tensions. Leaders with strong EI can de-escalate conflicts, mediate disputes, and create solutions that promote harmony and cooperation. Their ability to regulate their own emotions and respond thoughtfully rather than react impulsively ensures a constructive and balanced approach to leadership.

This study aims to explore the impact of EI on leadership effectiveness and its role in enhancing team dynamics, motivation, and organizational well-being. By analysing survey data from professionals across various industries, this research provides empirical insights into how EI influences leadership outcomes. The findings will inform strategies for integrating EI development into leadership training programs, ensuring that organizations cultivate leaders who can drive success through emotional and social competence. As businesses continue to evolve, understanding and applying emotional intelligence in leadership will remain crucial for fostering inclusive, high-performing workplaces. Organizations that fail to recognize the importance of EI risk falling behind in the ever-changing corporate environment. Thus, embracing EI-driven leadership strategies is not just beneficial but essential for sustained success and innovation.

2. The evolution and models of emotional intelligence

Over the past three decades, emotional intelligence (EI) has evolved from a relatively obscure scientific concept to a widely recognized and extensively discussed construct in both academic and practical contexts. Initially facing challenges in conceptualization and measurement, EI has endured skepticism and criticism to become a flourishing field of research. Despite early concerns regarding its definition and assessment, the domain of emotional intelligence continues to advance. Ongoing efforts aim to refine its components and measurement tools, incorporating insights from emotion theory and related disciplines to develop innovative approaches for assessing emotional intelligence (Mortillaro, Schlegel, 2023). These approaches are grounded in foundational scientific literature on emotions and appraisal theories, ensuring a more comprehensive understanding of EI within contemporary research frameworks.

Emotional intelligence is a multifaceted concept that has gained increasing significance across various disciplines. The core components of EI include self-awareness, self-regulation, empathy, and social skills (Miao, Humphrey, Qian, 2017). Self-awareness entails recognizing and understanding one's own emotions and their influence on thoughts and behaviors. Self-regulation refers to effectively managing emotions and adapting to different situations without becoming overwhelmed. Empathy is the ability to understand and share the feelings of others, facilitating improved interpersonal relationships. Social skills encompass effective communication, conflict resolution, and teamwork abilities, all of which are crucial for successful interactions in both personal and professional contexts (Walter, Humphrey, Cole, 2012). Collectively, these components contribute to an individual's overall emotional intelligence and play a vital role in personal and professional success.

Different researchers have provided various definitions of emotional intelligence, each emphasizing different aspects of its application. Salovey and Mayer (1990) described EI as the ability to monitor and differentiate emotions in oneself and others, using this information to guide thoughts and actions. Goleman (1995) expanded on this by incorporating interpersonal skills such as self-motivation, relationship management, and empathy, which are crucial for success in professional and personal settings. Bar-On (1997) focused on EI as a set of competencies and skills necessary for coping with environmental demands, highlighting adaptability as a key feature. Meanwhile, Caruso and Salovey (2004) stressed emotional regulation and awareness as essential for intelligent and adaptive behaviour. Barsade and Gibson (2007) underscored the importance of EI in workplace performance, emphasizing the ability to manage emotions effectively to foster collaboration and efficiency. These varying perspectives reflect the broad scope of EI, demonstrating its significance in both personal development and organizational success.

In the academic literature, two main models of emotional intelligence have been distinguished: the mixed model (popular approach) and the ability model (scientific approach).

The mixed model, also referred to as the popular model of emotional intelligence, was popularized by Daniel Goleman in his 1995 book *Emotional Intelligence* (Goleman, 1995). Goleman defines EI as a combination of traits and skills encompassing both emotional and social aspects. This model integrates elements such as self-awareness, emotional regulation, self-motivation, empathy, and social skills. Reuven Bar-On further refined this perspective by distinguishing five key functional areas: intrapersonal skills (e.g., assertiveness, self-awareness, independence), interpersonal skills (e.g., empathy, relationship management), adaptability (e.g., flexibility, problem-solving), stress management (e.g., emotional control, stress resilience), and general mood (e.g., optimism, happiness) (Sadowska, Brachowicz, 2008). While widely used in management and personal development contexts, the mixed model has been criticized for its broad and imprecise definition, as it combines various traits rather than focusing solely on cognitive abilities.

The ability model, often regarded as the scientific model of emotional intelligence, was introduced by John D. Mayer and Peter Salovey in 1990. This model focuses exclusively on cognitive abilities related to emotions, viewing emotions as structured responses that operate through multiple psychological subsystems, including physiological, cognitive, and motivational components (Mayer, Salovey, 1990).

Mayer and Salovey (1990) define EI as the ability to perceive emotions in oneself and others, use emotions to support cognition and problem-solving, understand their complexities and evolution, and regulate emotions to foster intellectual and emotional growth.

These abilities are key determinants of emotional intelligence. The ability model is regarded as more scientific and precise since it is based on measurable cognitive functions and has been extensively validated through empirical research. It has been applied in various contexts, including education, mental health, and workplace performance (Sadowska, Brachowicz, 2008). Additionally, Czesław S. Nosal (1998) proposed that EI consists of two key psychological domains: intellectual and emotional. He argued that emotional intelligence results from the interaction of mechanisms responsible for the generation, categorization, and interpretation of emotions, which influence emotional states and cognitive processing.

Unlike Mayer and Salovey's ability model, Goleman's mixed model expands on the fundamental abilities of perceiving, using, understanding, and managing emotions by incorporating additional elements such as social skills, motivation, and self-regulation (Salovey, Grewal, 2005). This broader perspective highlights the importance of interpersonal competencies in emotional intelligence. Bar-On's framework further emphasizes personal and social competencies over specific cognitive functions related to emotion processing. The mixed model thus underlines the integration of emotional awareness with social proficiency and self-regulation, positioning it as a practical approach to emotional intelligence in professional and personal development (Salovey, Grewal, 2005).

3. Emotional intelligence in management

Emotional intelligence plays a crucial role in effective workplace performance and organizational success. Goleman (1999) emphasized that EI is fundamental to professional achievement, arguing that managing one's emotions and recognizing the emotions of others contribute significantly to leadership and teamwork. While general intelligence remains important, EI has been identified as a key factor in distinguishing high-performing employees and leaders. Bradberry and Greaves (2006) noted that although some individuals achieve success with lower EI levels, their accomplishments often stem from high general intelligence and strong self-discipline.

Recent studies highlight the growing relevance of EI in professional settings. Research by Matczak and Knopp (2013) suggests that individuals with higher EI levels perform better in job interviews, exhibit greater leadership effectiveness, and achieve higher career success. Further empirical studies reinforce these findings. Skwarek's research on professional athletes demonstrated that those with higher EI scores excel in competitive environments due to their superior emotional regulation and resilience (Matczak, Knopp, 2013). Additionally, studies by Basińska, Jaskólska, and Piórowski (2007) on military personnel revealed that emotionally intelligent soldiers display higher job satisfaction and career ambition, while those with lower EI levels are more susceptible to occupational burnout.

From an organizational perspective, EI is essential for managing team dynamics and improving workplace culture. Goleman (1999) argued that EI-driven leadership enhances team productivity, fosters positive communication, and mitigates workplace conflicts. Modern companies increasingly seek employees with strong interpersonal skills, adaptability under pressure, and self-motivation. The ability to recognize, understand, and manage emotions contributes to building high-performing teams and sustainable business growth. Consequently, organizations that invest in developing EI competencies among employees gain a competitive advantage by enhancing collaboration, employee engagement, and overall job performance.

Recent research further deepens the understanding of how emotional intelligence (EI) competencies contribute to organizational effectiveness. Iyer (2024) conducted a comprehensive study examining the impact of self-awareness, self-management, social awareness, and relationship management on key leadership outcomes such as decision-making, team performance, and employee engagement. The findings revealed that emotionally intelligent leaders are better equipped to navigate complex organizational dynamics, foster trust, and resolve conflicts effectively. Moreover, the study emphasized the mediating role of transformational leadership behaviors and social exchange mechanisms, such as mutual respect and trust-building, in enhancing leadership outcomes. Leaders with high EI were shown to inspire commitment, drive team cohesion, and improve organizational performance through emotionally attuned interactions.

Recent findings by López González et al. (2024) confirm a strong positive correlation between emotional intelligence and leadership competencies among university students, particularly highlighting the predictive role of the "use of emotions" dimension. The study demonstrates that specific components of emotional intelligence can reliably forecast leadership potential, suggesting that developing emotional regulation and expression skills is vital for cultivating future leaders in higher education contexts.

Further supporting the critical role of emotional intelligence in leadership, Nwagwu and Henry (2025) emphasize that emotionally intelligent leaders are more capable of regulating their own emotions and understanding the emotional states of their teams. This emotional atonement enables them to build stronger relationships, communicate effectively, and make more informed decisions in high-pressure environments. The study highlights that high EI levels among leaders contribute directly to improved leadership effectiveness by fostering trust, motivation, and team alignment. As a result, organizations are encouraged to integrate emotional intelligence training into leadership development programs, recognizing its value in enhancing both individual and organizational performance.

4. Research material and methodology

The survey questionnaire consisted of 21 questions. The questions were designed to test respondents' knowledge of a leader's emotional intelligence and to assess the impact of emotional intelligence on management.

The research was conducted on a social network via Google Forms, where a digital version of the questionnaire was prepared. The developed survey tool received 100 responses from randomly selected respondents who decided to respond to the request to complete the questionnaire.

The following is a list of questions answered by the respondents:

1. Do you know what emotional intelligence is?
 - A. Yes.
 - B. No.
2. What do you think emotional intelligence is?
 - A. The ability to control and manage your emotions in stressful and conflict situations.
 - B. The ability to recognise and understand one's own emotions and the emotions of others in a team.
 - C. The ability to make decisions based on data analysis and intuition.
3. Do you think your current leader has a high level of emotional intelligence?

Scale from 1 to 5

1 – Definitely no.

- 2 – No.
 - 3 – Neutral.
 - 4 – Yes.
 - 5 – Definitely yes.
4. What leadership qualities in your experience are the best examples of high emotional intelligence?
 - A. Empathy.
 - B. Fairness.
 - C. Analytical mind.
 5. Have you noticed that your leader is able to manage his/her emotions effectively during conflicts?
 - A. Yes.
 - B. No.
 6. How does your leader manage emotions?
 - A. Can adapt them to the current situation.
 - B. Reacts nervously.
 - C. Is calm and does not show emotion.
 7. How does your leader resolve conflicts?
 - A. Through dialogue.
 - B. Through stressful conversations with employees.
 - C. By waiting for the conflict to resolve itself.
 8. Does your leader demonstrate a high level of empathy with your team?
Scale from 1 to 5
 - 1 – Definitely no.
 - 2 – No.
 - 3 – Neutral.
 - 4 – Yes.
 - 5 – Definitely yes.
 9. How has your leader's empathy influenced team collaboration?
 - A. It integrated and motivated the team.
 - B. The team works without commitment.
 - C. Team members are stressed.
 10. Do you think your leader acts in accordance with ethical principles?
 - A. Yes.
 - B. No.
 11. What actions or decisions of your leader show his/her compliance with ethical principles?
 - A. Treatment of colleagues.
 - B. Resolving conflicts within the team.

- C. Respecting others and being respectful.
12. Can your leader effectively motivate the team to achieve goals?
- Scale from 1 to 5
- 1 – Definitely no.
- 2 – No.
- 3 – Neutral.
- 4 – Yes.
- 5 – Definitely yes.
13. What motivational methods does your leader use?
- A. Recognition and rewards.
- B. Opportunities for professional development.
- C. Creating a friendly workplace.
14. Does your leader have developed social skills?
- Scale from 1 to 5
- 1 – Definitely no.
- 2 – No.
- 3 – Neutral.
- 4 – Yes.
- 5 – Definitely yes.
15. What personality traits of your leader help to build positive team relationships?
- A. Empathy.
- B. Communicativeness.
- C. Authenticity.
16. How old are you?
- A. 18-26.
- B. 27-35.
- C. 36-45.
- D. 46-55.
- E. 55-59
17. Where do you live?
- A. Village.
- B. City of up to 50 000 inhabitants.
- C. City of 50,000 to 100,000 inhabitants.
- D. City with more than 100,000 inhabitants.
18. How many years' work experience do you have?
- A. Up to 5 years.
- B. Between 5 and 15 years.
- C. Over 15 years.

19. What education do you have?
 - A. Vocational.
 - B. Secondary.
 - C. Higher.
20. What position in the organisation do you hold?
 - A. Serial employee.
 - B. Management position.
21. How many people does your organisation employ?
 - A. Up to 20.
 - B. Between 21 and 200.
 - C. More than 200.

4.1. Findings

The survey data was analysed using statistical methods. Once the data was collected, the results were visualized using bar charts and pie charts to highlight key trends and distributions. Bar charts were used to compare the scale of survey responses, while pie charts illustrated proportional relationships in the data sets. The survey data were organized, and all visualizations and calculations were performed in Microsoft Excel.

The study does not strictly follow either the mixed model of emotional intelligence as proposed by Goleman, or the ability model by Mayer and Salovey. However, it draws on elements from both frameworks to assess emotional intelligence in leadership. Goleman's mixed model is more comprehensive in integrating personality traits and leadership qualities, making it a suitable basis for evaluating how emotional intelligence impacts leadership behaviors and team outcomes. Mayer and Salovey's model, on the other hand, offers a more structured approach to measuring emotional competencies. While the study does not solely rely on one specific model, incorporating elements from both frameworks strengthens the theoretical foundation of the research, providing a broader understanding of emotional intelligence and its effects on leadership.

It is important to treat this study as a pilot project due to the relatively small number of respondents. With only 100 participants completing the survey, the sample size is limited, which may impact the generalizability of the findings. A small sample size can also result in a higher margin of error, potentially affecting the reliability and validity of the results. Additionally, the diversity of the respondents while offering some range of perspectives might not fully represent the broader population of professionals across various industries.

Given these limitations, the results of this study should be seen as exploratory and not definitive. The findings provide valuable preliminary insights into the role of emotional intelligence in leadership, but further research with a larger and more diverse sample is needed to confirm these results and draw more robust conclusions. The study's pilot nature also allows

for refinements in the research design, which could improve the accuracy and applicability of future investigations into this area.

A collective summary of the research results for all 100 respondents, in accordance with the 15 questions in the survey, is presented in Figures 1 to 22.

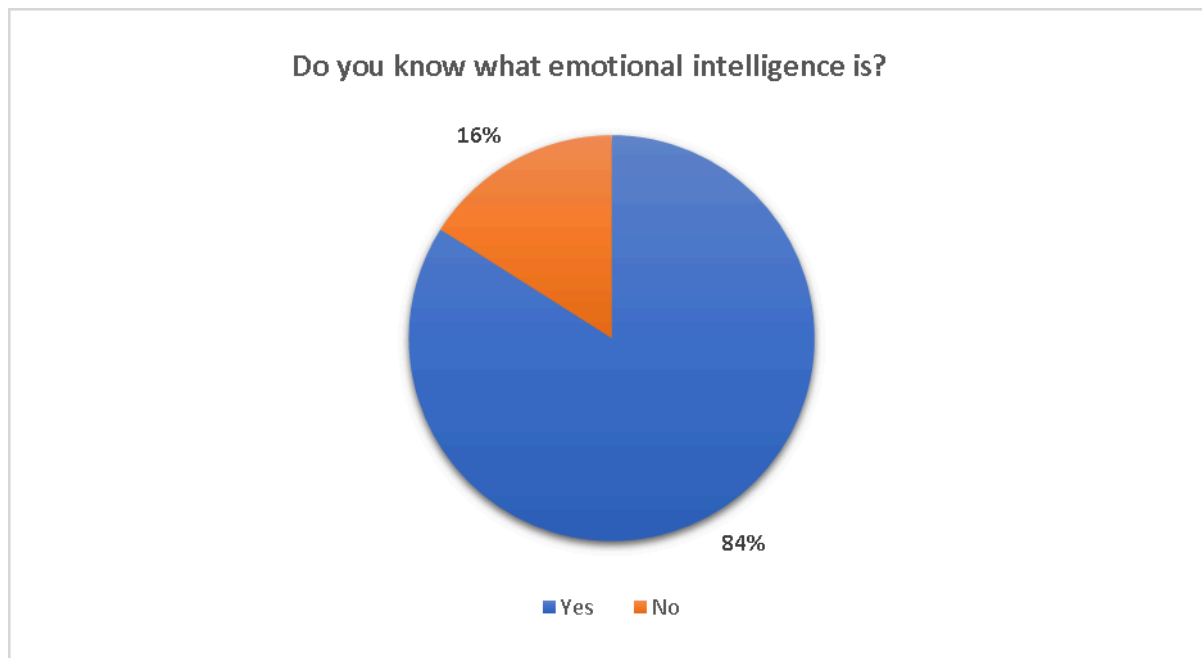


Figure 1. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 1 of the research survey.

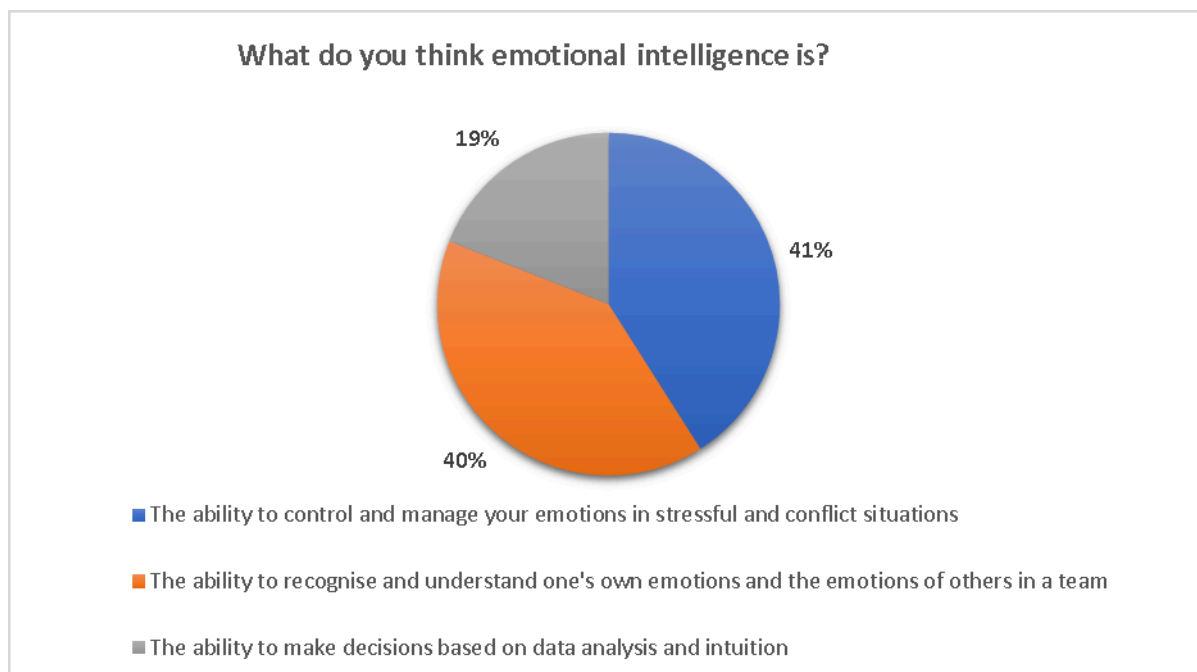


Figure 2. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 2 of the research survey.

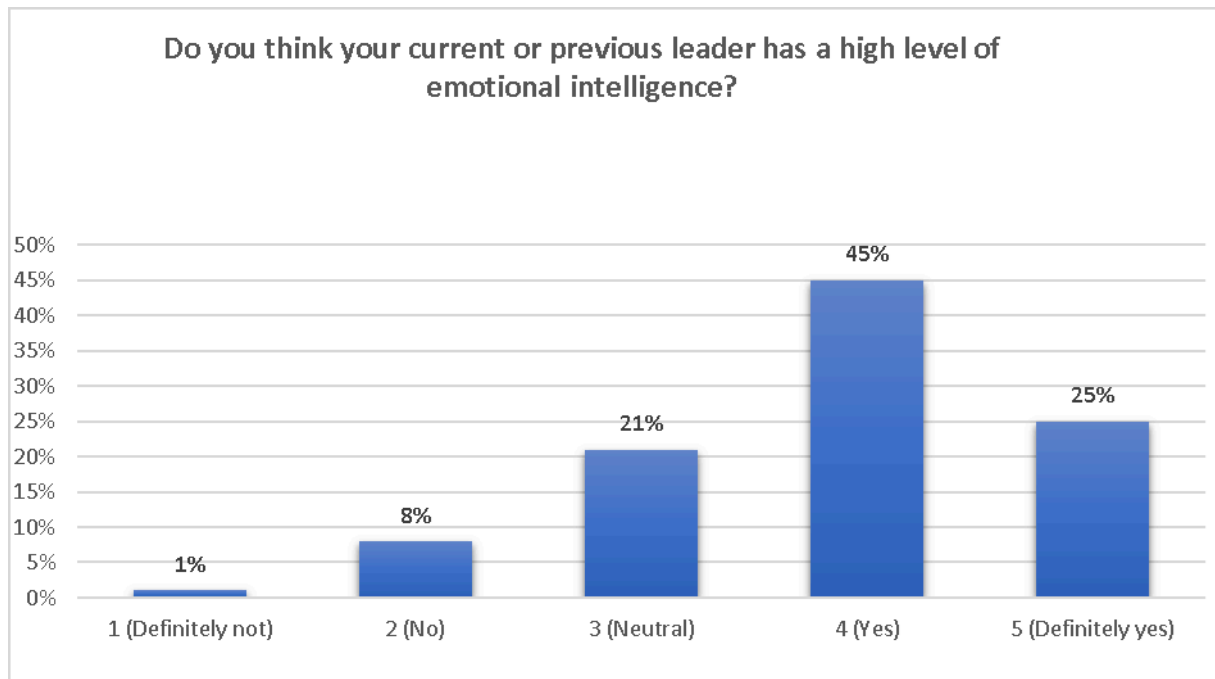


Figure 3. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 3 of the research survey.



Figure 4. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 4 of the research survey.

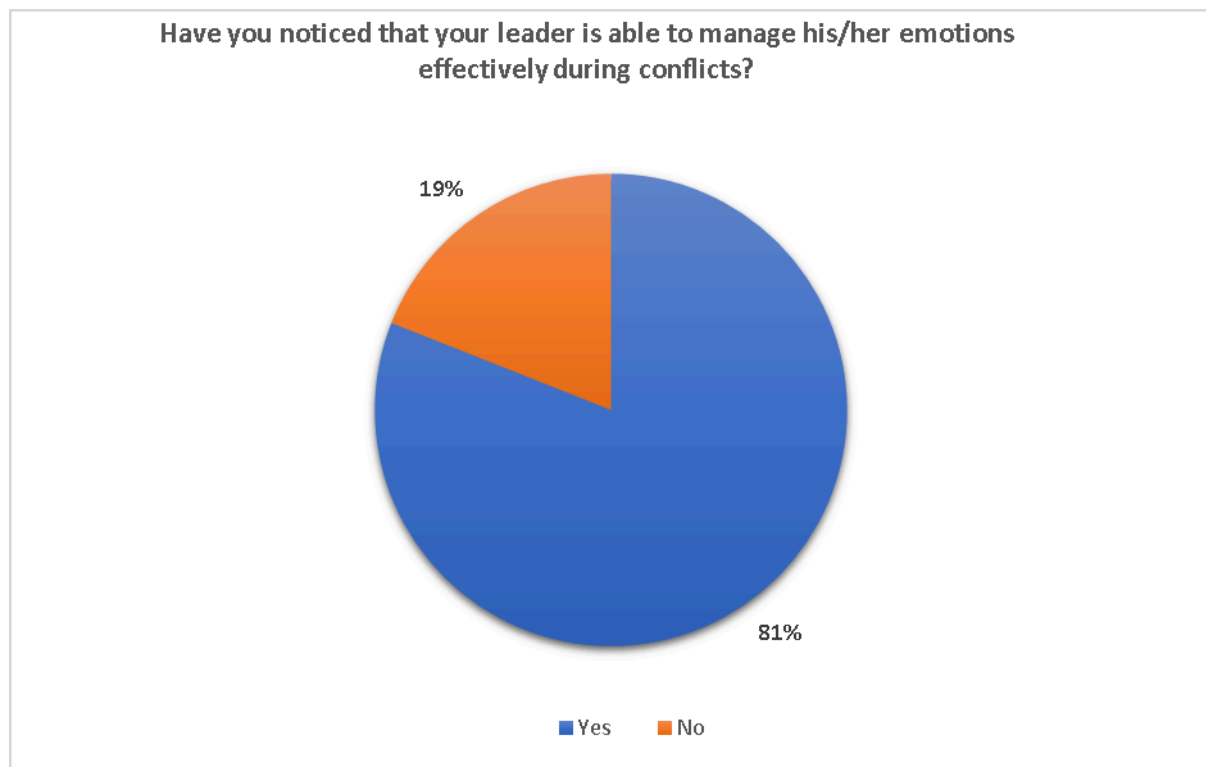


Figure 5. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 5 of the research survey.



Figure 6. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 6 of the research survey.

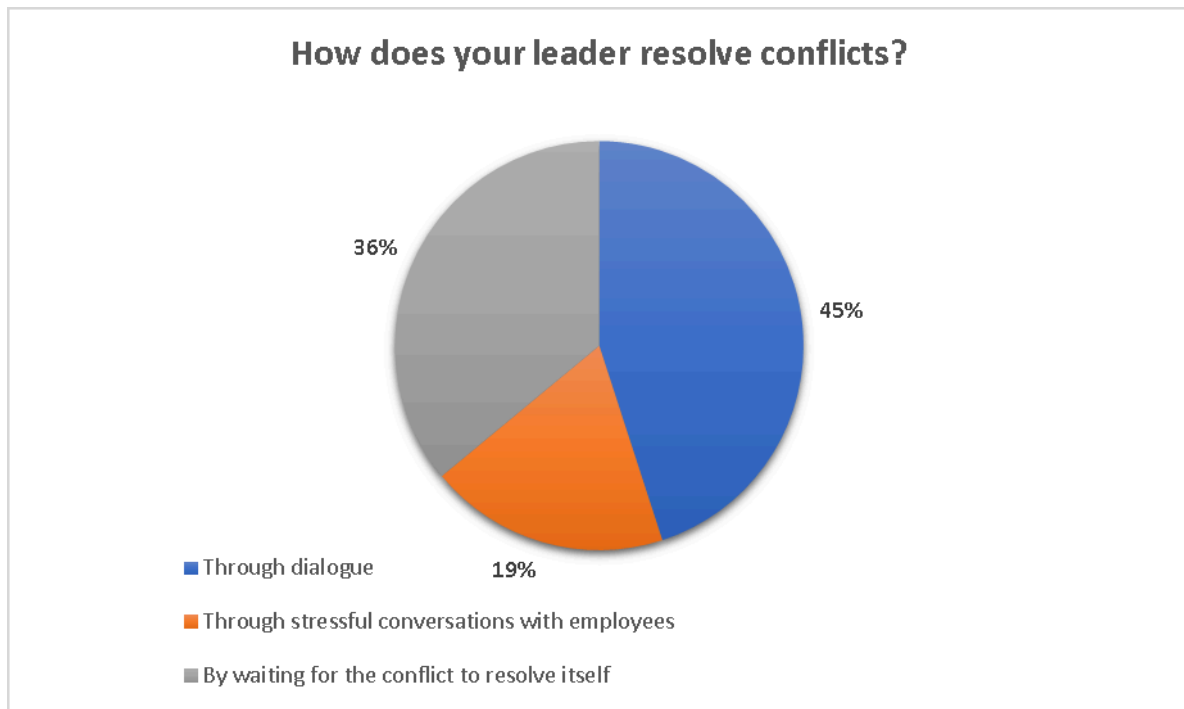


Figure 7. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 7 of the research survey.

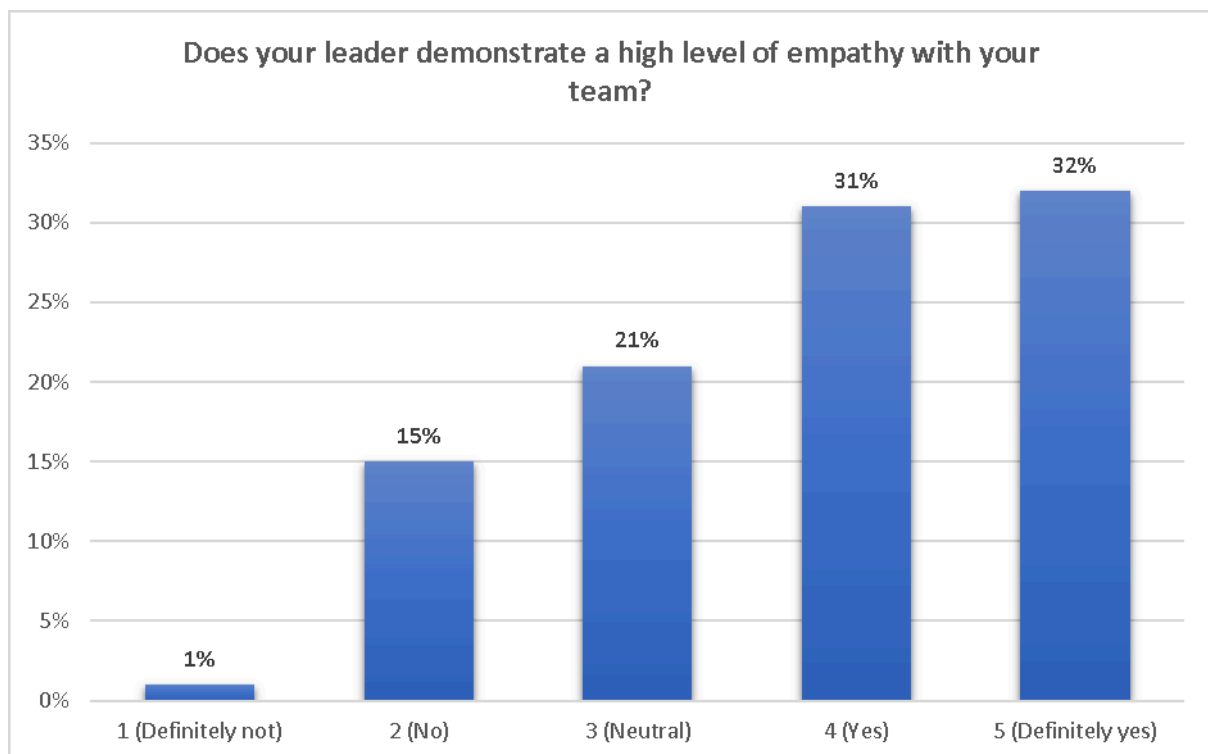


Figure 8. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 8 of the research survey.

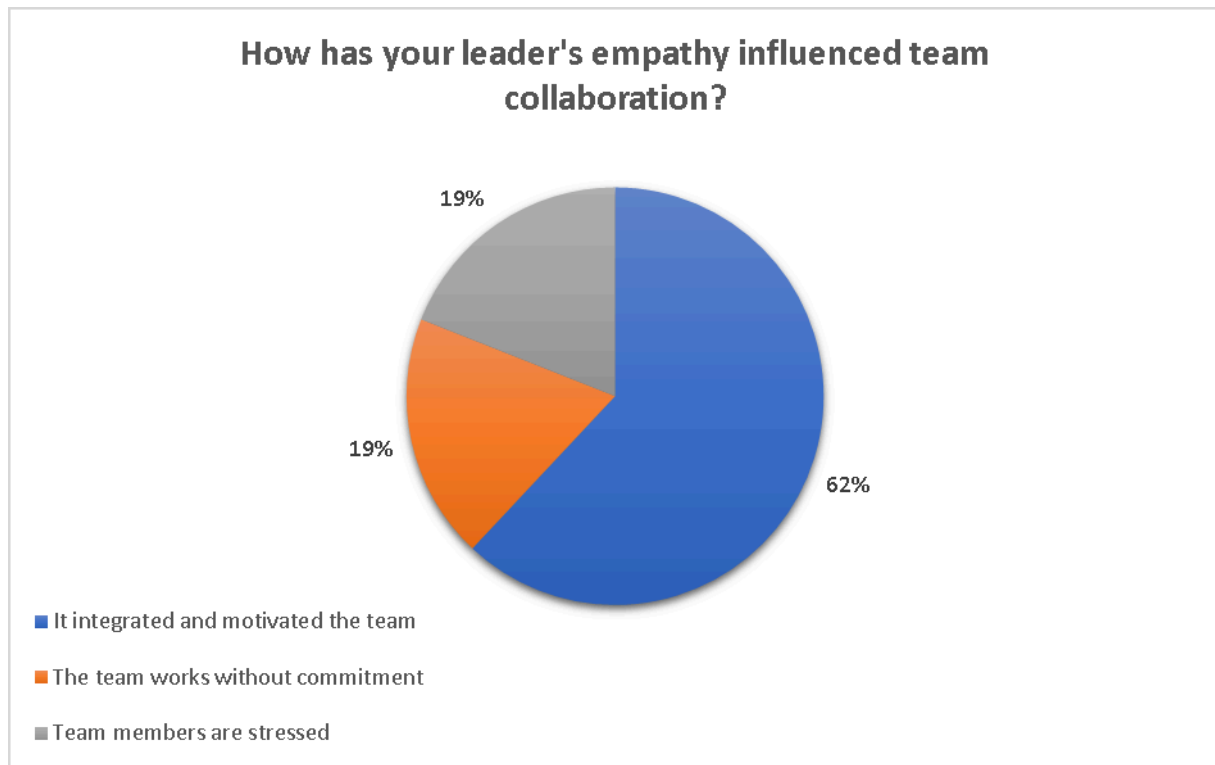


Figure 9. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 9 of the research survey.

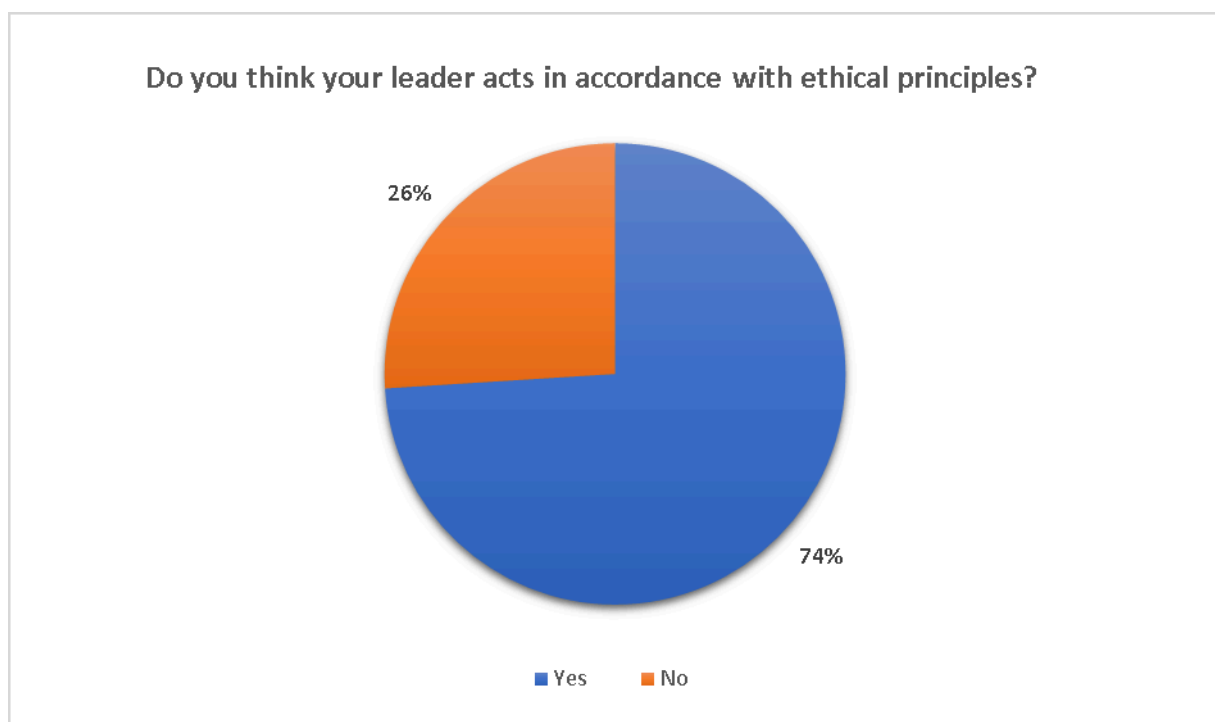


Figure 10. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 10 of the research survey.

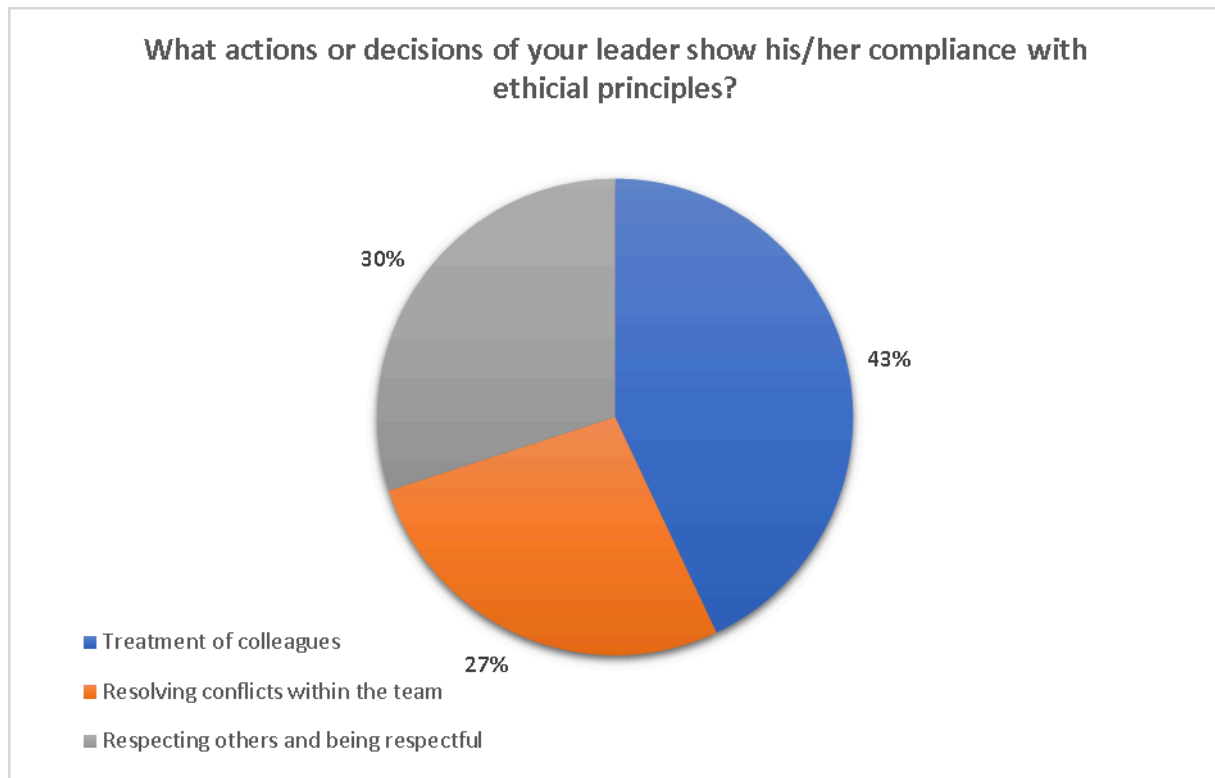


Figure 11. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 11 of the research survey.



Figure 12. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 12 of the research survey.

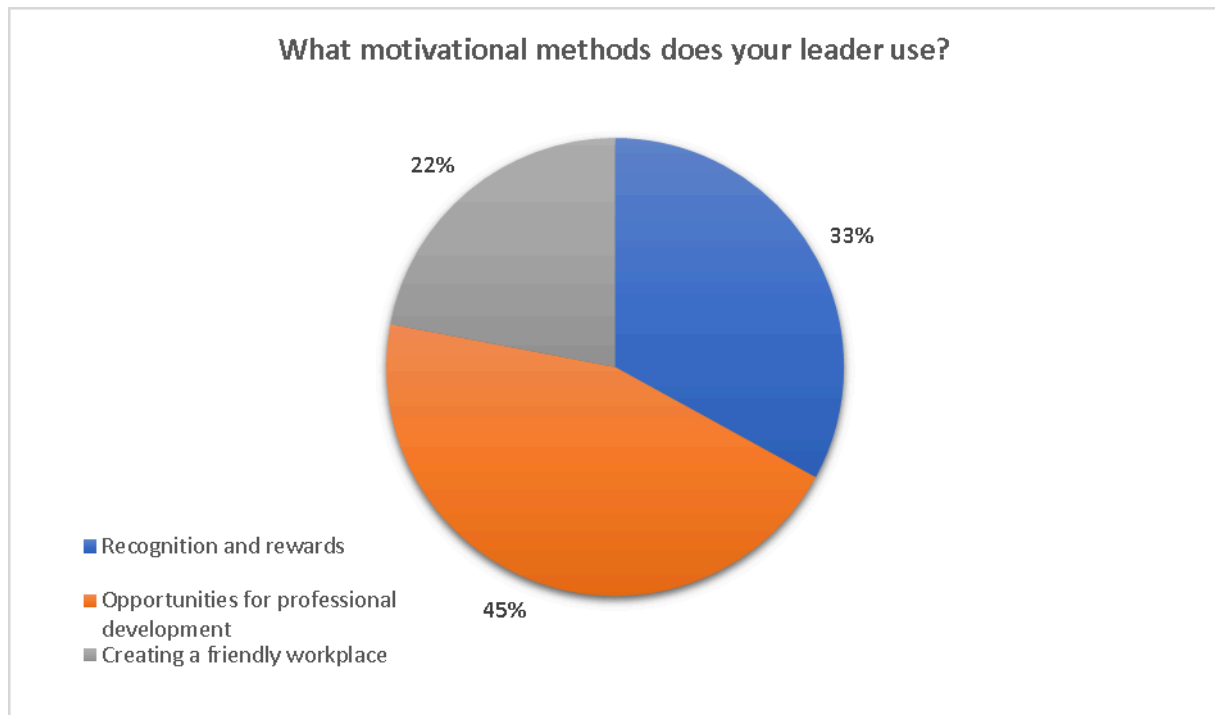


Figure 13. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 13 of the research survey.

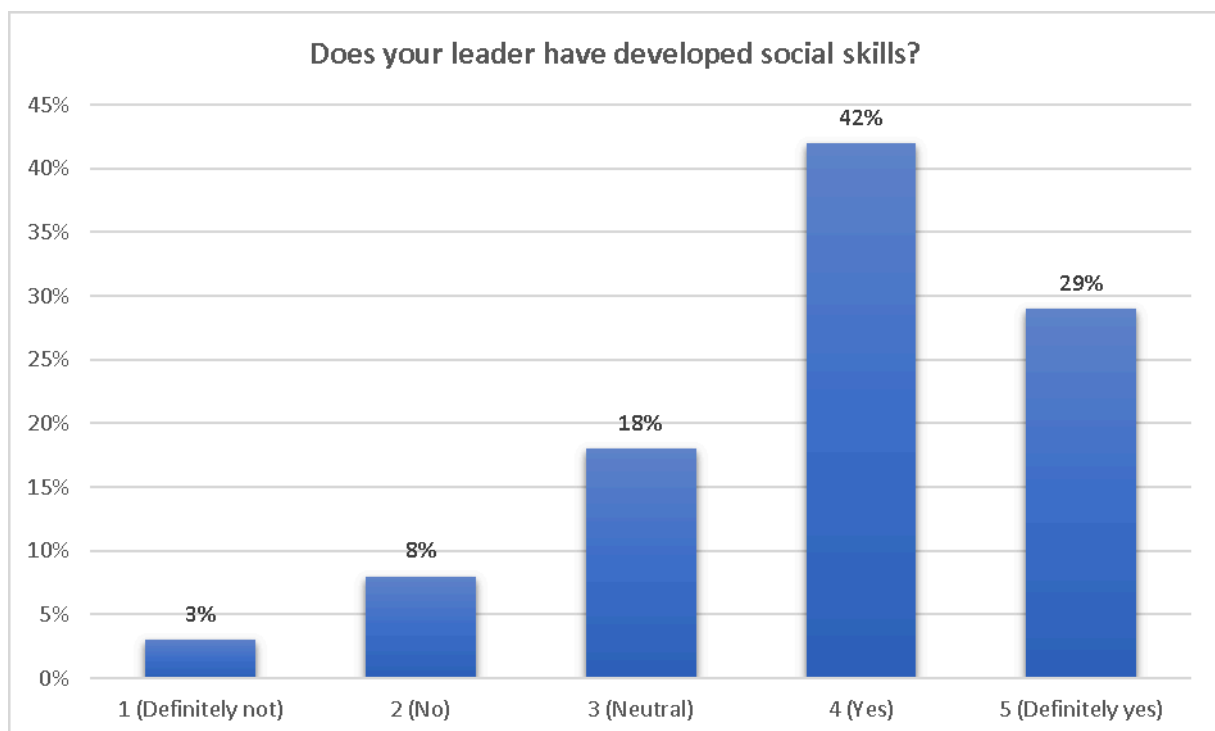


Figure 14. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 14 of the research survey.



Figure 15. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 15 of the research survey.

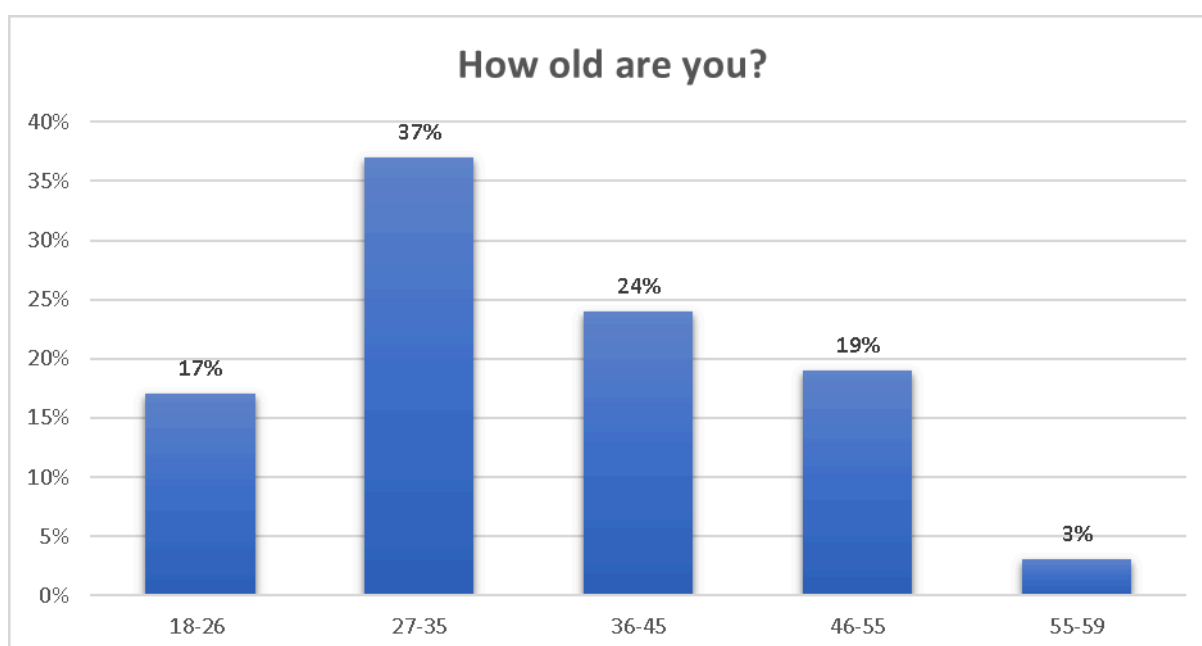


Figure 16. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 16 of the research survey.

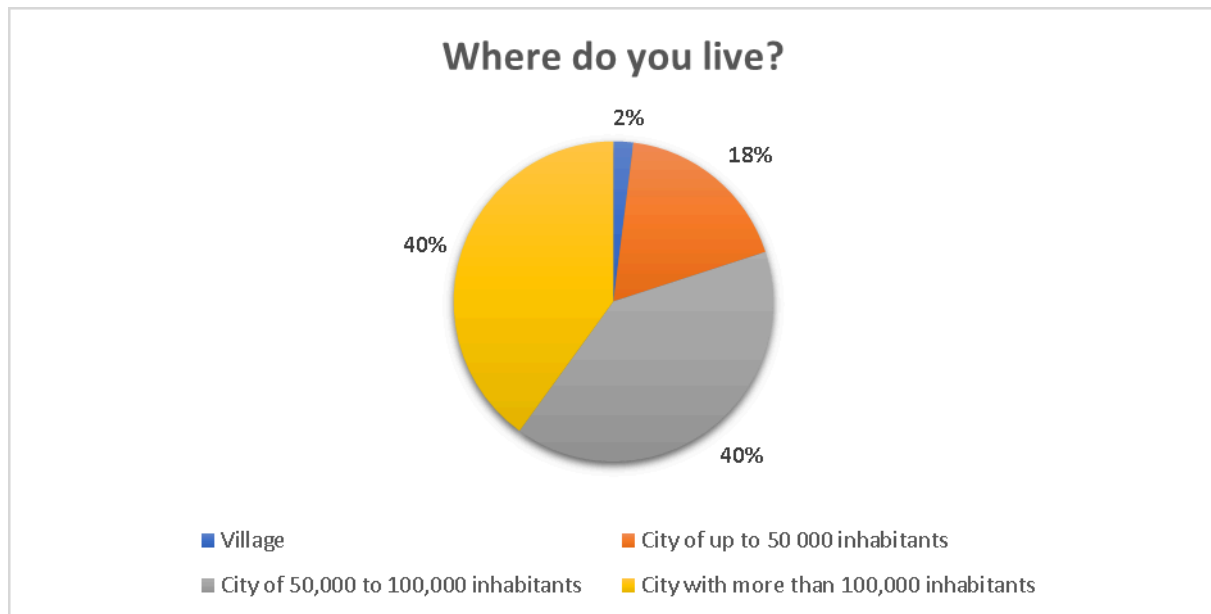


Figure 17. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 17 of the research survey.

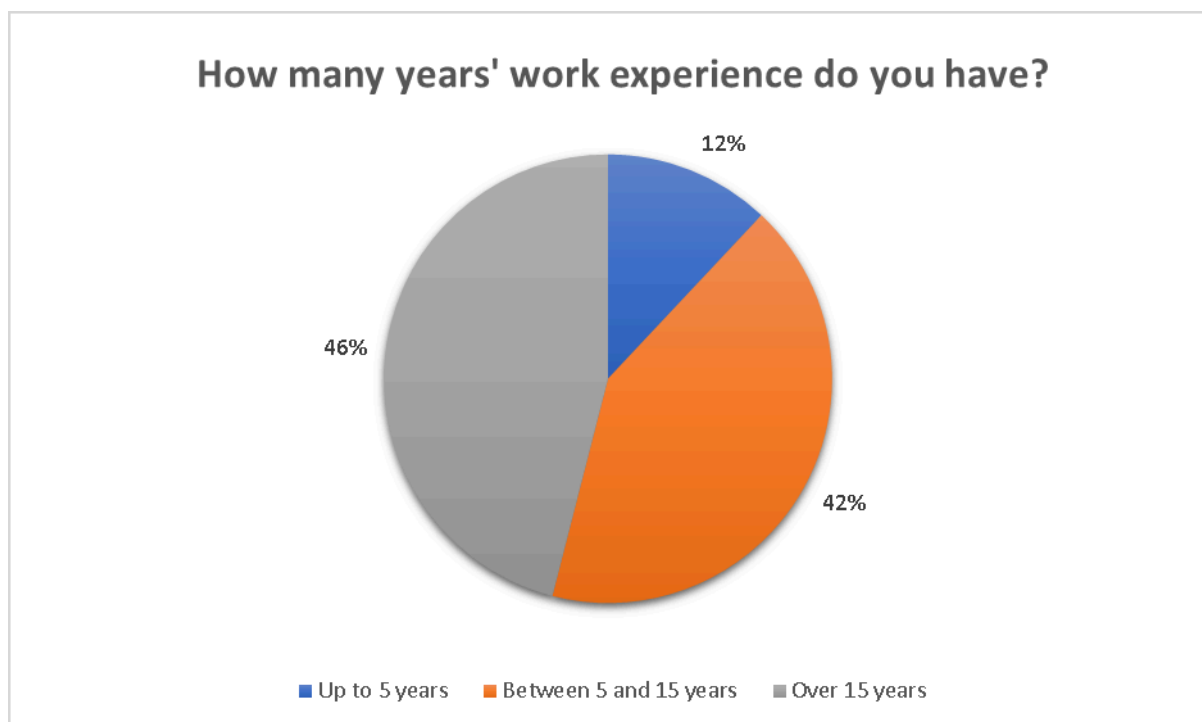


Figure 18. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 18 of the research survey.

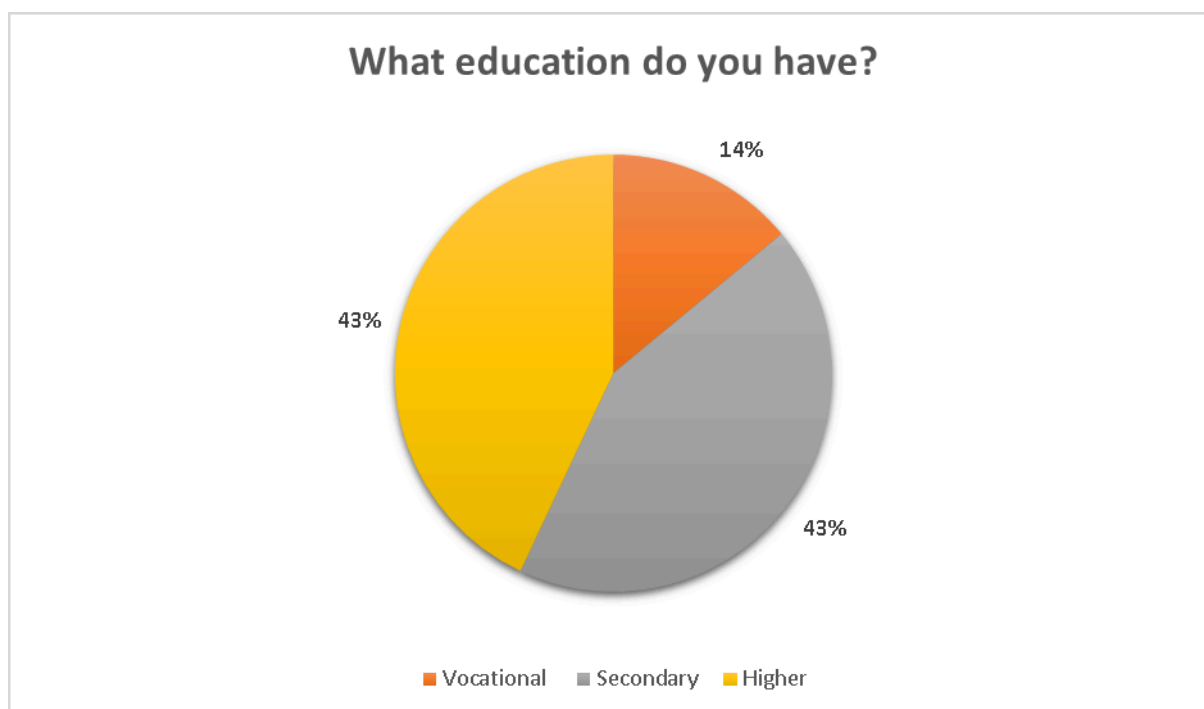


Figure 19. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 19 of the research survey.

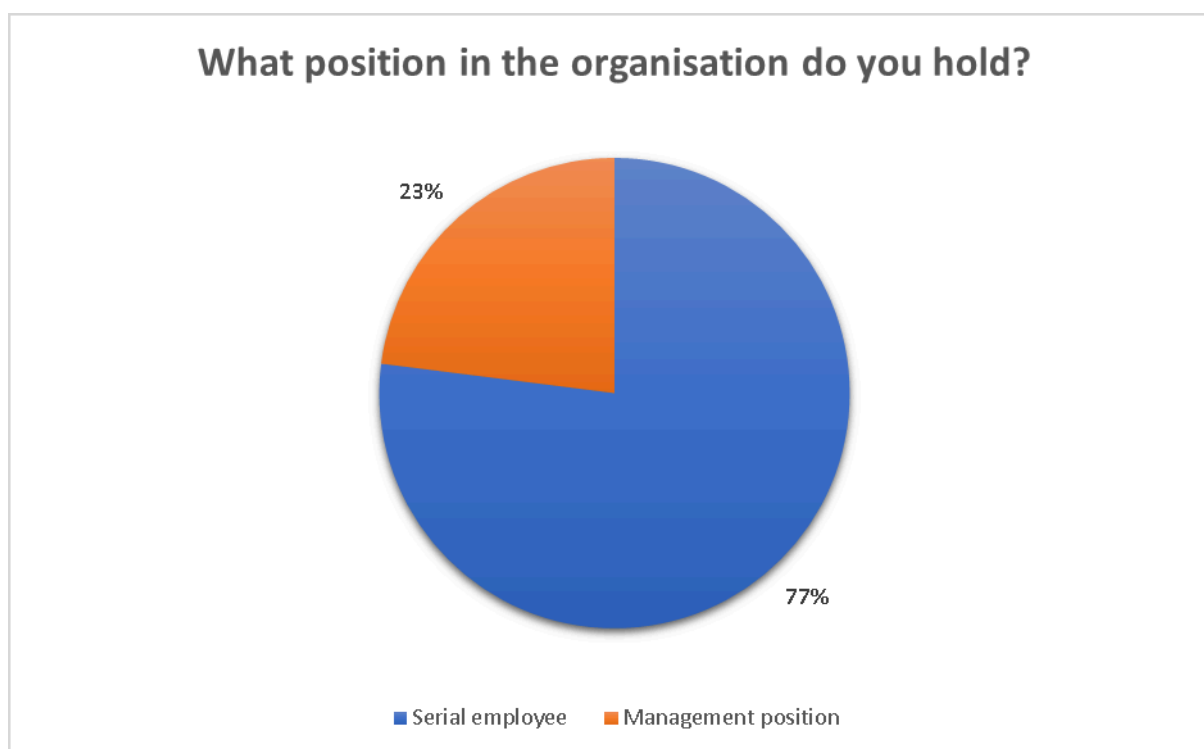


Figure 20. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 20 of the research survey.

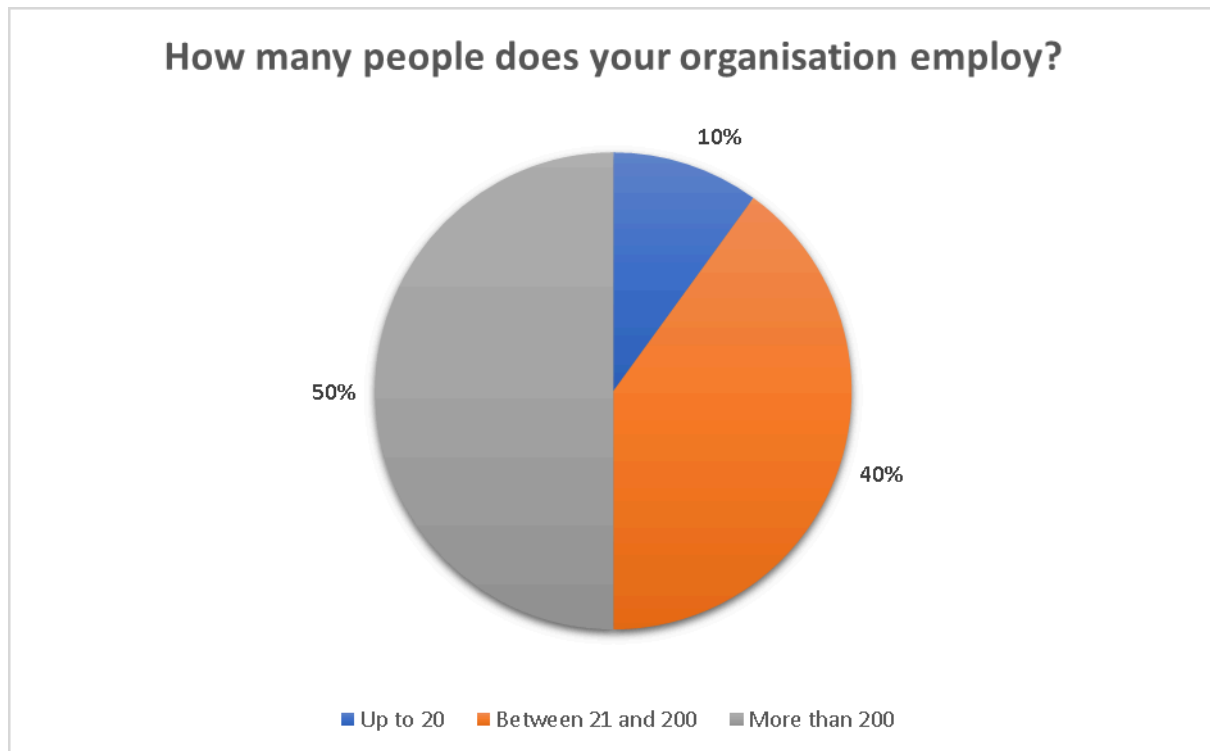


Figure 21. Answers from enterprise employees who have experienced a variety of leaders' management styles to question 21 of the research survey.

The analysis reveals that most respondents recognize emotional intelligence as a crucial factor in leadership effectiveness. The study employed elements from both Goleman's mixed model, which integrates personality traits, and Mayer and Salovey's ability model, focusing specifically on emotional competencies. Due to its pilot nature and limited sample size ($n = 100$), the results should be considered preliminary, indicating a significant role of emotional intelligence in team management but requiring further validation through larger and more diverse research samples.

4.2. Analysis of research results

The first question in the survey served as an introductory inquiry, assessing respondents' familiarity with the concept of emotional intelligence. The results indicate that the vast majority of participants (84%) confirmed their awareness of the term, whereas 16% admitted that they were unfamiliar with it.

The following question aimed to explore how respondents understood the concept of emotional intelligence. Participants were presented with three possible definitions and asked to choose one. The most frequently selected response (41%) defined emotional intelligence as the ability to control and manage one's emotions in stressful and conflict situations. A nearly equal proportion (40%) of respondents emphasized the ability to recognize and understand one's own emotions and those of others within a team. The least selected option (19%) linked emotional intelligence to decision-making based on data analysis and intuition.

The responses revealed varying assessments of emotional intelligence levels among leaders. A total of 1 respondent (1%) assigned a rating of 1, indicating a very low level of emotional intelligence. Similarly, 8 respondents (8%) rated their leader at level 2, suggesting a low level of emotional intelligence, albeit slightly higher than the previous category. A moderate level of emotional intelligence was reported by 21 respondents (21%), who selected a rating of 3. The largest proportion of participants, 45 respondents (45%), assigned a rating of 4, indicating a high level of emotional intelligence. Furthermore, 25 respondents (25%) explicitly stated that their leaders exhibited a high level of emotional intelligence. These findings suggest that a substantial majority of respondents perceive their leaders as possessing at least a moderate to high level of emotional intelligence, with a significant proportion assigning ratings at the upper end of the scale.

Respondents were asked about traits that confirm a leader's high emotional intelligence. Of the respondents, as many as 37% believe that an analytical mind is the most important indicator of high intelligence in a leader. 34% of respondents indicated that fairness best reflects a leader's high emotional intelligence. Empathy received the fewest responses (29%), suggesting that it is seen as a less important element of a leader's emotional intelligence.

An essential aspect of the study focused on assessing leaders' ability to manage their emotions during conflicts. The results indicate that over 80% of respondents perceive their leaders as capable of effectively regulating their emotions in such situations. Conversely, 19% of participants reported that they had not had the opportunity to observe these competencies in their leaders.

Additionally, the survey included a question evaluating team members' perceptions of their leaders' emotional expression. A majority of respondents (56%) indicated that their leader expresses emotions in a manner appropriate to the given situation. Meanwhile, 28% of participants assessed that their leader remains composed and does not outwardly display emotions. The smallest proportion of respondents (16%) perceived their leader as reacting nervously in conflict scenarios. These findings suggest that most leaders are viewed as demonstrating effective emotional management, with a prevailing tendency toward either appropriate emotional expression or emotional restraint.

Respondents were also asked about how their leaders resolve conflicts. The most frequently selected answer was that the leader conducts a dialogue with his subordinates (45%). A smaller number of respondents indicated that they had witnessed situations where their superiors waited for conflicts to resolve themselves (36%). The fewest respondents (19%) experienced stressful conversations between leaders and employees.

Respondents were asked to assess their leaders' empathy toward their subordinate team on a scale from 1 to 5, where 1 signifies "definitely not" and 5 denotes "definitely yes". The results indicate that 63% of respondents perceive their leaders as highly empathetic (rating 4 or 5), while 21% rate their leaders' empathy at an average level (3), and 16% believe their leaders lack empathy (rating 1 or 2). The statistical analysis further supports these findings, with a mean

score of 3.78, reflecting a generally positive perception, and a median score of 4, indicating that at least half of the respondents rated their leaders' empathy at this level or higher. The standard deviation of 1.08 suggests moderate variability in responses, highlighting differing experiences among employees. These results confirm that a significant proportion of employees recognize empathy in their leaders.

As part of the survey, respondents were asked to evaluate the influence of leaders' empathy on team collaboration. The majority (62%) reported a positive impact, highlighting that empathetic leadership fosters team integration and enhances motivation. However, 19% of respondents noted a lack of team engagement, while an equal proportion (19%) indicated that insufficient empathy from leaders contributed to stress within the team. These findings suggest that while empathy is largely perceived as a crucial factor in strengthening teamwork, its absence may lead to adverse effects on team dynamics.

Another critical dimension of the study involved assessing the perception of ethical leadership. The data presented in the accompanying chart illustrate respondents' views on the extent to which their leaders adhere to ethical principles. A significant majority (74%) affirmed that their leaders demonstrate ethical behavior, reflecting a generally high assessment of their moral integrity and professional conduct. Conversely, 26% of respondents expressed concerns regarding the ethical practices of their leaders, suggesting the presence of ethical ambiguities or inconsistencies that warrant further investigation.

The next question was designed to detail the ethical actions of leaders. Respondents were asked to indicate what actions are taken by supervisors. 43% of respondents indicated that leaders' ethical actions are most evident in the area of treating co-workers. 30% of respondents believe that ethical actions are based on respecting co-workers and therefore: respecting the leader. The third group, which indicated the smallest number of responses, i.e. 27%, believes that ethical actions are evident in the way conflicts are resolved within the team.

Respondents were asked to rate the effectiveness of team motivation to achieve goals. The responses are in the form of a five-point scale, where 1 means that leaders are unable to motivate teams to any degree, while 5 means that leaders have the competence to motivate teams effectively. The vast majority of respondents, as many as 61%, believe that their leaders have the ability to effectively motivate a team to achieve goals. 28% of respondents rated their leaders as having moderate effectiveness, while 11% of responses indicate that leaders do not have any ability to motivate their subordinates to achieve their goals.

One of the key aspects examined in the survey was the identification of specific motivational strategies employed by leaders. The most frequently cited method, indicated by 45% of respondents, was the provision of professional development opportunities. Recognition and rewards from superiors were identified as a motivational factor by 33% of participants. The least frequently mentioned approach (22%) was the creation of a supportive and friendly work environment as a means of employee motivation. These findings suggest that while

professional growth and recognition are primary drivers of motivation, workplace atmosphere is considered a less dominant factor.

Another critical dimension of the study involved assessing the level of social competence among leaders. Respondents evaluated their leaders' social skills on a five-point scale, where 1 represented a lack of developed social competencies and 5 denoted a high level of proficiency. The results indicate that over 70% of respondents perceive their leaders as possessing well-developed social competencies. Additionally, 18% of participants rated their leaders' social competence as moderate, while 11% expressed the view that their leaders exhibit a lack of social skills.

The 15 question was about the personality traits of leaders that have a positive impact in the process of building positive relationships in the team. Responses to this question are as follows: the largest group of respondents (40%) indicated that the leader's communicativeness has an impact on building positive relationships in the team. 30% felt that empathy was the most important trait. The same number of respondents (30%) believe that the leader's authenticity contributes to the creation of positive relationships in the team.

Further questions are metric questions. Participants in the survey are people of working age, which covers a wide age range. The youngest respondent participating in the survey is 19 years old, while the oldest is 59 years old. The largest number of respondents participating in the survey reside in cities while a minority (2%) live in villages. The largest group (43%) among those surveyed were respondents with higher education than those with secondary education. The vast majority (77%) of the respondents declared that they held positions as rank-and-file employees, while the rest held managerial positions. In terms of work experience, about half of the respondents declared that they have more than 15 years of education. Most people (50%) work in organisations that employ more than 200 people.

The correlation analysis examines, which is shown in figure 22 the relationship between key leadership characteristics, including emotional intelligence, empathy, motivation effectiveness, social competence, and ethical leadership. The correlation matrix provides insights into the strength and direction of these relationships. The heatmap visualizes these correlations, highlighting the strongest relationships in warm colors and weaker associations in cooler tones. These findings emphasize the interconnected nature of leadership traits and provide empirical support for leadership development strategies focusing on emotional intelligence, ethics, and interpersonal skills.

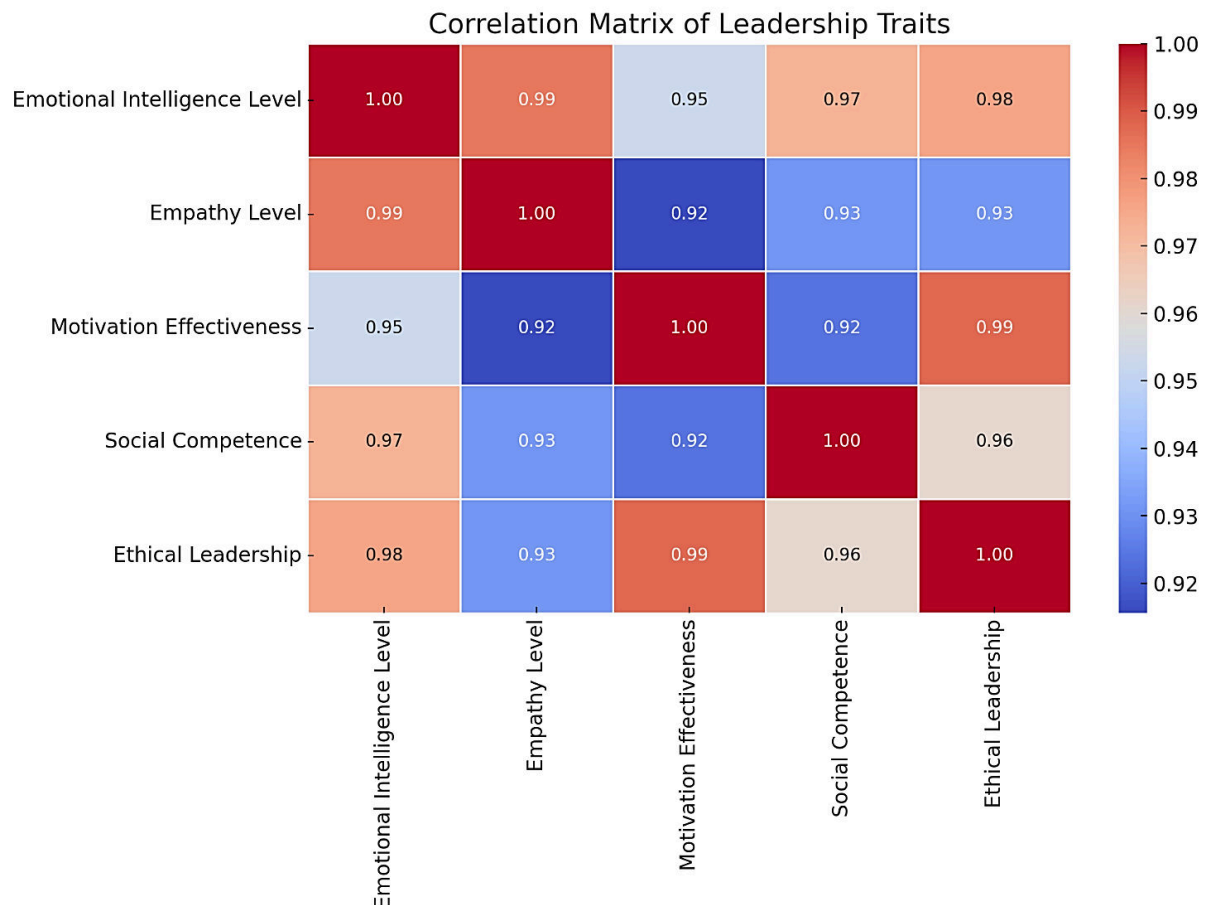


Figure 22. Correlation Matrix of Leadership Traits created from survey data.

The analysis revealed the following correlations:

Strong correlation between Emotional Intelligence and Empathy (0.98) - leaders with higher levels of emotional intelligence tend to be perceived as more empathetic. Emotional Intelligence and Social Competence correlation (0.97) - leaders with well-developed emotional intelligence are also rated highly in terms of social competence. This aligns with existing theories suggesting that emotional intelligence is a foundational component of effective interpersonal skills in leadership. Ethical Leadership and Motivation Effectiveness (0.99) - the strongest correlation in the dataset indicates that leaders perceived as ethical are also seen as highly effective in motivating their teams. Empathy and Ethical Leadership (0.93) - a high correlation suggests that leaders who are seen as empathetic are also perceived as ethical. Motivation Effectiveness and Social Competence (0.92) - social competence is crucial for motivating teams effectively. Leaders who can navigate social dynamics skillfully are better equipped to motivate their teams.

In summary, the correlation analysis reinforces the premise that key leadership traits do not operate in isolation but are closely interwoven, with emotional intelligence emerging as a central factor. The strongest associations, particularly between emotional intelligence, empathy, social competence, and ethical leadership, suggest that cultivating emotional awareness and interpersonal sensitivity significantly enhances a leader's effectiveness.

These findings provide practical guidance for leadership development programs, emphasizing the need to nurture emotional and ethical dimensions alongside technical competencies to foster holistic and impactful leadership.

5. Conclusions

The analysis of the collected empirical material provided important information on the emotional intelligence of leaders and its impact on team management. The research was conducted among 100 employees who had the opportunity to experience a variety of leaders' management styles at different stages of their careers. The collected data, including evaluations and opinions of the respondents, made it possible to draw conclusions.

The results of the study present that emotional intelligence is correlated with the positive perception of leaders by subordinates. The degree of development of emotional intelligence can be an evaluation criterion during recruitment processes and promotions.

The analysis confirms that emotional intelligence is a central factor in effective leadership, strongly correlating with empathy, social competence, and ethical leadership. Leaders who demonstrate emotional intelligence are also perceived as more ethical, empathetic, and socially competent, reinforcing the idea that emotional awareness enhances leadership effectiveness.

Additionally, a very strong correlation between ethical leadership and motivation effectiveness suggests that employees are more motivated when they perceive their leaders as ethical and fair. The findings highlight that social competence plays a key role in motivating teams, further emphasizing the importance of interpersonal skills in leadership.

Survey results show that leaders' ethical performance is highly valued by employees. As a result, companies can introduce a code of ethics for employees to promote leaders and their ethical actions and can implement business ethics training that can help leaders make decisions that are in line with the company's mission and values.

The results of our own research indicate the importance of emotional intelligence in managing subordinate personnel. Leaders who develop competence in this area contribute to the creation of more integrated, motivated and effective teams. In business practice, this means that organizations should invest in emotional intelligence training for their leaders. This is important to promote an organizational culture based on empathy, fairness and effective conflict resolution.

In order to strengthen the practical applicability of this study, it is recommended that organizations develop targeted emotional intelligence programs specifically for leaders and managers. Such programs may include workshops focusing on key interpersonal competencies such as active listening, empathy, emotional self-regulation, and stress management. Additionally, incorporating coaching methods tailored to enhancing emotional intelligence and

integrating EI assessment tools, such as EI-focused 360-degree feedback instruments, into existing leadership evaluation systems would facilitate the practical implementation of emotional intelligence principles in managerial practice.

Considering the methodological limitations arising from the pilot nature of this study due to the limited number of respondents, it is recommended to conduct further research involving a larger and more diverse sample of specialists representing various sectors and organizational contexts. Such expanded research would enable broader validation of the obtained results, enhance their generalizability, and strengthen the practical implications of the study's conclusions.

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THE IMPACT OF LEADERSHIP STYLES ON PROJECT EFFICIENCY

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Purpose: This study aims to investigate the impact of various leadership styles on project efficiency within different organizational contexts. It seeks to identify the key leadership behaviors that contribute to the successful attainment of project goals, stakeholder satisfaction, and overall project performance.

Design/methodology/approach: Quantitative research using a questionnaire with 100 project professionals. Data analyzed through statistical methods, including Spearman's correlation.

Findings: Leadership styles significantly affect project efficiency. Constructive feedback, clear goals, role clarity, and team initiative are key factors.

Research limitations/implications: Limited sample size and scope. Future studies should include diverse industries and cultural contexts.

Practical implications: Highlights the need for clear communication, feedback, and team empowerment to improve project outcomes.

Social implications: Effective leadership fosters trust, collaboration, and employee satisfaction, boosting productivity.

Originality/value: Provides empirical evidence on leadership styles' effect on project efficiency, offering actionable insights for managers.

Keywords: leadership styles, project efficiency, feedback, team initiative, project management.

Category of the paper: research paper.

1. Introduction

This study provides an original contribution by empirically exploring the nuanced relationship between leadership styles and project efficiency, a topic often discussed theoretically but seldom quantified in practice. By using a unique dataset gathered directly from project participants across multiple industries, it offers fresh insights and practical guidance that bridge the existing gap between abstract leadership concepts and measurable project outcomes. Additionally, this paper provides empirical verification of specific leadership behaviors, offering quantitative evidence of their direct influence on project success, thus enriching existing theoretical discussions.

Leadership plays a pivotal role in determining the success and efficiency of project implementation within various organizational contexts. This study was undertaken to investigate the extent to which different leadership styles influence project outcomes, particularly in terms of efficiency, goal attainment, and stakeholder satisfaction. The primary research question guiding this study is: *How do different leadership styles impact the efficiency of project teams?*

The theoretical framework of this research is grounded in classical and contemporary leadership theories. It encompasses foundational models such as trait theory, behavioral theory, situational leadership, and transformational leadership, extending to modern approaches like servant leadership and participative leadership. These theories provide the basis for understanding the diverse mechanisms through which leaders can affect team dynamics, decision-making processes, and overall project performance.

The motivation for this study arises from the recognition of a significant knowledge gap in understanding the direct correlation between specific leadership styles and measurable project efficiency outcomes. While extensive literature exists on leadership theories and their qualitative impact on organizations, there is limited empirical evidence quantifying these effects in project-based environments. This gap necessitates a focused investigation to provide actionable insights for practitioners and scholars alike.

This study aims to identify and categorize prevalent leadership styles within project teams, analyze the relationship between these leadership styles and key project performance indicators, and determine the leadership behaviors most conducive to enhancing project efficiency. The study employs a quantitative research methodology, utilizing a structured questionnaire distributed to professionals working in project teams across various industries. The collected data is analyzed using statistical techniques to establish correlations between leadership styles and project efficiency metrics.

By addressing the outlined research question and objectives, this study aims to contribute to the academic discourse on leadership in project management and offer practical recommendations for optimizing leadership practices to improve project outcomes.

2. The beginnings of leadership theories

Leadership concepts have evolved over the years. Initially, traditional approaches to leadership, which focused on leaders' personality traits, transformed into more complex and flexible relational and situational models. The development process that the concept of leadership has undergone, as well as the theories concerning it, influences how leadership is perceived today. Therefore, it is worthwhile to recount the history of theories formulated about leaders, their traits, and actions to gain the perspective necessary for analyzing contemporary leadership models.

One of the earliest theories aimed at explaining the essence of effective leadership was the trait theory. This theory suggested that leaders are individuals who inherently possess qualities like intelligence, charisma, communication skills, determination, and self-confidence (Northouse, 2016). In Polish literature, Tadeusz Kotarbiński contributed to the development of trait theory by emphasizing the critical importance of moral values and the responsibility leaders bear in their work (Kotarbiński, 2000). While this theory enjoyed significant popularity in the first half of the 20th century, its prominence declined as certain limitations became evident. Observations indicated that not all people exhibiting these traits become effective leaders. It was recognized that innate character traits and ethical values, though important, are not the sole determinants of a leader's success. Additionally, it was noted that individuals in leadership roles can develop their competencies and traits over the course of their careers. This realization suggested that the trait theory was too simplistic to fully explain what characterizes a successful leader (Zaccaro, 2007).

Further advancements in leadership research emerged in the early part of the second half of the 20th century. The focus shifted from examining innate traits of leaders to analyzing their behaviors. This shift led to the development of behavioral theories, which posited that a leader's actions are the primary factors influencing their effectiveness (Yukl, 2013). However, these theories also had limitations and were not adequate for explaining all situations.

Paul Hersey and Kenneth Blanchard developed the situational leadership theory to address the shortcomings identified in earlier leadership theories. At the time of its creation, this concept was considered highly innovative. It builds upon previous observations and is based on the belief that an effective leader adapts their approach to match the readiness level of their subordinates. The leader selects their style of behavior to appropriately guide the project and fulfill its requirements (Yukl, 2013; Blanchard, 2007). The emergence of this theory significantly impacted the progression of other contemporary project management methods by highlighting the importance of leader flexibility when managing a project. Research in this area has shown that this management style is particularly effective in projects characterized by dynamic changes in economic conditions (Kozłowski, Jemielniak, 2011).

Another leadership approach that gained popularity in the second half of the 20th century is the relationship-oriented management style. As the name suggests, this style focuses on building strong relationships between the leader and team members. Leaders who employ this style make an effort to understand their coworkers' needs, support their development, and maintain mutual respect and trust within the team (Bass, Riggio, 2006). Oblój identified that fostering relationships with the team positively influences the project's final results, as team members become engaged and feel responsible for the tasks entrusted to them. Therefore, this concept is particularly effective in project teams where the nature of the tasks requires close cooperation and high-level communication (Oblój, 2007).

Classical leadership concepts have undeniably shaped how contemporary models are utilized today. The theories previously discussed have been updated with continually expanding knowledge in this field and adjusted to align with current realities. They have provided a robust foundation for the development of management models such as transformational leadership and servant leadership (Yukl, 2013). Understanding and analyzing classical leadership theories enables leaders to better adapt modern models in their work. This also facilitates the development, enhancement, and customization of practices within modern project teams (Koźmiński, Jemielniak, 2011).

3. Contemporary leadership styles

The evolution of modern leadership models arose from the need for more complex and flexible leadership techniques. Although contemporary approaches have roots in classical leadership concepts, they have been expanded and adapted to suit changing times and working conditions. We include among contemporary the following leadership styles:

- Transformational leadership (Bass, Riggio, 2006),
- Transactional leadership (Burns, 1978),
- Participative leadership (Stocki et al., 2008),
- Democratic leadership (Gastil, 1994),
- Servant leadership (Greenleaf, 1977),
- Situational leadership (Blanchard, 2007).

Transformational leadership centers on inspiring teams to achieve shared goals through engagement and vision. Leaders who adopt this style focus on motivating employees, enhancing their commitment, and developing their personal competencies (Bass, Riggio, 2006). This approach emphasizes creating strong emotional bonds within the team. Key characteristics include the leader's charisma, individualized consideration for team members, and actions aimed at intellectually stimulating employees. Teams are encouraged to think creatively and innovate (Chmiel, 2003). In practical terms, transformational leadership is particularly

significant in projects requiring high levels of innovation. Leaders can inspire colleagues to seek new solutions continuously, positively impacting project outcomes (Bass, Riggio, 2006).

Conversely, transactional leadership is based on a clear system of rewards and penalties—a transactional relationship between the leader and the team. This approach assumes that employees are most motivated and perform at their best when leaders establish clearly defined goals and provide appropriate rewards (material or non-material) for their achievement. Inadequate results may lead to consequences for employees (Burns, 1978). This style is most effective in projects requiring strict control and precision, such as those with high operational complexity and significant risk. Essentially, transactional leadership focuses on motivating employees through a straightforward system of incentives and sanctions. (Schultz, Schultz, 2006).

Despite their differences, these two leadership styles are often used together to complement each other. Combining them is effective in teams where leaders need to manage both creative and operational aspects efficiently. By drawing from the transformational style, leaders focus on inspiring the team to achieve visionary goals by stimulating innovative solutions and adapting to new challenges. Utilizing the transactional approach ensures that daily work aligns with project assumptions, taking care of task execution within the set time and budget (Bass, Avolio, 1994). Employing a hybrid of these styles is effective in complex projects requiring flexibility, creativity, and precise operational management. Leaders guiding their teams in this manner balance fostering innovation with maintaining high efficiency levels (Avolio, Bass, 2004).

Participative leadership is a management approach in which organizational members actively participate in decision-making, having genuine influence over setting goals and determining the company's direction of development. This method enhances employee engagement because they feel valued and partly accountable for the organization's success. Collaboration under this model encourages the growth of personal competencies within the team, contributing to overall organizational advancement. Adopting participative leadership involves decentralizing authority, which requires the leader to be open-minded and trusting toward employees (Stocki et al., 2008). In project teams, this style increases effectiveness, especially in settings that demand innovative solutions to problems.

Similarly, democratic leadership entails equal involvement of all team members in decision-making processes. This style is ideal for teams that need a facilitator or advisor rather than a traditional manager. Team members develop a sense of responsibility for the success and efficiency of their work. Implementing democratic leadership necessitates strong collaboration skills from all participants, fostering creativity and enabling the full use of the team's collective knowledge and abilities. However, it may introduce challenges in time management since reaching decisions can take longer compared to authoritarian styles. In rapidly changing project environments where swift decision-making is crucial, this can be particularly challenging (Gastil, 1994).

The concept of servant leadership is based on the belief that a leader should act as a servant. It means prioritizing the needs of coworkers and supporting their personal development rather than directing the team authoritatively. Introduced by Robert K. Greenleaf (1977), a servant leader operates with humility and focuses on the growth and needs of team members. Fundamental features of this concept include the leader's modesty and lack of desire to exert power over employees, active listening to understand coworkers' needs better, and a commitment to helping others achieve their full potential rather than focusing on personal career advancement (Blanchard, 2007). It also promotes building interpersonal relationships and fostering an atmosphere of shared responsibility (Spears, 2010). Empathy is essential for building mutual trust and improving team communication (Spears, 1995).

In servant leadership, the leader embodies the principles and values underlying the concept. Initially, they play a visionary or strategic role, conveying the organization's mission and values and outlining general goals and directions. Once employees have the necessary knowledge, the leader's role shifts to being a servant, and the organizational hierarchy transforms. Employees then take responsibility for meeting customer expectations, while the leader responds to their needs (Wliziło, 2021). In project work, adopting servant leadership facilitates greater team autonomy, effective communication, and team development through the personal growth of its members (Blanchard, 2007).

Although previously described as a classical management style due to its innovativeness at the time of inception, situational leadership remains relevant and widely used still today. It is based on flexibility and the ability to adapt actions to specific situations. The leader adjusts their style considering the team's competence, commitment, and maturity. Typically, a directive style at the beginning gradually evolves into a delegating and supporting style (Blanchard, 2007). This approach places significant emphasis on the leader's abilities. Blanchard, Zigarmi, and Nelson (1993) reviewed situational leadership 25 years after its introduction, highlighting its effectiveness and popularity. They concluded that leaders using this concept must continually enhance their skills, especially in assessing and adapting to team needs. Essential leader competencies include flexibility, accurate assessment of employees' readiness and commitment levels, open and clear communication, delegation of responsibility as the team matures, and the ability to motivate employees by tailoring strategies to their needs.

While flexibility and adaptability are core to situational leadership, technological progress and globalization have added new challenges. Leaders frequently oversee global teams dispersed across various regions, requiring them to navigate time zone differences, cultural diversity, and distinct communication styles. This scenario demands exceptional flexibility and the ability to manage diversity effectively (Northouse, 2016). In project management, situational leadership is highly effective because it allows leaders to adjust their approach to both tasks and team members in a flexible manner. This style is particularly advantageous in dynamic projects where requirements, goals, or external factors may change during the project's lifecycle (Northouse, 2016). Additionally, agile project management methodologies

incorporate many values from situational leadership. Similarities can be observed between the approaches of Scrum Masters and situational leaders (Rubin, 2012). Many of these leadership styles are widely used today, as they provide effective strategies for various organizational challenges. Leaders often combine elements from different styles to tailor their approach to their team's specific needs.

As Bwalya (2023) described, leadership style plays a significant role in shaping the success and effectiveness of a leader in various organizational contexts. As highlighted in recent literature, there is no universal or optimal leadership style suitable for all situations. Instead, effective leadership is highly dependent on the leader's ability to assess the context and adapt accordingly. Each style has distinct strengths, limitations, and practical implications. A deeper understanding of these elements enables leaders to maximize their impact by aligning their behaviors and strategies with team needs and organizational goals. According to Bwalya (2023), leadership style embodies a leader's values, attitudes, and behaviors and strongly influences team motivation, communication patterns, and workplace culture. Leaders must consciously select and adapt their styles to enhance team dynamics, productivity, and long-term performance. The ability to do so not only promote trust and engagement but also fosters a resilient and adaptive organizational climate.

Employee engagement has become a critical factor for organizational success, as it directly influences productivity, commitment, and workplace culture. According to Shrivastava and Mathur (2025), there is a clear and significant relationship between leadership style and employee engagement. Leaders who adopt a relationship-oriented approach—showing care, support, and commitment to employee development - positively influence engagement levels. Furthermore, a collaborative work environment, where coworkers are perceived as allies rather than competitors, reinforces this effect. Clear and reasonable job expectations also contribute to higher engagement by reducing ambiguity and stress.

4. Leadership styles and research methodology

The authors conducted their own survey-based research using a questionnaire. A quantitative method was chosen, which allows for the collection of a large amount of data and the conduction of statistical analysis.

The research tool is a questionnaire constructed using Google Forms, which was distributed to respondents working in project teams. The survey was completed by 100 individuals: 50 women, 46 men, and 4 individuals who preferred not to disclose their gender. The respondents represented various industries including IT and technology, public sector and administration, and marketing and advertising. The questionnaire began with questions on socio-demographic characteristics (gender, age, working status and country). The questionnaire

consists of 16 closed questions with two or three answers. The format of the questions and answers in the questionnaire was designed to be as accessible as possible for the respondents. Below is a template of the questionnaire with questions and possible answers.

The aim of this study is to understand the impact of different leadership styles on the effectiveness of project teams. To answer the research question, a quantitative approach was employed, based on questionnaires distributed to professionals working in project teams across various industries. The collected data were analyzed using statistical techniques to identify correlations between leadership styles and project efficiency metrics.

One of the main limitations of the study is the subjectivity of the responses obtained from the participants. When evaluating leadership styles, respondents may be influenced by personal preferences or professional experiences, which could affect the results of the study. Additionally, the study, relying solely on questionnaires, may not capture the full range of variables influencing project effectiveness, such as resources, organizational structure, or industry context. Due to the cross-sectional nature of the study, its results may not reflect the long-term impact of leadership styles on project outcomes, nor account for changes occurring in project teams over time.

The survey data were analyzed using statistical and correlation methods. After data collection, results were visualized using bar charts and pie charts to highlight key trends and distributions. Bar charts were employed to compare specific variables across different categories, while pie charts illustrated proportional relationships within the datasets. Additionally, stacked bar charts, grouped bar charts, and ring charts were utilized for more detailed visual representations. The data from one section of the survey were organized into tables, with all visualizations and calculations performed in Microsoft Excel.

Statistical analysis focused on calculating percentile distributions for all responses. Mean and median values were computed for certain datasets to rank evaluated elements from best to worst. Responses were scored using a scale where "1" represented the most favorable answer, "0.5" was neutral, and "0" was the least favorable. These statistical metrics provided a comprehensive understanding of central tendencies and patterns in the data.

In the correlation analysis, the relationship between constructive feedback from leaders and achieving project goals was examined using Spearman's rank correlation. Constructive feedback from leaders was treated as the independent variable, coded as "Yes" = 1, "Varies" = 0.5, and "No" = 0. Achieving project goals was the dependent variable, coded as "Yes" = 1 and "No" = 0. With a sample size of 100 respondents, the analysis determined the strength and direction of the relationship between these variables. Spearman's method was chosen due to the ordinal nature of the data. The significance of the correlation was also tested to verify statistical reliability, ensuring a robust interpretation of the results. All calculations were conducted using Microsoft Excel, enabling clear comparisons and identifying patterns within the observed relationships.

4.1. Findings

A collective summary of the research results for all 100 respondents, in accordance with the 16 questions in the survey, is presented in Figures 1 to 9.

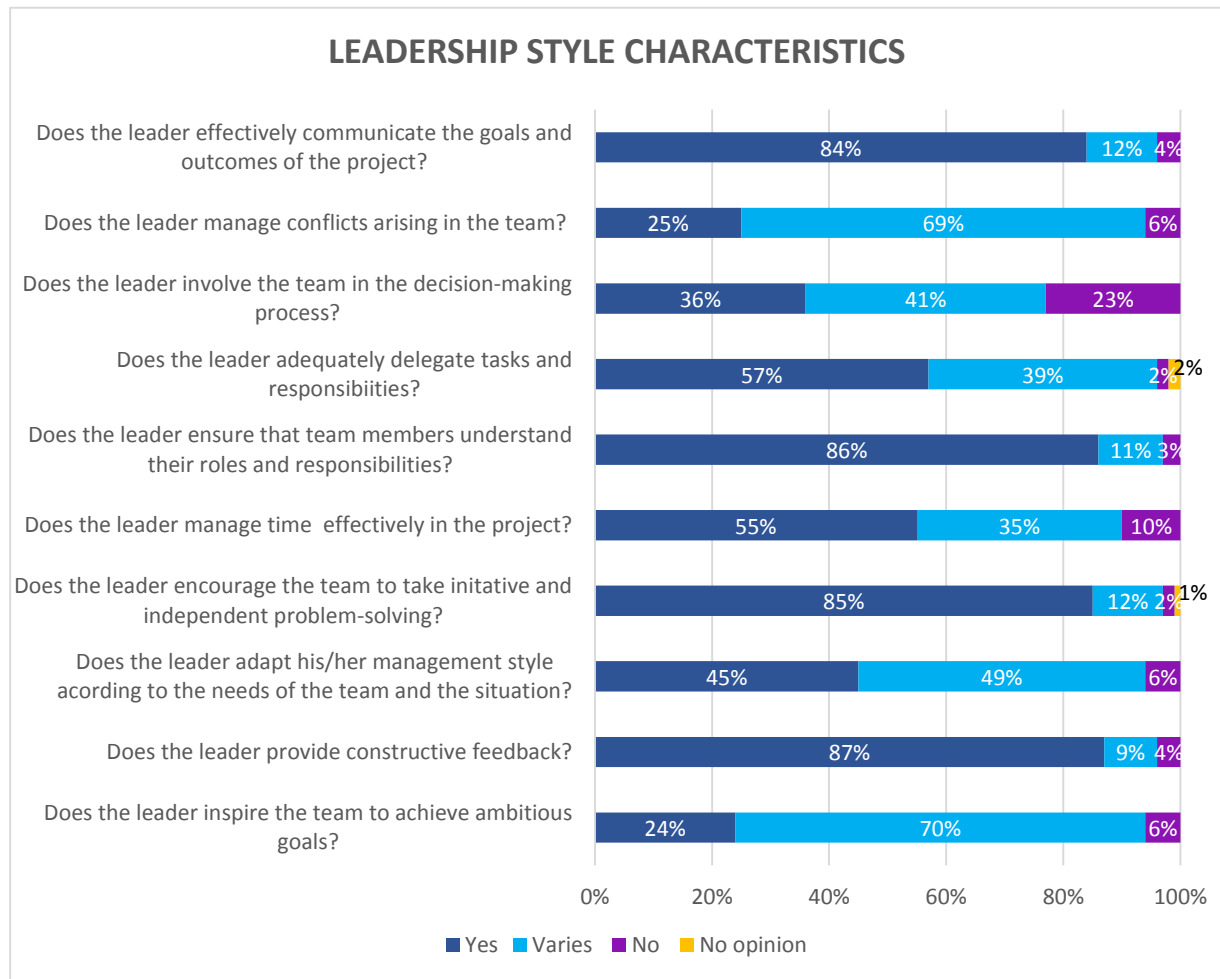


Figure 1. Answers from Project Team Members of enterprises from different sectors to questions 1-10 of the research survey.

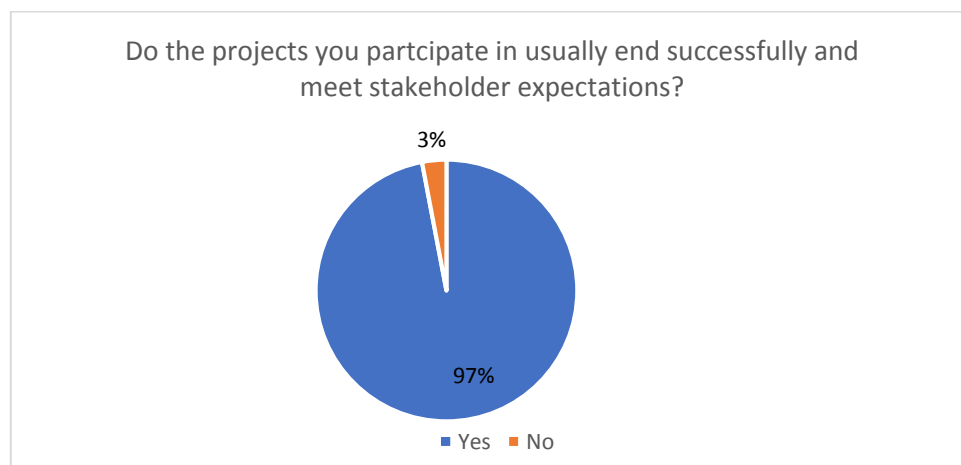


Figure 2. Answers from Project Team Members of enterprises from different sectors to question 11 of the research survey.

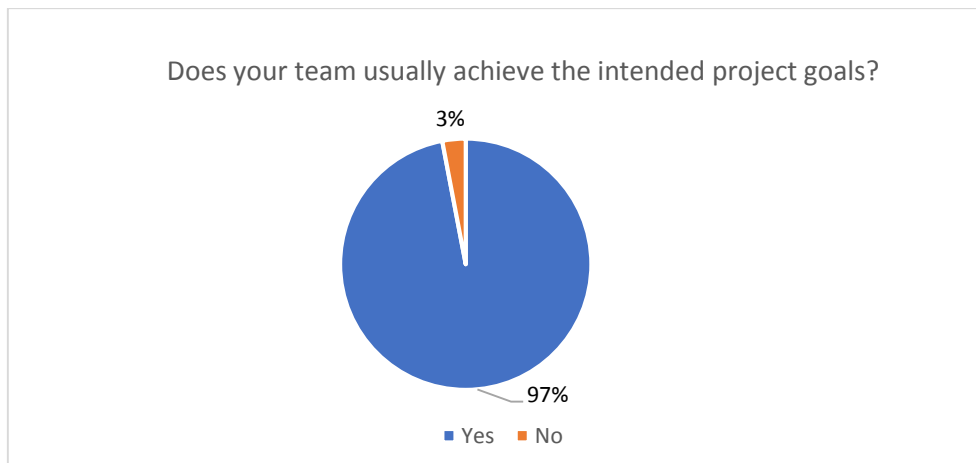


Figure 3. Answers from Project Team Members of enterprises from different sectors to question 12 of the research survey.

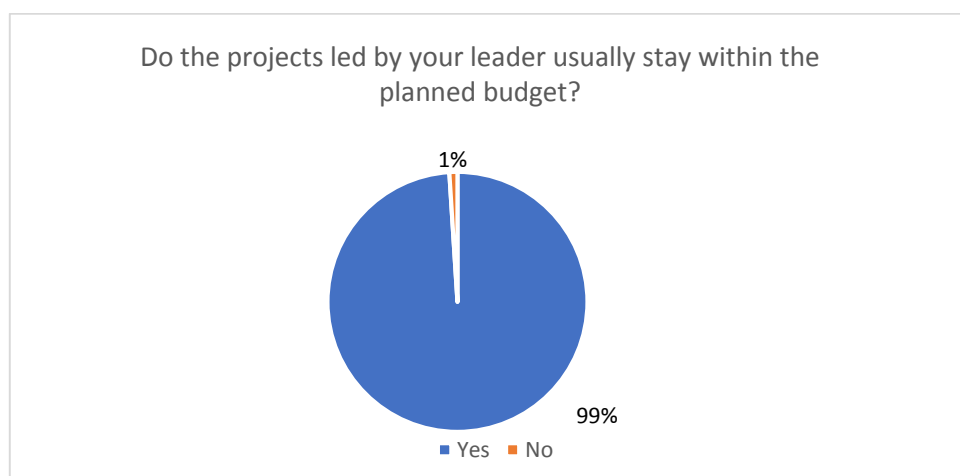


Figure 4. Answers from Project Team Members of enterprises from different sectors to question 13 of the research survey.

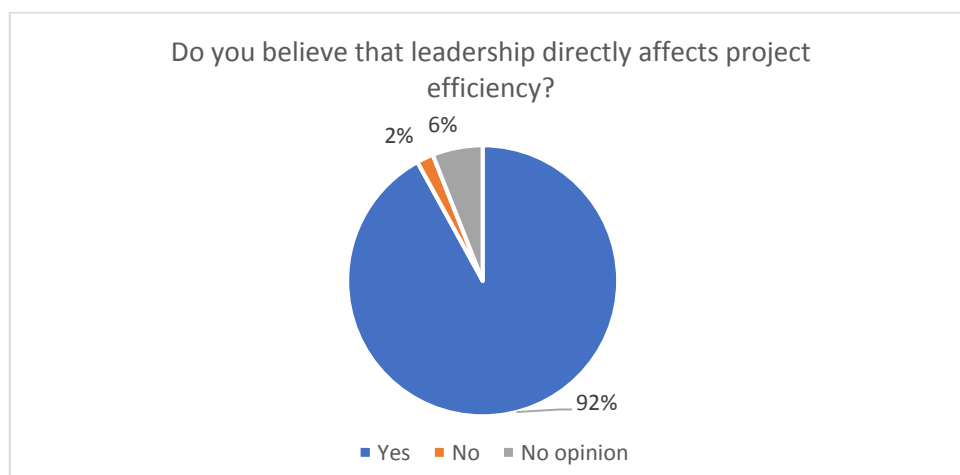


Figure 5. Answers from Project Team Members of enterprises from different sectors to question 14 of the research survey.

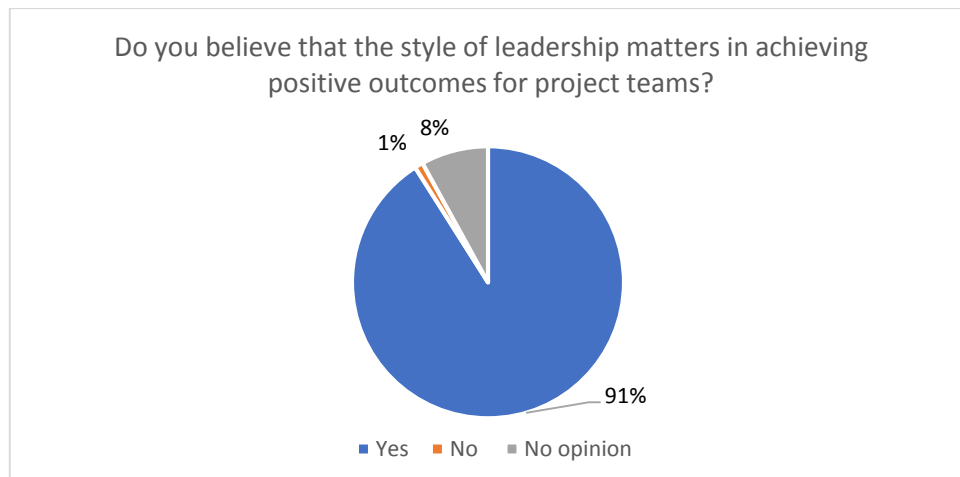


Figure 6. Answers from Project Team Members of enterprises from different sectors to question 15 of the research survey.

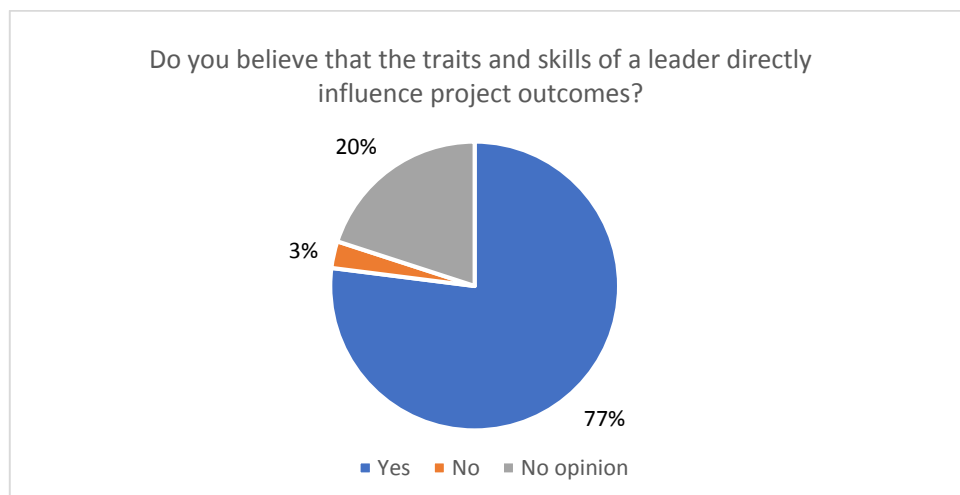


Figure 7. Answers from Project Team Members of enterprises of different sectors to question 16 of the research survey.

Data from 100 respondents indicate that leadership behaviors such as providing constructive feedback, clearly defining roles, encouraging independent problem-solving, and effectively communicating project goals significantly contribute to project success. The statistical analysis identified constructive feedback as the most strongly correlated factor with achieving project objectives. However, the study also revealed areas needing improvement, particularly in time management, conflict resolution, and engaging team members in decision-making processes. Given the limited sample size, further research with broader demographic and industry diversity is recommended to enhance the generalizability of these findings.

4.2. Analysis of research results

The first part of the questions focused on the leadership style of the leader. The questions addressed specific leader actions characteristic of selected leadership styles. The statistical analysis in this case includes the percentage distribution of responses as well as the calculation

of means and medians. The means and medians were calculated based on the assumption that the response "Yes" = 1, the response "Varies" = 0.5, and "No" = 0.

To the question, "Does the leader effectively communicate the goals and outcomes of the project?", the majority of respondents (84%) answered "Yes". 12% of respondents chose the answer "Varies", while the remaining 4% selected "No". The mean was 0.900, and the median was 1.0.

For the question, "Does the leader manage conflicts arising in the team?", 25% of respondents answered "Yes". Most respondents (69%) chose "Varies", and the remaining 6% indicated "No". The mean was 0.595, and the median was 0.5.

The responses to the question, "Does the leader involve the team in the decision-making process?", were as follows: 36% of respondents answered "Yes", 41% chose "Varies", and the remaining 23% selected "No". The mean was 0.565, and the median was 0.5.

To the question, "Does the leader adequately delegate tasks and responsibilities?", 57% of respondents answered "Yes". 39% of respondents selected "Varies", 2% chose "No", and 2% of respondents did not answer this question. The mean was 0.781, and the median was 1.0.

The majority of respondents (86%) answered affirmatively to the question, "Does the leader ensure that team members understand their roles and responsibilities?" 11% of respondents chose "Varies," and 3% selected "No". The mean was 0.915, and the median was 1.0.

To the question, "Does the leader effectively manage time in the project?", 55% of respondents answered "Yes". 35% of respondents stated that the leader manages time "Varies", and the remaining 10% indicated that the leader "No" does not manage time effectively. The mean was 0.725, and the median was 1.0.

To the question, "Does the leader encourage the team to take initiative and solve problems independently?", the majority of respondents (85%) answered "Yes". 12% of respondents selected "Varies", while 2% chose "No". 1% of respondents did not answer this question. The mean was 0.919, and the median was 1.0.

The responses to the question, "Does the leader adapt their management style depending on the team's needs and situation?", were as follows: 45% of respondents answered "Yes", 49% chose "Varies", and 6% indicated "No". The mean was 0.695, and the median was 0.5.

In response to the question, "Does the leader provide constructive feedback?", 87% of respondents answered "Yes," 9% selected "Varies," and 4% chose "No." The mean was 0.915, and the median was 1.0.

To the question, "Does the leader inspire the team to achieve ambitious goals?", only 24% of respondents answered affirmatively. The majority of respondents (70%) chose "Varies", and 6% selected "No". The mean was 0.590, and the median was 0.5.

In summary, in this part of the survey, respondents most frequently selected "Yes" when asked about:

- providing constructive feedback by the leader (87%),
- ensuring that all team members understand their roles and responsibilities (86%),
- encouraging initiative and independent problem-solving (85%),
- effectively communicating the goals and priorities of the project (84%).

The answer "Varies" was most often chosen when the question concerned:

- inspiring the team to achieve ambitious goals (70%),
- managing conflicts by the leader (69%).

The highest number of "No" responses was given to the question about whether the leader involves the team in decision-making (23%).

An in-depth analysis, including the calculation of means and medians for the obtained responses based on the previously described assumptions, allowed for ranking various leadership elements according to respondents' evaluations. The results are as follows:

- Encouraging the team to take initiative in independently solving problems (mean: 0.919, median: 1),
- Providing constructive feedback (mean: 0.915, median: 1),
- Ensuring that team members understand their roles and responsibilities (mean: 0.915, median: 1),
- Effectively communicating project goals and priorities (mean: 0.900, median: 1),
- Adequately delegating tasks and responsibilities (mean: 0.781, median: 1),
- Effectively managing time (mean: 0.725, median: 1),
- Adapting management to the team's and project's needs (mean: 0.695, median: 0.5),
- Managing conflicts within the team (mean: 0.595, median: 0.5),
- Inspiring the team to achieve ambitious goals (mean: 0.590, median: 0.5),
- Involving the team in decision-making (mean: 0.565, median: 0.5).

Figure 8 presents the means and medians calculated for the questions included in the first section of the study.

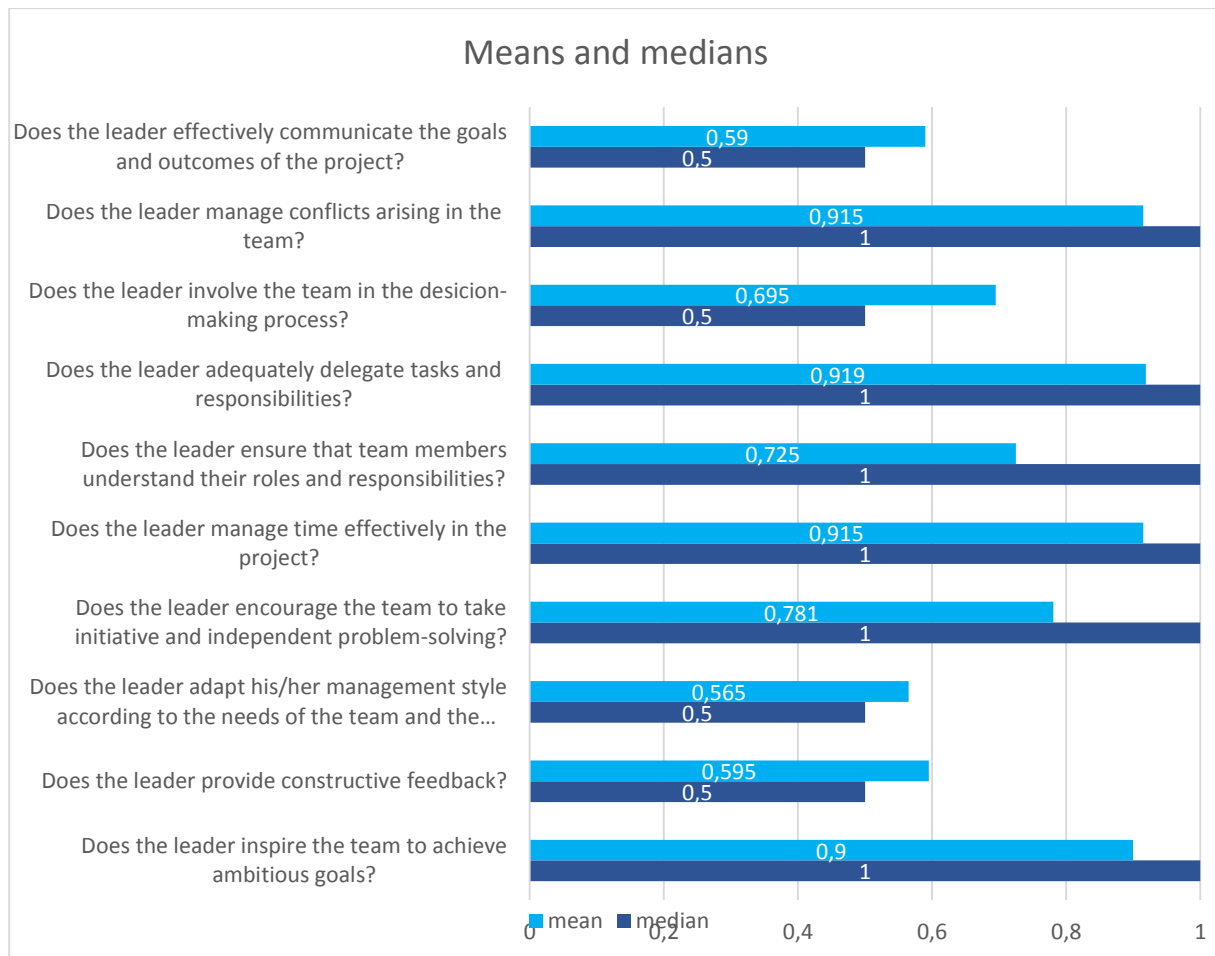


Figure 8. Presents the means and medians calculated for the questions included in the first section of the study.

For question 11 "Do the projects you participate in usually end successfully and meet stakeholder expectations?", the vast majority of respondents (97%) answered "Yes", while only 3% responded "No". Identical results were obtained for question 12, "Does your team usually achieve the intended project goals?" 97% of respondents answered "Yes", and 3% answered "No". For question 13, "Do projects led by your leader usually stay within the planned budget?" as many as 99% of respondents answered "Yes", with the remaining 1% responding "No". In summary, the response patterns for these three questions were quite similar.

For question 14, the vast majority of respondents, as many as 92%, answered "Yes". 2% of respondents selected "No", while the remaining 6% chose "No opinion". Similarly, for question 15, the majority of respondents (91%) answered "Yes". 1% of respondents answered "No". and 8% selected "No opinion". For the final question, the response structure was not as uniform as in the previous two questions. 77% of respondents answered "Yes", 3% responded "No", and 20% chose "No opinion".

The Spearman rank correlation analysis was conducted to examine the relationship between leaders providing constructive feedback and teams achieving their project goals. The analysis used survey responses to the questions, "Does your leader provide constructive feedback?" and "Does your team usually achieve its intended project goals?".

The results yielded a Spearman correlation coefficient (ρ) of 0.286, indicating a weak positive correlation. This suggests that teams with leaders who provide constructive feedback are more likely to achieve their project goals. To assess the statistical significance of this correlation, a significance test for the Spearman coefficient was performed. The resulting p-value was 0.004, which is less than the 0.05 threshold for significance.

This indicates that the correlation is statistically significant at the 5% level, meaning the relationship between the variables is unlikely to be random and can be considered reliable.

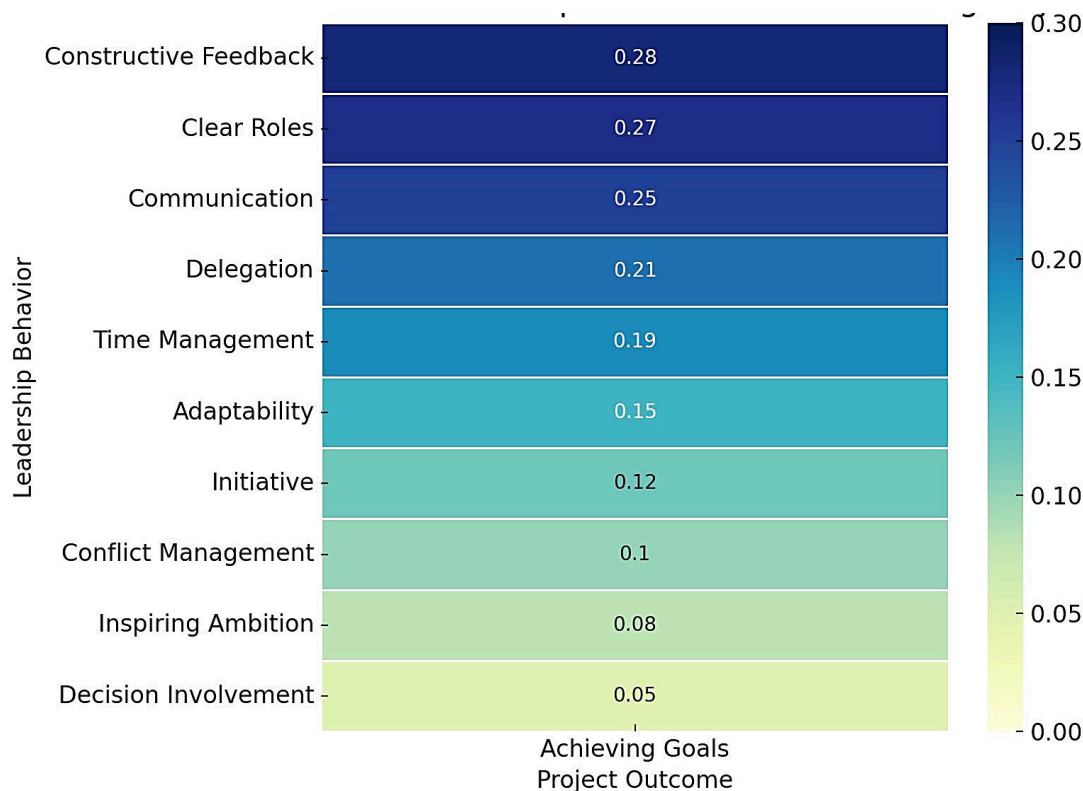


Figure 9. Presents the Correlation Between Leadership Behaviors and Achieving Project Goals.

This graph visualizes the strength of correlation between selected leadership behaviors and the likelihood of achieving project goals, based on survey responses from project team members. The values displayed represent Spearman correlation coefficients, where values closer to 1 indicate a stronger positive relationship.

Strongest Positive Correlations:

- Providing Constructive Feedback ($\rho = 0.28$): This behavior shows the highest correlation with project success, confirming that teams with leaders who offer regular, constructive input are more likely to reach project goals.
- Clearly Defining Roles ($\rho = 0.27$) and Effectively Communicating Goals ($\rho = 0.25$) also demonstrate strong links to performance, emphasizing the importance of clarity and direction in leadership.

Moderate Correlations:

- Delegating Responsibilities ($\rho = 0.21$) and Time Management ($\rho = 0.19$) indicate that operational efficiency contributes meaningfully to outcomes but may be less impactful than interpersonal leadership behaviors.
- Adaptability ($\rho = 0.15$) and Encouraging Initiative ($\rho = 0.12$) suggest that flexible and empowering leadership has moderate value in driving success.

Weaker Correlations:

- Conflict Management ($\rho = 0.10$) and Inspiring Ambitious Goals ($\rho = 0.08$) showed lower correlation levels, possibly due to varied individual perceptions or inconsistent application.
- Involving Team in Decision-Making ($\rho = 0.05$) was the weakest, which could suggest that while democratic leadership is valued, it might not directly translate into measurable performance outcomes in the short term.

The results suggest that clarity, communication, and feedback are the most impactful leadership behaviors in project settings. While inspiration and participation are important, their direct correlation with project success appears less immediate or more context-dependent. Leaders aiming to improve team performance should prioritize feedback, structured communication, and clear role definition.

5. Conclusions

The findings of this study confirm that leadership has a significant impact on project success, particularly through clear communication, constructive feedback, and role clarity. However, to further enhance project outcomes, leaders should focus on improving time management, team engagement in decision-making, and conflict resolution strategies.

The study confirmed that leadership significantly influences project efficiency, with 92% of respondents recognizing its direct impact on project outcomes. Similarly, 91% agreed that leadership style plays a vital role in achieving project success. These findings align with the conclusions drawn by Bwalya (2023), who emphasized that leadership style shapes team motivation, communication, and overall effectiveness. Likewise, Shrivastava and Mathur (2025) confirmed a strong relationship between leadership style and employee engagement, which indirectly boosts project performance.

Our research adds empirical support to these claims by identifying specific leadership behaviors that contribute most to project efficiency:

- Encouraging team initiative - leaders who motivate team members to independently solve problems were highly rated.
- Providing constructive feedback - effective feedback was strongly correlated with achieving project goals.
- Ensuring role clarity - leaders who ensure that team members understand their responsibilities achieved satisfactory project outcomes as well.
- Communicating project goals effectively - clear communication of goals and priorities emerged as a critical factor.

While leadership attributes like communication and constructive feedback were highly rated, several areas for improvement were noted such as:

- Time management.
- Engaging team members in decision process.
- Conflict management.

Compared to previous research, which focused primarily on general leadership outcomes, our study provides a more project-specific perspective. It bridges the gap between abstract leadership theory and concrete project management practices by offering measurable insights into behaviors that drive efficiency.

This study had several limitations. The sample was limited to 100 respondents and did not assess self-perceived leadership styles, which would provide more nuanced insights. Future studies should explore:

- Broader, cross-industry samples including varied cultural and organizational settings.
- Longitudinal research to measure the impact of leadership behaviors on project success over time.

The findings of this study confirm that leadership has a significant impact on project success, particularly through clear communication, constructive feedback, and role clarity. However, to further enhance project outcomes, leaders should focus on improving time management, team engagement in decision-making, and conflict resolution strategies. The following practical implications would be recommended:

- Develop structured training programs focused on constructive feedback, communication, and conflict management.
- Promote leadership flexibility by introducing models such as situational leadership, which proved effective in varying project contexts.
- Encourage participative practices to involve team members in decision-making, which fosters engagement and ownership.
- Implement tools for leadership self-assessment, allowing leaders to identify their dominant style and their alignment with team needs.

In conclusion, our study contributes to the growing body of knowledge on leadership in project environments by offering both empirical validation and practical guidance. Effective leadership - defined by communication as well clarity - remains a cornerstone of project success. However, addressing identified weaknesses and pursuing further research will be essential to equip future leaders with the tools necessary for navigating increasingly complex project landscapes.

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"SILENT SELLER" IN BUSINESS PRACTICE: PRELIMINARY RESEARCH RESULTS BASED ON THE FMCG INDUSTRY

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Purpose: Based on preliminary empirical research results, the study examined the assumption that a typical customer of large-format stores in the FMCG sector is susceptible to the influence of merchandising. The conducted study, involving 97 respondents and 3 industry leaders, aimed to define the specifics of merchandising activities in the context of improving the shopping process for the average consumer.

Design/methodology/approach: Two research tools were used in the study: a survey questionnaire and an interview questionnaire. The survey was directed at customers of all age groups who use large-format stores specializing in the FMCG sector across Poland. Meanwhile, the interviews were conducted with employees of a company operating within the FMCG sector.

Findings: The findings indicate that customers of large-format FMCG stores are aware of the impact of merchandising and can accurately define their needs and expectations regarding these retail outlets.

Research limitations/implications: Due to the small sample size and its specific nature, as well as the scope of the conducted analyses, the obtained results should not be regarded as definitive and conclusive. Future research should focus on a more in-depth and extensive exploration of this issue.

Practical implications: The practical objective of this study is to identify which specific merchandising activities in the FMCG sector most effectively influence consumers.

Originality/value: This research contributes to a deeper understanding of the essence of commercial merchandising in the FMCG sector. The publication is intended primarily for researchers but is also relevant to entrepreneurs, managers, and marketing professionals. The data presented may be useful both in academic contexts and in business practice.

Keywords: "Silent Seller", merchandising, FMCG industry.

Category of the paper: Research paper.

1. Introduction

Merchandising in Poland has undergone a significant evolution, transitioning from the era of a centrally planned economy - characterized by poorly equipped stores and a limited selection - to the present-day ubiquity of merchandising techniques, introduced with the arrival of large international retail chains after the political and economic transformation. Despite increasing consumer awareness of these practices, merchandising continues to spark discussions, often being mistakenly perceived as manipulation, whereas, in reality, it aims to enhance the shopping experience. This dynamic transformation and the growing complexity of the market have led to the increasing importance of merchandising in both research and business practice in recent years. It has become a subject of numerous academic discussions, as reflected in the rising number of publications in national and international scientific journals (e.g. Matysik-Pejas, Pakosz, 2013; Ha-Brookshire, 2015; Werenowska, 2015; Batko, 2021; Karabıyık, Elgün, 2021; Barreleta et al., 2023; Stoica, 2023). It is also a real challenge faced by managers in organizational practice. From the author's perspective, the issue of merchandising is particularly relevant to the FMCG (fast-moving consumer goods) industry. The modern FMCG market is characterized by intense competition, making effective merchandising management in retail outlets extremely demanding and complex. A particular challenge arises from the abundance of product substitutes and the fact that many customers make their final brand selection decision only at the point of sale. For this reason, well-thought-out merchandising strategies are crucial for stimulating sales and ensuring customer satisfaction by enabling them to quickly and conveniently find the products they are looking for. However, despite the growing conviction among professionals about the critical role of merchandising in contemporary organizations, there are still many aspects that warrant further investigation. This study aims to fill the gap in strategic awareness regarding the role of merchandising and the importance of developing an effective sales policy in this sector. A thorough analysis of research findings will provide a better understanding of the essence of merchandising in large-format FMCG stores and its most effective aspects in influencing customer behavior.

2. Merchandising in the Context of Definitional Dilemmas

In Poland, the first mentions of merchandising appeared in the early 1990s. At that time, the main challenge was the low awareness of the term's meaning. There was no clear definition, and merchandisers struggled to precisely define their role. A decade later, the situation changed significantly. Manufacturers and retail chain managers began to recognize the importance of promotional activities at the point of sale. Additionally, dynamic market changes, such as

a 50% increase in the number of supermarkets and a threefold rise in hypermarkets between 2000 and 2004, contributed to the development of merchandising. Small stores of less than 100 m² were gradually pushed out of the market, and more than 66% of Polish consumers started shopping in hypermarkets or large shopping centers (Buczyk, Kliniewicz, 2024), further accelerating the industry's growth. Although customers' shopping preferences have evolved over the years, recent survey data commissioned by Cushman & Wakefield indicate a shift in consumer habits. Currently, 66% of Poles prefer small, local stores close to home primarily for convenience, while 62% choose discount stores for larger grocery purchases exceeding PLN 100 (Cushman, Wakefield, 2024). Despite these changing preferences, merchandising activities continue to gain significance.

The term "merchandising" has no direct equivalent in Polish. In Poland, the original English term is commonly used, although it can be translated as "goods for sale" or simply "merchandise". The literal translation, "merchandising", also conveys the concept, though it is not widely adopted (Witek, 2007). The increasing recognition of merchandising's impact on a company's competitiveness and operational efficiency has led to a growing body of publications and research in this field. However, the available literature remains diverse, complex, and multidimensional, making it challenging to standardize definitions. The primary difficulty lies in defining the key term and reaching even partial agreement on its interpretation.

Merchandising is a broad and evolving concept, with definitions that have shifted alongside market developments. Nevertheless, the operationalization of the concept based on the analysis of source literature includes two main approaches (Table 1). The first approach, known as the narrow approach, focuses on the visual aspects of product display in the store, i.e., visual merchandising. The second approach, the broad one, considers merchandising as an integral part of the company's broader marketing strategy, known as primary merchandising.

Table 1.
Two Approaches to Defining Merchandising: Selected Interpretations

Author	Definition
Narrow approach	
Mills, Paul, Moorman	Visual merchandising is the presentation of a store or brand and its merchandise to customers through the collaboration of the store's advertising, display, special events, fashion coordination, and merchandising departments, with the goal of selling the goods and services offered.
Diamond, Diamond	Visual merchandising is the presentation of a store and its merchandise in a way that captures the attention of potential customers and motivates them to make a purchase.
Kotler, Armstrong	Visual merchandising is the art of designing attractive and functional in-store arrangements that draw customers' attention and encourage them to buy. A key aspect of this process is the strategic use of space, lighting, and color to create a welcoming and engaging shopping environment.

Cont. table 1.

Broad approach	
Borusiak	Merchandising encompasses all activities carried out by hypermarkets, supermarkets, and manufacturers at the point of sale to promote products and distinguish specific items from the overall assortment.
Drab	Merchandising is an integral part of retail marketing activities and a crucial element of effective product management at the point of sale.
Rojewska	Merchandising is a strategic approach to product presentation and sales, which can determine the success or failure of a commercial enterprise.

Source: own elaboration based on (Mills et al., 1995; Diamond, J. Diamond, E., 2007; Kotler, Armstrong, 2017; Borusiak, 2008; Drab, 2010; Rojewska, 2024).

A systematic literature review indicates that existing studies range from detailed analyses based on the narrow approach (e.g. Bandara, 2021; Dhillon et al., 2024; Gajewska, Piskrzynska, 2016; Gigola, 2016; Mardani, Krisnawati, 2022; Mehta, Chugan, 2012) to broader examinations of merchandising strategies (e.g. Batko, 2021; Konštiak et al., 2016; Nikolaeva, Kotov, 2023; Paramonov, Berketova, 2023; Piotrowska, 2012; Smith, 2021; Tarczydło, 2016; Wu et al., 2022).

For the purposes of this study, merchandising is defined as point-of-sale activities undertaken by retailers and manufacturers to promote and differentiate products within the overall product range.

3. Merchandising Strategies and Tools vs. Customer Experience

The general definition of a merchandising strategy is based on knowledge from retail marketing and sales management, encompassing various activities aimed at promoting products at points of sale. This definition includes key elements of merchandising, such as product presentation in stores, assortment management, pricing and promotional strategies, customer communication through packaging and labeling, and the analysis of sales data and customer behavior to optimize the strategy (Cyrek Digital, 2023). Understood in this way, a merchandising strategy is implemented both through long-term strategic plans that set the overall direction of store operations (Harvard Business Review, 2023) and through ongoing operational activities that ensure the effective execution of these plans in daily retail practice (Dawson et al., 2008).

The choice of a merchandising strategy depends on various factors related to the retail establishment, market, supplier, manufacturer, and the product itself (Rzemieniak, 2006). Based on this, different types of merchandising strategies can be identified:

- Location strategy: selecting the appropriate store location, considering customer profiles and accessibility.
- Assortment strategy: selecting the product range according to market expectations and efficiency.

- Pricing strategies: *off-price*: selling branded products at lower prices (outlets) and *trading-up*: raising product and pricing standards to create an exclusive brand image.
- Service strategies: *hard-selling*: aggressive sales tactics, persuading customers to purchase and *soft-selling*: trust-based sales, providing assistance upon customer request (Chwałek, 1992; Kotra, Pysz-Radziszewska, 2001; Rzemieniak, 2006).

Planning an effective merchandising strategy requires the use of appropriate tools. A review of the literature identifies two approaches to defining the fundamental instruments of merchandising:

- Approach 1: this includes merchandise (assortment and related services), margin (discounts, allowances, profit), technology (sales methods, equipment, location), and promotion (communication with customers and suppliers to increase demand) (Kałużna-Drewińska, Iwankiewicz-Rak, 1997).
- Approach 2: this highlights uniform staff attire, appropriate lighting, sales promotions, proper product display, promotional campaigns, store environment design, staff training, and POS materials (Witek, 2007).

For the purposes of this study, given its empirical nature and focus on examining the impact of merchandising on customers of large-format stores in the FMCG sector, the analysis of merchandising instruments will be conducted based on Approach 2.

Well-thought-out merchandising strategies can attract customers' attention, encourage them to make a purchase, and directly increase sales by stimulating their senses through various experiences:

- Visual - including store color schemes, product shapes and sizes, and color intensity.
- Auditory - related to music, its tempo, and type.
- Olfactory - utilizing different scents and their intensity.
- Gustatory - referring to the taste experiences offered.
- Tactile - linked to the subtlety of textures and the temperature within the store (Witek, 2007).

In summary, well-developed and systematically implemented merchandising plans, combined with appropriately selected instruments, directly influence customers' perception of the store by stimulating their sensory perception and motivating them to make purchases. As a result, conscious management of merchandising activities is fundamental to increasing sales, strengthening customer relationships, and achieving a competitive advantage in the market.

In the following sections of this study, selected theoretical issues presented in sections 2 and 3 will be compared with the results of the conducted empirical research. This will allow for the practical application of key concepts, such as the understanding of merchandising, the identification of merchandising strategies and instruments, as well as sensory impressions, and an assessment of their role in the business realities of the FMCG sector.

4. Presentation of Survey Results

4.1. Survey Methodology

Merchandising plays a fundamental role in sales activation, especially in the competitive FMCG industry. It influences customers on multiple levels, from conscious perception of product displays to subconscious reactions to visual, auditory, and other stimuli. It is a dynamic and evolving tool aimed at increasing profits for retailers and manufacturers while also facilitating the shopping process for customers. The significance of this issue, stemming from the outlined problem, formed the basis for defining the research objectives: cognitive and practical. The cognitive objective focused on the theory and identification of merchandising elements, while the practical objective aimed to apply this knowledge to determine the most effective merchandising strategies influencing consumer purchasing decisions.

To capture the specificity of the issue and achieve the research objectives, a main hypothesis was formulated, assuming that the average customer of large-format FMCG stores is susceptible to merchandising techniques. Additionally, three specific hypotheses were proposed: H1: Customer susceptibility to merchandising techniques occurs at a subconscious level; H2: The key merchandising instruments effectively influencing customer purchasing decisions are proper product placement on shelves and the competence of store personnel; H3: The strongest influence on large-format store customers comes from visual and auditory stimuli.

Achieving these objectives and verifying the hypotheses paved the way for both cognitive and practical insights in the study. To explore this topic further, independent research was conducted in collaboration with Jakub Pękała (Pękała, Dudzik-Lewicka, 2022). The research was carried out using a methodology based on primary research, incorporating both quantitative and qualitative methods. Quantitative research was conducted through an online survey, which was distributed electronically and shared in online groups, ensuring nationwide reach. The research sample was selected non-randomly, and 97 completed questionnaires were obtained.

4.2. Characteristics of Respondents

The complete profile of the respondents, developed based on the survey's demographic criteria such as gender, age, education, and place of residence, is presented in Table 2.

Tabela 2.
Characteristics of The Surveyed Respondents

Synthetic criterion	Elementary criterion	Wyniki % ogółem
Gender	Woman	55,7%
	Male	44,3%

Cont. table 2.

Age	do 25	44,3%
	25-40	12,4%
	40-60	35,1%
	Powyżej 60	8,2%
Education	Basic	0%
	Professional	1,0%
	Medium	63,9%
	Higher	35,1%
Place of residence	Village	42,3%
	City with up to 20,000 inhabitants	27,8%
	City with 20,000 to 50,000 inhabitants	12,4%
	City with 50,000 to 200,000 inhabitants	0%
	City with 200,000 to 500,000 inhabitants	0%
	City with more than 500,000 inhabitants	0%

Source: own graphic design based on (Pękała, Dudzik-Lewicka, 2022).

Summarizing the characteristics of the respondents participating in the survey, the sample consisted of 97 individuals with a diverse demographic profile in terms of gender, age, education, and place of residence. This diversity provides insight into the opinions of a broad spectrum of customers of large-format stores in the FMCG sector.

4.3. Selected Results of the Quantitative Survey

In response to the multiple-choice question regarding the most frequent grocery shopping locations, discount stores were indicated by the largest group of respondents, accounting for nearly two-thirds of the total (64,9%, $n = 63$). Slightly fewer participants (62,9%, $n = 61$) selected hypermarkets as their preferred shopping destination. Proximity supermarkets were popular among one-quarter of respondents (23,7%, $n = 23$). Meanwhile, fewer than 20% of surveyed individuals chose supermarkets (16,5%, $n = 16$) or convenience stores (14,4%, $n = 14$) as their most frequent grocery shopping locations.

An analysis of responses to the question about the most important factors influencing the choice of a grocery store, conducted using a one-way chi-square test, revealed that the distribution of responses significantly differed from a random pattern [χ^2 (4, $N = 97$) = 65,01; $p < 0.001$]. The most frequently indicated criterion was a wide product assortment ($n = 41$; 42.3% of respondents). Low prices were a key factor for one-third of participants (35.1%, $n = 34$). A good location was important to fewer than one in five respondents (17.5%, $n = 17$). Meanwhile, the options "shopping convenience and intuitiveness" (4.1%, $n = 4$) and "all of the above" (1.0%, $n = 1$) were chosen only sporadically.

An analysis of responses to the question regarding the familiarity with the term "merchandising" among customers of large-format grocery stores revealed that the frequency of responses significantly deviated from a random distribution [χ^2 (1, $N = 97$) = 54,94; $p < 0.001$]. The majority of respondents (87,6%, $n = 85$) confirmed that they had heard of the strategies employed by stores to influence customers' purchasing decisions, referred to as merchandising. Only a small percentage of respondents, accounting for 12,4% ($n = 12$), stated that they were unfamiliar with this term.

Further analyzing the respondents' answers, a chi-square test was conducted to determine which of the provided definitions of merchandising was considered the most accurate. The test results [χ^2 (3, N = 97) = 54,55; $p < 0.001$] showed statistically significant deviations from a random distribution of responses, suggesting clear preferences among participants. The most frequently chosen option, selected by more than half of the respondents (56,7%, $n = 55$), was "activities carried out by stores and manufacturers". Less frequently chosen definitions included: "a struggle between manufacturers" (19,6%, $n = 19$), "influencing the customer" (15,5%, $n = 15$), and "an inseparable element of marketing activities" (8,2%, $n = 8$).

An analysis of responses regarding the awareness of merchandising practices used by stores also revealed a clear trend [χ^2 (1, N = 97) = 67,64; $p < 0.001$]. The vast majority of respondents - nine out of ten (91,8%, $n = 89$) - confirmed that they were aware of such practices being employed by stores. Only a small group, representing one in ten individuals (8,2%, $n = 8$), was unaware of this.

After examining respondents' awareness and definitions of merchandising, the next analysis focused on their opinions regarding the role merchandising plays in grocery stores. A chi-square test clearly showed that the distribution of responses significantly deviated from randomness [χ^2 (4, N = 97) = 89.96; $p < 0.001$], indicating diverse opinions on this issue. The most frequently identified role of merchandising was directly stimulating a company's sales (46,4%, $n = 45$). A significant group of respondents also recognized its function in influencing customer behavior during the shopping process (40,2%, $n = 39$). Less frequently mentioned roles included controlling a company's economic results (8,2%, $n = 8$) and "shaping an appropriate approach to the customer" (4,1%, $n = 4$). One person stated that they had no knowledge of the topic (1, 0%, $n = 1$).

The next step in the study was to examine the merchandising strategies used by grocery stores. To achieve this, respondents were asked which of the presented strategies they believed positively influenced their choice of a specific store and which did not. The analysis, conducted using a two-variable chi-square test, revealed statistically significant differences in the evaluation of strategies [χ^2 (5, N = 97) = 305,49; $p < 0.001$], as detailed in Table 3.

Table 3.

Strategies Positively Influencing Customers' Store Choice (n = 97)

	Yes		No	
	N	%	N	%
Store staff providing assistance in product selection only upon the explicit request of the customer	83	85,6%	14	14,4%
Store staff interfering with customers' purchasing decisions	4	4,1%	93	95,9%
A sense of luxury immediately upon entering the store and a wide range of additional services	59	60,8%	38	39,2%
Low prices and a maximized level of self-service	89	91,8%	8	8,2%
Access to all necessary products	92	94,8%	5	5,2%
Convenient store location	92	94,8%	5	5,2%

Source: (Pękała, Dudzik-Lewicka, 2022).

The analysis of respondents' answers revealed which merchandising strategies are perceived positively and which negatively in terms of grocery store selection. The positively rated merchandising strategies include:

- Assistance from store staff, but only upon the explicit request of the customer – as many as 85,6% of respondents considered this strategy to have a positive impact on their store choice.
- Offering low prices and ensuring a high level of self-service – 91,8% of respondents identified this strategy as positive.
- Providing access to all necessary products, which received a 94,8% positive rating from respondents.
- Convenient store location, also positively rated by 94,8% of respondents.
- Creating a sense of luxury at the store entrance and offering a wide range of additional services, which 60,8% of respondents viewed positively.

The only strategy that was negatively rated by the vast majority of respondents (95,9%) was store staff interfering with customers' purchasing decisions.

Continuing the analysis of the impact of merchandising on customers, the next stage compared respondents' answers regarding which of the listed merchandising instruments they considered the most important during the shopping process. To identify any statistically significant differences in the importance of individual instruments, the Friedman rank ANOVA test was applied (Table 4).

Table 4.

Which of the Following Instruments Do You Consider Most Important During the Purchasing Process?

	Group	Mdn	Mrang
I	Spotlighting on products	0	3,95
II	Promotions	1	5,84
III	Product placement on shelves	0	4,50
IV	Seasonal promotional campaigns	0	4,48
V	Pleasant store atmosphere	0	4,98
VI	Competent store staff	1	5,27
VII	In-store informational materials (POS)	0	3,30
VIII	Impulse purchases	0	3,68
$\chi^2(7)$	110,26**		
p	< 0,001		
Post-hoc	I < II; I < VI; III < II; IV < II; VII < II; VII < III; VII < IV; VII < V; VII < VI; VIII < II; VIII < V; VIII < VI;		

Source: (Pękała, Dudzik-Lewicka, 2022).

A statistical analysis of the respondents' answers revealed significant differences in the perception of the importance of various merchandising instruments during shopping [$\chi^2(7) = 110,26$; $p < 0.001$]. The study results indicate that spotlighting products is considered less important in the shopping process compared to promotions and competent store staff. Similarly, product placement on shelves was perceived as less significant than available

promotions. It was also found that seasonal promotional campaigns are regarded as less important than regular promotions. Moreover, in-store informational materials (POS) were deemed by respondents to play a smaller role than promotions, product placement, seasonal promotions, a pleasant store atmosphere, and staff professionalism. Additionally, the study revealed that impulse purchases hold less significance than promotions, positive shopping experiences related to store ambiance, and staff competence (Table 5).

Table 5.

Descriptive Statistics of the Importance of Individual Instruments in the Purchasing Process (n = 97)

	R	M	SD	Mdn	Sk	Kurt	W
Spotlighting on products	0-3	0,48	1,02	0	1,84	1,70	0,51**
Promotions	0-3	1,12	0,83	1	0,98	0,78	0,75**
Product placement on shelves	0-3	0,78	1,18	0	1,01	-0,74	0,65**
Seasonal promotional campaigns	0-3	0,76	1,15	0	1,02	-0,68	0,65**
Pleasant store atmosphere	0-3	1,00	1,17	0	0,55	-1,34	0,75**
Competent store staff	0-3	1,13	1,18	1	0,36	-1,47	0,79**
In-store informational materials (POS)	0-3	0,14	0,63	0	4,24	16,59	0,23**
Impulse purchases	0-3	0,33	0,88	0	2,54	4,94	0,41**

* $p < 0.05$; ** $p < 0.01$.

Source: (Pękała, Dudzik-Lewicka, 2022).

The next part of the analysis focused on assessing which sensory experiences have the greatest impact on customers when making purchasing decisions. To this end, the Friedman test was applied, and its result proved to be statistically significant [$\chi^2(9) = 168,14$; $p < 0.001$], indicating a varying effectiveness of different sensory stimuli (Table 6).

Table 6.

Which Sensations Most Effectively Influence You When Making Purchasing Decisions?

	Group	Mdn	Mrang
I	store color scheme	0	5,79
II	shapes and sizes in the store (e.g., decorations)	0	4,68
III	color intensity	0	5,02
IV	type of scent	0	6,02
V	scent intensity	2	6,70
VI	taste experiences	0	4,52
VII	in-store textures	0	4,26
VIII	store temperature	1	6,92
IX	type of music (or its absence)	1	6,80
X	music tempo	0	4,30
$\chi^2(9)$	168,14**		
p	< 0,001		
Post- hoc	II < IX; II < V; II < VIII; III < IX; III < V; III < VIII; VI < IV; VI < IX; VI < V; VI < VIII; VII < I; VII < IV; VII < IX; VII < V; VII < VIII; X < I; X < IV; X < IX; X < V; X < VIII;		

Source: (Pękała, Dudzik-Lewicka, 2022).

A detailed post hoc analysis revealed that some sensory experiences have a significantly greater influence on purchasing decisions than others. Respondents also assessed the impact of store aesthetics and sensory experiences on their shopping decisions. They considered the

shapes and sizes of decorations, color intensity, and taste experiences to be less important than the type of music (or its absence), the intensity of scents, and the temperature inside the store. Taste experiences were also perceived as less influential than the type of scent. Additionally, store textures and music tempo were rated as less significant than store color schemes, the type and intensity of scent, music selection (or its absence), and the store's internal temperature (see Table 7).

Table 7.

Descriptive Statistics of the Sensations Most Effective in Influencing Purchase Decisions (n = 97)

	R	M	SD	Mdn	Sk	Kurt	W
store color scheme	0-3	0,77	1,20	0	1,11	-0,55	0,63**
shapes and sizes in the store (e.g., decorations)	0-3	0,25	0,71	0	3,03	8,41	0,40**
color intensity	0-3	0,40	0,87	0	1,98	2,52	0,51**
type of scent	0-3	0,81	1,17	0	1,05	-0,54	0,68**
scent intensity	0-3	1,12	1,14	2	0,18	-1,63	0,74**
taste experiences	0-3	0,22	0,74	0	3,42	10,33	0,31**
in-store textures	0-3	0,11	0,56	0	4,85	22,41	0,20**
store temperature	0-3	0,86	0,76	1	0,97	1,29	0,77**
type of music (or its absence)	0-3	1,23	1,29	1	0,28	-1,68	0,75**
music tempo	0-3	0,12	0,56	0	4,66	20,86	0,22**

* $p < 0.05$; ** $p < 0.01$.

Source: (Pękała, Dudzik-Lewicka, 2022).

The analysis of responses to the question of whether the average customer of large-format FMCG stores is susceptible to merchandising activities, conducted using a one-factor chi-square test, showed a statistically significant deviation from a random distribution [$\chi^2 (2, N = 97) = 154,66$; $p < 0.001$]. The results of this analysis indicated that the vast majority of respondents (92.8%, $n = 90$) agreed with this statement.

5. Presentation of the Information Obtained from Interviews

5.1. Survey methodology

In order to compare the respondents' answers with the views of the leaders of an FMCG company, a qualitative study using interviews was conducted. Structured interviews were chosen, based on a set of 10 pre-prepared open-ended questions. The study, which took place in January 2022, involved employees of a company operating in the FMCG market. Employees in various positions within the company, such as Account Sales Advisor, Key Account Manager oraz H&S Field Manager, participated in the study. One person from each of these groups was selected using a non-random sampling method.

5.2. Characteristics of Respondents

Three people participated in the qualitative interviews. The studied group included one woman and two men with varying lengths of work experience (H&S Field Manager – 5 years, Key Account Manager – 4 months, Account Sales Advisor – 20 years).

5.3. Selected Results of the Qualitative Study

For the sake of clarity in the presentation of the research material, the leaders' responses are presented in Table 8.

Table 8.
Presentation of Information Obtained from Leaders

What factors most often influence a customer's choice of a grocery store?	Respondent 1: Assortment, promotions, and prices. An important variable is also the type of shopping: daily vs. weekly. Respondent 2: Location and a wide product assortment. Promotions (big discounts, freebies, etc.) also matter. Respondent 3: A wide product assortment and prices
Does the average FMCG customer know what merchandising is?	Respondent 1: The average FMCG customer has no idea what merchandising is. They are satisfied when they can easily find the product they are looking for in the store but frustrated when they cannot. Respondent 2: They have no idea and do not think about it at all. Respondent 3: Whether they know depends mainly on the customer and whether they are familiar with industry practices, but the vast majority of FMCG customers are unaware of merchandising.
Are customers aware that stores use merchandising strategies?	Respondent 1: Yes, customers are aware that stores use merchandising strategies, but they do not fully understand how they work and often perceive them as manipulation. Respondent 2: Yes, customers are aware that stores implement specific strategies to guide them through the store. However, they do not have detailed knowledge of how it works or what benefits it brings to retailers. Respondent 3: Whether customers are aware depends on their familiarity with the industry, but in most cases, they have no idea.
Which merchandising instruments are most important to customers?	Respondent 1: The key merchandising instruments from the customer's perspective are product placement on the shelf, promotions, and in-store informational materials (POS). Respondent 2: Depending on the category and point of sale, the most important factors for the average customer are product placement on the shelf, promotions, and in-store informational materials (POS). Respondent 3: The most important merchandising instruments for customers are product placement on the shelf, promotions, and in-store informational materials (POS).
Which merchandising strategy is best and why?	Respondent 1: The key strategy in the FMCG segment is the soft-selling strategy, where purchase repetition is very important. Respondent 2: The key strategies are the off-price strategy and the assortment strategy. Respondent 3: The best strategy currently is the off-price strategy, as evidenced by the popularity of discount stores among customers.
What sensory experiences have the greatest impact on customers?	Respondent 1: The average FMCG customer is influenced by the type and intensity of scent, temperature, and the presence or absence of music. Respondent 2: The most influential sensory factors affecting customers and their purchasing decisions include the type of scent, scent intensity, and store temperature. Respondent 3: The biggest influence on customers comes from the type of scent, scent intensity, and temperature.

Cont. table 8.

Do you agree with the statement that the average FMCG customer is susceptible to merchandising strategies?	<p>Respondent 1: Yes, the average FMCG customer is susceptible to merchandising strategies. The broad scope of these activities ensures that no customer remains indifferent to them.</p> <p>Respondent 2: Yes, I agree with this statement.</p> <p>Respondent 3: Yes, FMCG customers are susceptible to merchandising strategies. The impact of these strategies is significant, which is why stores focus heavily on such activities.</p>
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Interviewee 1: H&S Field Manager; Interviewee 2: Key Account Manager; Interviewee 3: Account Sales Advisor

Source: own graphic design based on (Pękała, Dudzik-Lewicka, 2022).

The analysis of responses provided by FMCG industry leaders in section 5.3 indicates that they emphasize the crucial role of a wide assortment and pricing in customers' choice of a store. At the same time, they note the limited awareness among customers regarding the essence of merchandising, despite their susceptibility to its influence. They identify product placement on shelves, promotions, and in-store informational materials (POS) as the most significant merchandising instruments from the customer's perspective. Regarding the best merchandising strategy, opinions among industry leaders vary, considering approaches such as soft-selling, off-price strategy, and assortment strategy. However, there is consensus on the significant impact of olfactory experiences (type and intensity of scent) and store temperature on customers' purchasing decisions, which ultimately confirms their overall susceptibility to merchandising activities.

6. Conclusions and Recommendations for Practice

Based on the conducted research proceedings, the following conclusions can be formulated:

- Conclusion 1 - The key factors determining the choice of a grocery store, according to both surveyed respondents and industry leaders, are a wide assortment and low prices.
- Conclusion 2 - Most respondents are aware of what merchandising is and the benefits it brings to manufacturers, stores, and buyers. They also recognize that stores implement merchandising strategies. Industry leaders confirmed this opinion but noted that the average consumer does not have full knowledge of how merchandising works and remains susceptible to its influence. Consequently, Hypothesis H1: Customers' susceptibility to merchandising techniques occurs at an unconscious level was not confirmed.
- Conclusion 3 - The opinions of industry leaders and survey respondents regarding key merchandising instruments differ. Industry leaders highlight product placement on shelves, promotions, and informational materials (POS), whereas respondents prefer promotions, competent store staff, and a pleasant in-store atmosphere. Hypothesis H2: The key merchandising instruments that effectively influence purchasing decisions are

proper product placement on shelves and store staff competencies was partially confirmed.

- Conclusion 4 - Both respondents and industry leaders agree that customers dislike store staff interfering with their purchasing decisions.
- Conclusion 5 - Industry leaders believe that olfactory experiences and store temperature are the most important factors for customers. Respondents, on the other hand, indicated that auditory experiences and scent intensity are significant, but temperature is the key factor. Hypothesis H3, which assumed that visual and auditory experiences have the strongest impact on customers in large-format stores, was partially confirmed.

Summary, the analysis of responses from both respondents and industry leaders shows that although the average customer is aware of the existence of merchandising, they remain susceptible to it. This is due to the wide range of merchandising activities, which even a well-informed person cannot fully resist. This confirms the main hypothesis of the study, which assumes that the average customer of large-format FMCG stores is susceptible to merchandising influence.

Consumers demonstrate a high level of awareness regarding merchandising, which enables them to clearly and precisely define their needs and expectations toward FMCG retail stores. Their insights have led to the formulation of the following recommendations for business practice:

- Recommendation 1 - To operate effectively, large-format stores should offer a wide assortment that meets customer needs and reduces shopping time. It is also crucial to set competitive prices to avoid being perceived as too expensive.
- Recommendation 2 - Promotional campaigns on products are highly important for customers shopping in large-format stores.
- Recommendation 3 - A smoother shopping process can be ensured through competent store staff and a pleasant in-store atmosphere.
- Recommendation 4 - Since customers prefer to make their own purchasing decisions and do not want to be pressured, stores are advised against using hard-selling strategies.
- Recommendation 5 - During shopping, store temperature and background music selection are key factors in enhancing the customer experience.

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ENHANCING STUDENT LEARNING THROUGH EXPERIMENTAL RESEARCH: TRADITIONAL METHODS OF CONSTRUCTING HALF-TIMBERED WALLS

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Purpose: The main aim of the experiment was to introduce architecture students to the practical science of construction techniques used in historic timber buildings. It represented a return to the original concept of architectural education based on the master–apprentice model.

Design/methodology/approach: This article presents an evaluation of the teaching process during a student workshop that enriched the education of future architects. The goal was to provide hands-on experience with timber-framed wall construction techniques and conservation methods for historic buildings.

Findings: Participants developed practical skills, increased their environmental awareness, and strengthened their competencies in teamwork and international cooperation. The teaching process was assessed based on student engagement, the effectiveness of team collaboration, problem-solving abilities, and the quality of group interaction. The use of both quantitative and qualitative methods enabled a better understanding of the workshops' impact on students' readiness for professional practice, supporting the optimisation of future learning initiatives.

Practical implications: The workshops demonstrated their practical value through measurable conservation outcomes while also preparing students to meet the challenges of sustainable architectural practice. The initiative had broader social benefits, fostering cultural ties between Poland, Germany, and the Czech Republic, and promoting the preservation of unique regional architectural heritage.

Social implications: The project raised awareness of cultural heritage and sustainability in architecture. It encouraged international exchange and may inspire more institutions to include traditional techniques in education and policy.

Originality/value: This article is addressed to architecture educators and students. Returning to traditional teaching methods, such as the master–apprentice model, can be seen as an innovative approach in today's educational landscape. In an era dominated by digital tools and remote learning, opportunities for direct, hands-on experience are increasingly rare. Yet it is precisely this kind of embodied, relational learning that responds to current educational challenges. It encourages deeper engagement, develops practical and social skills, and restores a human dimension to the learning process.

Keywords: heritage conservation, practical education, ancient building techniques.

Category of the paper: viewpoint and case study.

1. Introduction

The preservation of architectural heritage is of paramount importance for maintaining the cultural and historical identity of communities. Historic buildings function as material manifestations of past eras, serving as repositories of intangible cultural knowledge. This knowledge encompasses traditional construction techniques, aesthetic values, and social customs, which collectively contribute to the shaping of local and regional identities (Ashworth, 2011; Jokilehto, 2006). As Graham, Ashworth, and Tunbridge (2000) emphasize, heritage encompasses not only the physical fabric of buildings, but also the meanings and values attributed to them by successive generations.

The half-timbered wall system, utilised throughout Europe since the Middle Ages, exemplifies both technical ingenuity and ecological sustainability. Wooden frameworks were infilled with natural, locally sourced materials such as straw-reinforced clay, hand-moulded earth blocks, or lightweight fibres – enabling rapid, low-impact construction often carried out with community involvement. Regionally specific techniques like *Lehmstaken* and *Lehmwickel* were traditionally transmitted through apprenticeships but are now at risk due to urbanisation and educational shifts. These practices reflect a duality of craft-based knowledge and environmental adaptation rooted in vernacular architecture (Houben, Guillaud, 1994; Holmes, Rowan, 2021; ICOMOS, 2013).

The preservation of such heritage necessitates both technical conservation and cultural continuity, a fact that is especially evident in regions such as Upper Lusatia, which is located on the Polish-German-Czech border. In this region, vernacular forms such as *Umgebände* houses have survived to the present day. These hybrid wooden-log structures have attracted interdisciplinary interest and are the focus of both community-led and institutional conservation efforts (Rdzawska, 2007; Trocka-Leszczyńska, Rdzawska, 2009).

In recent years, international student workshops have emerged as a response to the dual challenge of conservation and education. These initiatives combine historical research, field-based instruction, and hands-on construction, immersing students in authentic heritage contexts. They create a unique learning environment where experiential education and cultural exchange intersect, allowing architecture students to engage directly with endangered building techniques (Tzonis, 2014).

The central research question guiding this study is: how do international, hands-on workshops in traditional timber-frame construction impact architecture students' technical skills, ecological awareness, and intercultural competencies?

The primary aim is to assess the educational effectiveness of such workshops by examining how direct engagement with historical building methods contributes to broader goals in architectural education – particularly in the areas of sustainability and heritage preservation.

Accordingly, this paper evaluates two international workshops held in Seifhennersdorf, Germany, in 2022 and 2024. Drawing on observational data, student reflections, and post-workshop survey responses, the study explores how experiential learning supports the development of competencies related to heritage conservation, ecological thinking, teamwork, and cross-border collaboration in the context of vernacular architecture.

2. Methodology

This study employs a mixed-methods research design to evaluate the educational effectiveness of two international student workshops focused on the conservation of timber-framed buildings. The workshops were held in Seifhennersdorf, Germany, in August 2022 and July 2024, as part of an academic collaboration between the Silesian University of Technology (Poland) and HTWK Leipzig (Germany). Participants included architecture students from both institutions, supervised by faculty members specializing in heritage conservation.

The pedagogical foundation of the workshops draws on principles of experiential learning, which emphasize the role of direct experience in developing knowledge, skills, and attitudes (Kolb, 1984). This approach is increasingly recognized as effective in architectural education, particularly when addressing complex, real-world challenges (Tzonis, 2014). By engaging students in authentic conservation activities, the workshops created conditions for learning through action, reflection, and problem-solving.

The structure of the workshops integrated three established instructional models:

- Action Learning, where students tackled real restoration tasks in groups and learned through doing.
- Problem-Based Learning, which encouraged them to collaboratively devise solutions to construction-related challenges.
- Case Study analysis, focused on the architectural and historical significance of the Umgebinde house typology.

Such a blended approach has proven effective in design and technical disciplines for cultivating creativity, cooperation, and critical thinking (Barrows, 1996; Ibrahim et al., 2021). The workshops further extended this model by emphasizing manual skill development, sustainable building practices, and intercultural teamwork in a hands-on setting.

To assess the workshops' impact, the study utilized three complementary data collection methods:

- participant observation, conducted by the instructors throughout the activities,
- informal student reflections, collected during and after the workshops,
- an anonymous post-workshop evaluation survey, completed by all participants.

This triangulation of data sources follows established educational research practices (Creswell, Plano Clark, 2011), providing both breadth and depth in evaluating learning outcomes and enhancing the reliability of the findings. The survey combined closed and open-ended questions across five categories: organizational quality, teaching methods, teamwork and atmosphere, working conditions and safety, and perceived educational value.

The evaluation framework was designed to be learner-centered, reflecting the growing emphasis in higher education on student voice and agency in the assessment process (Boud, Falchikov, 2007). This comprehensive methodology enables a nuanced understanding of how participation in heritage-focused workshops supports the development of technical, social, and cultural competencies among architecture students.

3. Workshop Process

The international workshops conducted in Seifhenndorf in 2022 and 2024 were structured into three main phases: contextual analysis, design development, and practical implementation. This division reflects established approaches to project-based learning and participatory design in architectural education (Salama, 2015; Schön, 1983), enabling students to gradually build understanding through observation, ideation, and hands-on practice.

To support the practical exercises, Figure 1 shows the key structural elements of a traditional half-timbered wall. These include the timber framework, typical infill techniques like *Lehmstaken* and *Lehmwickel*, and the use of natural insulation. Understanding these elements was essential before moving on to the construction tasks.

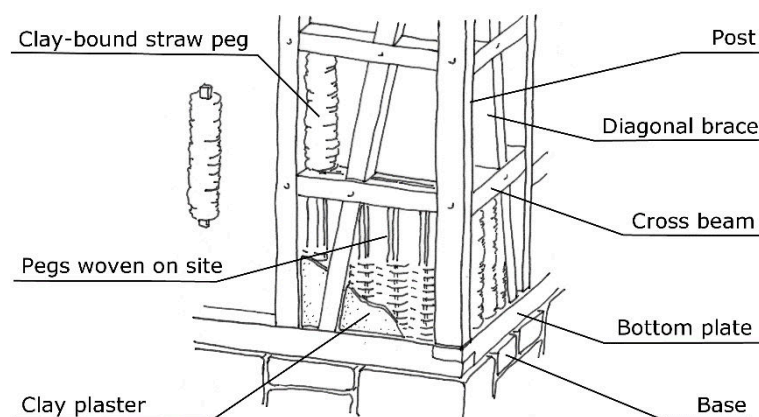


Figure 1. Structural elements of a traditional half-timbered wall, including straw-clay infill, timber frame joints, and various techniques of field filling such as *Lehmstaken* and *Lehmwickel*.

Source: Gerlic, 2024.

3.1. Phase I – Site research and analysis

The initial phase focused on understanding the historical, environmental, and social context of the *Umgebinde* houses located in Upper Lusatia. Students participated in guided tours of preserved buildings, museum sites, and contemporary restorations. A lecture on construction principles and the cultural significance of hybrid wooden-log systems provided theoretical grounding. Through site visits and collaborative reflection, students developed critical insights into spatial constraints, materials, and adaptive reuse potentials—an approach aligned with place-based learning strategies (Gruenewald, 2003).

3.2. Phase II – Concept development and design exploration

In the second phase, students formed interdisciplinary and international teams to create conceptual proposals. Sketching, diagramming, model-making, and perspective drawing were used to explore functional and aesthetic strategies for preserving authenticity while incorporating new uses. The iterative process emphasized sustainability and participatory design, consistent with experiential learning models (Kolb, 1984) and socio-constructivist pedagogy in design education (Tzonis, 2014).

Working in culturally diverse teams facilitated peer-to-peer learning and challenged students to negotiate differences in communication, methods, and expectations—a crucial competency in today's globalized professional environment (Dannels, 2002).

3.3. Phase III – On-site construction and material experimentation

The final and most immersive phase involved active engagement in a supervised yet student-driven setting, with traditional construction techniques. Under expert supervision, students rotated through a sequence of hands-on tasks, including:

- Preparation of natural materials: mixing straw and clay, selecting aggregates, shaping clay-straw blocks.
- Frame work: identifying structural nodes, marking joinery, stabilizing wooden elements.
- *Lehmstaken*: inserting straw-coated wooden rods into grooves or notches in the timber frame.
- *Lehmwickel*: preparing bundled straw soaked in clay, woven and pressed into the frame.
- Manual plastering with earth-based renders.
- Application of natural insulation (e.g. wood wool).

Rotating between tasks enhanced cross-functional learning, fostered peer support, and ensured comprehensive engagement with all aspects of traditional construction. This method resonates with "learning by doing" models and the studio-based tradition in architectural pedagogy (Cuff, 1991), while also emphasizing embodied learning—particularly relevant when working with tactile, heavy, and variable natural materials (Orr, Phoenix, 2010).

By participating in the full spectrum of activities, students developed technical proficiency, ecological awareness, and a holistic understanding of conservation challenges. This integration of theoretical knowledge and physical engagement illustrates the strength of field-based learning environments in developing professional competencies (Ibrahim et al., 2021).

4. Results

The results of the workshops were analyzed based on direct observations, student reflections, and an anonymous post-workshop evaluation survey. This multifaceted assessment provided a comprehensive picture of both the educational outcomes and the experiential quality of the workshops.

4.1. Educational outcomes and student performance

Throughout the workshops, students demonstrated increasing levels of engagement, technical curiosity, and adaptability. The opportunity to work with natural materials such as clay, straw, and timber in real construction conditions significantly enhanced their understanding of material behavior and traditional construction logic. Most students entered the workshop with little or no hands-on experience in building crafts, yet quickly adapted to the physical demands and developed practical competencies.

As observed by instructors, students exhibited steady improvement in manual skills, spatial reasoning, and confidence in tool use. The rotation of tasks and collaboration across small teams fostered peer-to-peer learning, allowing more experienced participants to support others. Furthermore, exposure to environmental challenges (e.g., handling wet clay, working in variable weather) built resilience and problem-solving abilities, often under informal time constraints.

These observations confirm previous research on the effectiveness of experiential, tactile learning in design education, particularly in contexts that demand adaptability and manual skill development (Kolb, 1984; Cuff, 1991).

4.2. Instructor reflections

The teaching team noted that the workshop format enabled a unique type of pedagogical interaction, distinct from traditional classroom settings. Students asked more practical, context-driven questions and showed initiative in seeking clarification. Working in international teams introduced linguistic and cultural dynamics, which, although occasionally challenging, encouraged students to develop communication strategies and leadership in small group settings.

The balance between freedom and structure proved effective. While students were encouraged to improvise and experiment, safety protocols and performance expectations were clearly communicated. Many participants expressed motivation that exceeded initial expectations – particularly when they began to see the tangible outcomes of their work.

This kind of hands-on engagement aligns with Schön's (1983) idea of the “reflective practitioner”, where students learn by reacting to immediate situations and refining their actions through feedback.



Figure 2. Students weaving straw and clay infill between timber elements using the *Lehmwickel* technique.
(Photo: E. Rdzawska-Augustin, 2022)



Figure 3. Straw-clay blocks formed and dried on site before being placed into timber frames.
(Photo: K. Gerlic, 2024)



Figure 4. Students rotating between construction tasks: mixing clay, preparing the timber frame, and applying plaster.
(Photo: E. Rdzawska-Augustin, 2022)



Figure 5. International student groups collaborating on-site, exchanging knowledge and supporting each other across language and skill differences.
(Photo: K. Gerlic, 2022)

4.3. Survey results

The evaluation survey, completed by all participants, revealed consistently high satisfaction across all categories:

- Workshop organization received the highest ratings. Students praised the clarity of pre-departure information, accommodation logistics, and the overall schedule. The introductory lecture and site visits (e.g., to Zgorzelec) were seen as valuable additions. A minor suggestion concerned the student union's involvement, unrelated to the core organization.
- Teaching methods and content were also rated very highly. Students highlighted the professionalism, clarity, and approachability of instructors. Practical tasks, particularly those involving clay and tool work, were described as the most memorable and beneficial. Some suggested shortening the theoretical component slightly in favor of more group interaction or physical modeling.
- Teamwork and atmosphere were evaluated as extremely positive. Despite minor language barriers, students enjoyed working in international groups. They recommended simple improvements to group cohesion, such as name badges or shared meals. Small, mixed teams (3-5 people) were preferred.
- Working conditions and safety were described as excellent. Students appreciated the availability of tools and materials, adherence to safety instructions, and the proximity of accommodation to the workshop site. Participants felt safe throughout the workshop.
- Knowledge and applicability were assessed as very high. Students emphasized the practical relevance and inspirational nature of the knowledge gained. Many expressed a desire to participate in future workshops and proposed expanding the program to include other heritage techniques such as stonework or community engagement with local residents.

Students' positive feedback regarding teamwork, atmosphere, and task rotation aligns with the findings of Dannels (2002), who emphasizes the role of communication and group structure in fostering design studio effectiveness.

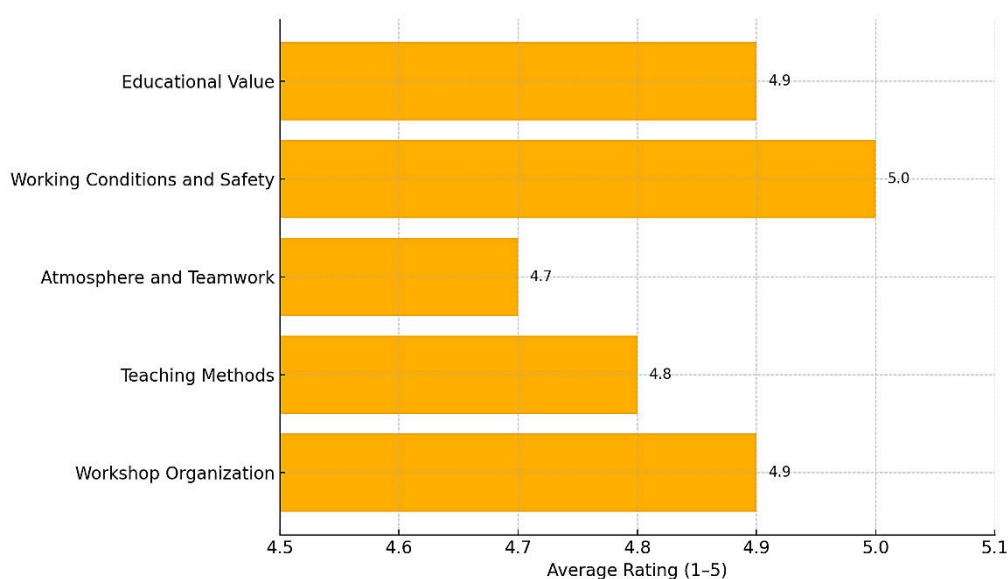


Figure 6. Summary of student evaluations across key workshop categories.

Source: Post-workshop evaluation survey, 2024.

5. Discussion

The findings of this study confirm the high educational value of practical, field-based learning in architectural education. The integration of manual work, historical context, and interdisciplinary collaboration within a real construction setting created a rich and engaging learning environment that extended far beyond the capabilities of traditional studio or classroom instruction.

5.1. Experiential learning as a foundation for architectural education

Experiential learning, grounded in direct engagement with materials, tools, and real architectural problems, fosters a deeper understanding of construction systems, building traditions, and spatial logic. Unlike theoretical instruction, hands-on workshops allow students to “think with their hands,” as Schön (1983) described it, by testing ideas in physical form and adapting intuitively to emerging challenges.

In the context of traditional timber construction, this method proved particularly effective: students developed an embodied understanding of weight, texture, resistance, and the time-intensive nature of manual processes – experiences rarely accessible in modern curricula. The presence of unpredictability (e.g. weather, material inconsistency, fatigue) contributed to a realistic approximation of professional practice, where adaptation and improvisation are crucial.

Unlike design courses focused on software and virtual modeling, these workshops reconnected students with the physical reality of construction. As Webster (2008) notes, architectural education often marginalizes manual labor in favor of abstract representation. In this sense, the workshops addressed a systemic gap by foregrounding craft, collaboration, and full-body engagement with architecture.

5.2. Student competencies: technical, social, cultural

In addition to acquiring construction-related skills (material mixing, tool handling, structural assembly), students improved their teamwork abilities, communication strategies, and intercultural sensitivity. Working in small, international groups required them to coordinate across language barriers, negotiate design decisions collaboratively, and adapt to different working styles. These competencies are crucial for future architects expected to operate in interdisciplinary, multicultural, and often transnational professional environments (Dannels, 2002; Ibrahim et al., 2021).

Importantly, many students expressed increased confidence not only in using tools or performing tasks, but also in taking initiative, solving problems creatively, and supporting their peers. The social dynamics within each group were often self-regulated, demonstrating high

levels of responsibility and mutual respect—especially noteworthy given the physical demands and novelty of the work.

Moreover, the exposure to vernacular heritage enhanced students' cultural awareness and ecological thinking. Understanding how historical buildings responded to environmental and social conditions strengthened their appreciation of sustainable design principles rooted in local traditions. This echoes current calls for a more place-based, culturally sensitive approach to sustainability in architecture (Gruenewald, 2003; ICOMOS, 2013).

5.3. The impact of the international setting

The cross-border nature of the workshops added an important layer of complexity and value. Working alongside peers from different academic, linguistic, and cultural backgrounds helped students develop soft skills such as adaptability, empathy, and openness to alternative perspectives.

The workshops also became informal spaces for cultural exchange. This aligns with the goals articulated in international charters on heritage and education, including the Faro Convention (Council of Europe, 2005) and UNESCO's World Heritage Education Programme, which emphasize youth participation and international collaboration in safeguarding cultural heritage. The workshops demonstrate how these values can be operationalized in a tangible, site-based learning format.

Furthermore, many students reported that the multicultural environment was one of the most memorable aspects of the workshop. The daily negotiations of language, humor, customs, and expectations turned the construction site into a microcosm of intercultural interaction – one that mirrors the complexity of contemporary architectural practice in Europe and beyond.

5.4. Recommendations for future practice

The workshops proved to be a valuable educational experience, and we believe this model could be successfully developed further. Suggested improvements include:

- opening the workshops to a wider group of students, for example through cross-faculty recruitment,
- introducing new themes, such as stone masonry, window restoration, or lime plastering,
- involving local communities more directly, including craftspeople, residents, and cultural institutions,
- sharing the results of the workshops, for example through open-access reports, photo documentation, or short instructional videos.

To make these workshops a regular part of architectural education, they could be formally included in study programs. This might take the form of:

- elective courses with ECTS credits based on participation,
- certificates or digital badges confirming the acquisition of specific skills,

- interdisciplinary courses offered jointly with other departments,
- final-year projects connected to the topics explored in the workshops.

Such integration would give the workshops more academic weight and make it easier to secure support and funding.

It's worth noting that the workshops involved a relatively small and self-selected group of students. This means the results may not fully reflect a wider student population. Still, the outcomes suggest that combining theory with physical work brings clear benefits. Students developed confidence with tools and materials, but also improved their teamwork and cultural awareness – things often harder to teach in traditional settings.

In the future, similar projects could cover other heritage crafts or work more closely with communities. It would also be interesting to follow up with participants and see how this experience influences their choices in internships or professional paths.

6. Conclusions

This study has demonstrated that experiential, site-based workshops focused on traditional building techniques can serve as highly effective educational tools in architectural training. The workshops conducted in Seifhennersdorf in 2022 and 2024 achieved multiple interconnected goals: they strengthened students' technical and manual skills, fostered teamwork and intercultural cooperation, and deepened awareness of heritage values and ecological principles.

By immersing students in the full process of heritage construction – from analysis and design to hands-on execution – these workshops created a learning environment that combined physical experience with intellectual reflection. The integration of cultural context, historical typologies, and manual techniques offered students a holistic perspective on architecture as both a technical discipline and a cultural practice.

The practical implications of these findings are twofold and highly relevant for both education and conservation practice. First, in the context of architectural education, such workshops provide a compelling alternative or supplement to studio-based learning. They equip students with real-world competencies: not only in handling materials and tools, but also in navigating group dynamics, intercultural exchange, and the unpredictability of construction conditions. Second, from a conservation perspective, engaging future architects in heritage practices at an early stage fosters greater appreciation for vernacular techniques and the ethics of preservation, potentially shaping their future career paths and priorities.

However, one of the main challenges in developing this model further is the lack of funding. A possible solution is to offer such workshops as optional courses for students who are interested. This way, universities could use their resources more effectively while still giving more students the chance to take part in hands-on heritage education.

The workshop model presented here is both replicable and adaptable. It can be successfully implemented in various educational settings – including architecture, civil engineering, cultural heritage studies, and vocational training. The key to its success lies in balancing freedom and structure, integrating theory with action, and grounding learning in local cultural and material contexts.

To realize its full potential, we recommend continued institutional support, strategic partnerships with heritage organizations, and the development of long-term frameworks for workshop-based learning. With such support, field-based heritage education can evolve into a standard, impactful component of sustainable architectural education across Europe and beyond.

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A DATA-DRIVEN FRAMEWORK FOR INCREMENTAL SUPPLY CHAIN OPTIMIZATION

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Purpose: This paper develops an incremental supply chain modeling framework using Big Data and Data Science methods to enhance decision-making, adaptability, and operational efficiency. By integrating advanced analytics, it offers a scalable approach to optimize real-world supply chains.

Design/methodology/approach: The model was developed utilizing the Design Science Research (DSR) methodology, ensuring a structured and rigorous approach to its creation and validation. I propose a four-phase approach—data collection, analysis, decision-making, and model enrichment—combining theoretical insights from supply chain modeling with practical Data Science methods. This iterative method was tested on a retail supply chain to validate its utility.

Findings: The results show that incremental modeling enhances adaptability by enabling quick reconfiguration amid changing conditions and improves decision-making through analytics integration. Each iteration reduces both the time and cost of technical implementation.

Research limitations/implications: Because the study focuses on one retail supply chain, the findings may not be fully generalizable. Future research could examine the framework in other sectors or explore its scalability to more complex supply chains.

Practical implications: By leveraging Big Data and Data Science, the framework provides deeper supply chain visibility, refined resource allocation, and cost reduction. Real-time insights also strengthen alignment between supply chain strategy and operational execution.

Social implications: More efficient resource use and lower waste levels support sustainable supply chain practices. These insights can guide corporate policies on environmental and social responsibility, while promoting data-driven decision-making.

Originality/value: This paper presents an innovative incremental model integrating Big Data and Data Science methods. It aids managers, analysts, and policymakers in boosting operational efficiency within dynamic environments. Moreover, it accounts for the resources and skills required at each stage of supply chain modeling.

Keywords: Supply Chain Modeling, Big Data Analytics, Data Science Applications, Supply Chain Optimization, Decision-Making.

Category of the paper: framework development.

1. Introduction

1.1. Research questions

A detailed analysis of competition for customers in the market highlights continuous product improvement. A thorough analysis of the literature was conducted on Big Data (BD) technology in supply chains (SC) and the methods of SC modeling. Insights gained from the literature were supplemented with business experts interviews. Previous work on the proposed method have been described in the author's earlier publication (Górtowski, Lewańska, 2019).

The literature review focused on several key aspects of SC modeling, including weaknesses in current methods and the use of BD in these models. Based on the above motivations, the following research questions were formulated:

- Q1: Who should be involved in creating the supply chain model? What competencies are required, and what roles are necessary for building such a model?
- Q2: What does an iteration of supply chain modeling look like?
- Q3: What Data Science methods can support supply chain modeling?

1.2. Methodology

To explore and systematically organize the challenges associated with implementing SC model in automated data analysis, the Design Science Research method was selected due to its widespread recognition and justification in the information systems literature (Hevner, 2004).

The study builds on existing definitions and frameworks for DS-supported business data analysis, which serve as the Knowledge Base, forming the theoretical foundation of the research and methodology. Simultaneously, evolving business needs and trends define the Business Environment, ensuring practical relevance and alignment with real-world applications, particularly in integrating modeling solutions into corporate infrastructures.

Key artifacts identified in this study include the SC modeling method architecture, a DS-supported data analysis model, and a working prototype of SC model. These artifacts are iteratively developed, evaluated, and refined through the Rigor and Relevance Cycles. The Rigor Cycle ensures the refinement of artifacts based on insights from the Knowledge Base, incorporating existing DS applications, data visualization automation, and best practices. The Relevance Cycle, guarantees that the study addresses practical business challenges through user evaluations and real-world testing, leading to continuous improvements.

At the core of this process, the Design Cycle bridges theoretical foundations (Rigor Cycle) with practical applications (Relevance Cycle) by facilitating the iterative development, evaluation, and enhancement of system modules and resources. Ultimately, the study contributes back to the Knowledge Base by defining requirements for automated business data

analysis and validating the proposed solutions through empirical testing. A summary of the Design Science Research components and their application is presented in Table (Table 1).

Table 1.

The Design Science method components and its application

Component	Definition	Application in Study
Knowledge Base	Fundamental principles established through existing scholarly studies.	Existing Data Science applications, supply chain optimization frameworks, and best practices. The study also contributes to the Knowledge Base by defining requirements for incremental supply chain modeling.
Business Environment	Practical industry dynamics, emerging trends, and organizational requirements.	Trends in supply chain management, particularly in integrating Data Science and Big Data solutions into corporate decision-making.
Artifact	Deliverables generated from the research, including conceptual models, analytical frameworks, and practical tools.	Proposed incremental supply chain modeling framework, including the methodology, data-driven decision-making approach, and a prototype application.
Rigor Cycle	Continuous improvement driven by established theoretical insights and past research findings.	Iterative development of the framework based on prior research and best practices, refining methodologies for incremental supply chain modeling.
Relevance Cycle	Ongoing adaptation informed by industry developments and stakeholder feedback.	System evaluation and adaptation based on user feedback and real-world supply chain scenarios.
Design Cycle	The fundamental cycle of developing, testing, and enhancing conceptual and practical components.	Development, evaluation, and refinement of framework components, ensuring practical applicability in supply chain optimization.

Source: own elaboration.

2. Literature review

This section discusses the evolution of SC modeling, focusing on the integration of advanced analytics and modeling approaches. It highlights the role of BD in addressing SC challenges and examines key Data Science (DS) methods applied in the field of SC improvement. Additionally, it identifies gaps in the existing literature that this study aims to address.

2.1. Supply Chain Modeling Methods

In the literature, SC models are often categorized through various methods, including mathematical models, simulation models, and hybrid models and by their treatment of randomness, i.e., deterministic versus stochastic (Wofuru-Nyenke et al., 2023). Researchers use various modeling methods to address challenges in SC management, including sustainability, efficiency, resilience, and uncertainty. The choice of modeling approach depends on the specific problem and data characteristics, with simulation and hybrid models gaining popularity due to their ability to handle uncertain and stochastic data (Wofuru-Nyenke et al., 2023).

These methods provide relatively safe and cost-effective means of exploring potential solutions, especially when real-world testing is impractical or costly.

Simulation tools, including discrete-event simulation and agent-based modeling, are employed to enhance SC resilience and manage disruptions (Benjamin Korder et al., 2024). Data envelopment analysis (DEA) is used to measure retail SC efficiency, with approaches such as standard DEA models, efficiency decomposition models, network models, and game-theory-based models (Andrejić, 2023). System dynamics modeling is employed to create cause-effect curves and improve SC performance, particularly focusing on agility and flexibility indicators (Liu et al., 2023). Uncertainty analysis and optimization modeling (UAO) are increasingly applied to SC management under uncertain conditions, with decision-making being a common application area (Chen et al., 2023).

Industry 4.0 has spurred innovations in SC optimization, introducing new modeling conditions, inputs, decisions, and algorithms (Xu et al., 2024). The paper identifies promising avenues for future research, such as self-adaptive models and uncertainty reduction techniques in SC networks.

Digital twin technology is increasingly applied across various sectors, enabling more effective SC management in areas such as infrastructure, manufacturing, and agriculture (Hirata et al., 2024). Additionally, by integrating machine learning methods, such as topic modeling, Hirata et al. identify key areas of innovation, including the role of AI, blockchain, and the physical internet, which collectively redefine the scope and capabilities of SC processes. This underscores the growing need for data-driven approaches in dynamic environments.

2.2. The Role of Big Data Analytics in Supply Chains

Business analytics plays a key role in enabling continuous improvement within Industry 4.0. As (Wolniak, 2024) indicates, advanced analytical tools—such as predictive modeling and real-time data visualization—enhance operational efficiency and improve the quality of supply chain management. The integration of these technologies allows organizations to identify inefficiencies, forecast potential issues, and respond swiftly to changing market conditions (Wolniak, Grebski, 2023; Wolniak, 2024).

Big Data Analytics (BDA) is crucial for enhancing supply chain management and decision-making. It improves strategic purchasing and supply management decisions—especially when combined with strong absorptive capacity (Patrucco et al., 2023)—and enables organizations to optimize operations, make informed decisions, and improve forecasting accuracy across the supply chain (Agrawal, 2024). Furthermore, BDA contributes to decarbonization efforts by fostering sustainable growth and innovativeness (Kumar et al., 2023). Despite its slower adoption compared to other business areas, its integration is increasingly important for enhancing operational efficiency, reducing costs, and meeting customer demands in today's dynamic market landscape (Patrucco et al., 2023; Agrawal, 2024).

In response to uncertain business climates, environmental challenges, and regulatory pressures, organizations are adopting sustainable supply chains supported by advanced data analytics. This multi-layered, cloud-based approach integrates business process modeling, machine learning, and visualization to enable intelligent, insight-driven decision-making. Such methodologies have been successfully applied in supplier quality management to improve supply chain performance and achieve sustainability goals (Stefanović et al., 2025). Additionally, when powered by artificial intelligence, BDA significantly influences green supply chain collaboration, sustainable manufacturing, and environmental process integration (Rashid et al., 2024), ultimately contributing to sustainable performance and competitive advantage in supply chains (Kumar et al., 2024; Rashid et al., 2024).

Data Science (DS) and BDA are increasingly applied in supply chain modeling to enhance efficiency, resilience, and sustainability (Jahani et al., 2023). These technologies support data-driven decision-making across various processes, from targeted marketing and inventory optimization to supplier risk assessment (Sanders, 2016). In agriculture supply chains, emerging technologies like IoT, blockchain, and big data are driving digital transformation and sustainability (Kamble et al., 2020). Applications of predictive analytics—such as time-series forecasting, clustering, neural networks, and support vector machines—are proving valuable for demand forecasting in supply chains (Seyedan, Mafakheri, 2020). However, further research is needed on BDA applications in closed-loop supply chains, as robust implementation requires careful planning and investment (Kamble et al., 2019; Sanders, 2016).

Machine learning (ML) has become increasingly important in addressing complex decision-making challenges in supply chain management (Babai et al., 2024). Recent applications have focused on demand forecasting, inventory management, and transportation. For example, ML algorithms like Random Forest and Artificial Neural Networks have shown high accuracy in predicting feedstock yield, productivity, and quality in biodiesel supply chains (Kim et al., 2024). Moreover, ML and AI have demonstrated excellent performance in fraud detection (Lokanan, Maddhesia, 2024), while IoT-based frameworks using ensemble ML methods have improved demand prediction accuracy in cross-border e-commerce (Wang, 2024). Deep learning architectures, such as LSTM and CNN models, have also shown promise in predicting late orders and classifying supply chain risks (Bassiouni et al., 2024), and data-driven robust optimization techniques are being employed to design sustainable cold supply chains for perishable products by integrating ML to construct uncertainty sets from historical data (Arabsheybani et al., 2024).

2.3. Gaps in Existing Literature

Lack of comprehensive frameworks that integrate Industry 4.0 tools like IoT, blockchain, and artificial intelligence into SC model. The article highlights the need for a holistic approach to align advanced technologies with sustainability objectives. General frameworks may lack

specificity for certain industries, leaving a gap in tailored solutions for sectors like manufacturing, services, retail or agri-food.

Limited focus on the role of human factors, such as training, collaboration, and resistance to change, in the successful implementation of SC modelling. Research on the importance of aligning workforce development with technological BD advancements is limited.

The dynamic nature of modern SCs, driven by frequent changes and the need for real-time decision-making, necessitates the adoption of advanced technologies. However, existing models often lack the ability to quickly reconfigure in response to shifting market conditions or unforeseen disruptions. This gap highlights the urgent need for innovative methods and tools that enable rapid adaptation and ensure SC resilience.

The diversity of SC modeling methods reflects the complexity and dynamic nature of SC systems. While traditional methods offer foundational approaches, the integration of BD, DS, and incremental strategies addresses modern challenges, enabling organizations to adapt to real-time changes and optimize their operations. The next section will elaborate on how these methods are incorporated into the proposed incremental SC modeling framework.

3. Adapting Supply Chain Modeling for Business Applications

The method of incremental modeling for supply chains is based on authors' experience in implementing the model within a retail supply chain. In today's rapidly changing economic environment, it is essential that the tools, models, and systems especially those supporting decision-making are integrated into the enterprise system and can quickly adapt to evolving conditions. Our approach not only embeds the model within the organizational framework but also clearly defines the roles and responsibilities of the involved team members.

This integration allows the model to respond effectively to shifts in market dynamics, ensuring that analytical accuracy is maintained despite the high costs and lengthy development times associated with traditional simulation models. The model's adaptability is further supported by a robust data environment that provides continuous access to up-to-date information, processing tools, and business insights. These adaptive elements and their operational specifics are further detailed in Section 4.

3.1. Supply Chain Modeling Assumptions

The model operates within a specific environment and must align with the enterprise's requirements. At the same time, it should deliver benefits that outweigh the costs of its construction and maintenance. The primary purpose of the model is to understand and describe dependencies within the (SC) and to integrate the results into decision-making systems.

This becomes particularly important when multiple stakeholders are involved in the modeling process, where one critical requirement is the ability to reconfigure the model promptly.

It is important to note that SC modeling extends beyond the creation of a mathematical representation. From an organizational perspective, it is a multi-stage task involving various units and individuals with diverse competencies. Figure 1 presents the simplified phases of a traditional modeling process.



Figure 1. Stages of creating a classic model.

Source: Own study.

Business needs evolve rapidly, making it impossible to define all relevant questions in advance. As these needs grow, greater precision or new areas may be required, and iterative feedback is necessary due to inevitable information transfer errors.

A mathematical representation links the supply chain's information with data—integrating sources, processes, and nodes via algorithms. Results must be clearly visualized to support decision-making and ensure a return on investment (see Figure 2), yielding benefits like risk avoidance, cost reduction, sales growth, and margin optimization.

However, this process has limitations, including unclear role definitions and missing steps such as data acquisition and governance. Moreover, shorter times to actionable results increase information value. Considering these challenges and our experience with similar models, the method was developed.

3.2. Method Phases

Building on the observations and experience gained from implementing similar models, the incremental modeling method was developed. Figure 2 illustrates the relationship between the environment and the SC model. The environment provides data describing SC objects, processes, performance measures, and KPIs, as well as data on external relationships.

The method consists of four main phases, each requiring different tools, knowledge, skills, human resources, and organizational input. These phases are numbered 1-4 in Figure 2. For each phase, a specific outcome is defined as its product. Letters (A–F) denote relationships between the phases and the environment. For instance, (A) represents the resources the environment provides to the model, while (D) indicates the model's influence on decision-making and, consequently, the SC.

3.3. Data Collection

Data collection forms the foundation of the incremental supply chain modeling framework. Data is gathered from diverse channels- both internal (e.g., transactional databases, ERP systems, IoT sensor data, master records) and external (e.g., public databases, government reports, social media, partner data) to capture a comprehensive view of supply chain dynamics. Supplementary datasets such as weather, internet traffic, and social media trends further enrich the model by providing both historical and real-time information for robust decision-making.

To ensure data integrity, potential errors and biases are systematically identified and corrected. Common issues like missing values, duplicate records, and inconsistent formats are closely monitored, while systematic biases (e.g., selection or confirmation bias) are assessed using statistical analyses and visualization techniques, such as distribution charts and correlation matrices. These measures ensure that the dataset accurately reflects underlying processes without distortion.

As shown in Figure 2, the first phase (Step 1) involves gathering, organizing, and verifying data quality, as well as defining performance measures and KPIs. Key tasks include:

- Collecting data in the warehouse.
- Keeping records updated.
- Enhancing data quality.
- Acquiring new datasets.

Additionally, the business environment provides essential knowledge to define measurement criteria, linking data origins to KPIs so that analysts can evaluate specific locations, participants, and processes. At this stage, a well-structured data warehouse is established for further analysis, with the flexibility to incorporate new datasets or performance measures as needed.

Rigorous quality control procedures are embedded throughout the process. This includes comprehensive cleaning routines (e.g., removing duplicates, imputing missing values), automated validation checks within the ETL processes, and periodic audits by domain experts. Detailed documentation of these procedures ensures transparency and reproducibility, reinforcing the credibility of subsequent analyses.

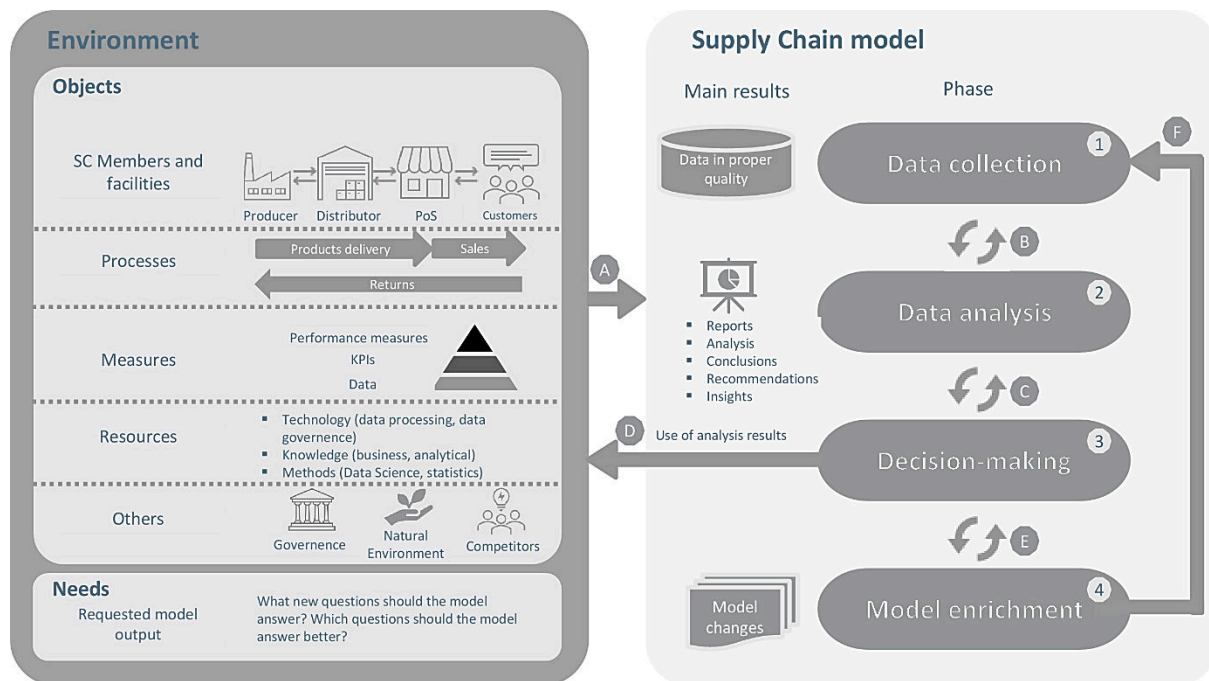


Figure 2. The relationship between the environment and the supply chain model.

Source: Own study.

3.4. Data Analysis

The second phase, data analysis (Step 2), lies at the core of the incremental modeling method. Its purpose is to generate insights, recommendations, and conclusions about the SC based on the collected data. A detailed flow of this phase is shown in figure (Figure 3).

Inputs to this phase include the data model (with connections, KPIs, and performance measures) and the information needs of the environment, often framed as business questions. These questions guide the analysis and define its expected outcomes, such as:

- optimization of indicator values,
- selection of relevant measures and KPIs,
- improved understanding of SC operations,
- prioritization of measures.

The analysis may also uncover insights beyond its scope, influencing future decision-making.

In Step 2.1, analysts interpret business questions and select a corresponding dataset, including fact tables and dimensions. These are translated into specific KPIs and target variables, forming the foundation for applying DS methods in Step 2.2. Various methods are utilized in this phase:

- Factor analysis identifies interdependent variables and reduces dimensionality, isolating key factors that influence outcomes.

- Classification and clustering group similar objects, such as customers or production units, revealing underlying structures. These clusters may evolve with each model iteration, dynamically adapting to changing environments.
- Outlier detection identifies anomalies that positively or negatively affect outcomes, highlighting areas for further investigation.
- The final products of this phase are reports and dashboards (Step 2.3) that present results in a clear and coherent manner. Effective visualization and storytelling techniques enhance the interpretability of these findings, which are then passed to the next phase.

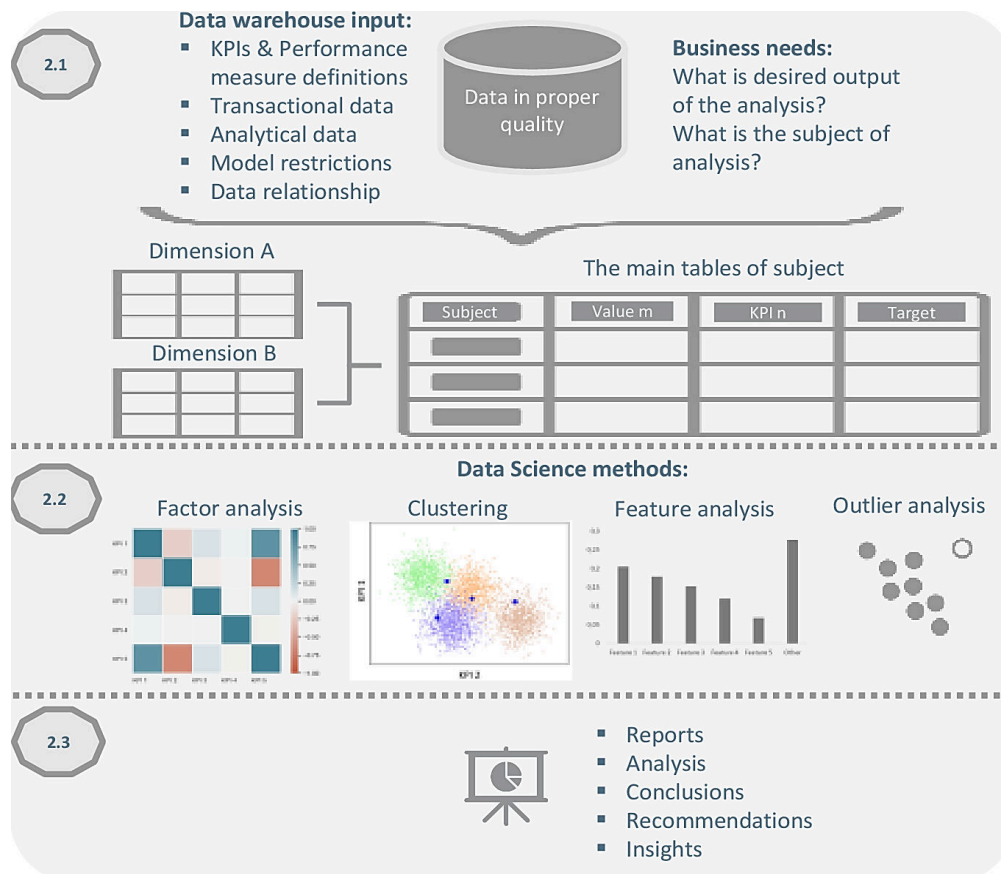


Figure 3. Data analysis phase.

Source: Own study.

3.5. Decision-Making

Phase 3 begins with the acceptance and validation of analytical results. Given real-world business constraints, constructing a second model for validation is often impractical. Instead, assessment relies on:

- expert evaluation of the results,
- sensitivity testing (e.g., reducing random data to observe impact),
- logical consistency (e.g., avoiding illogical dependencies or negative values).

Validated results inform decisions to refine the SC (Step D) and generate new questions for future iterations (Step E). The model's value is determined by its ability to deliver benefits that exceed its development costs.

Good data visualization facilitates understanding among decision-makers, bridging technical analyses and business insights. The model adapts to changing conditions through self-configuration, updating clusters, features, and outliers based on new data patterns.

3.6. Model Enrichment

Phase 4 focuses on refining the model to address new questions or challenges identified in the previous phase. Possible directions include:

- introducing new analytical methods,
- incorporating business-driven modifications,
- modeling additional elements,
- exploring alternative scenarios or business methods.

This phase concludes with Step F, marking the completion of the current iteration. Objectives may be achieved, deferred, or revised for the next cycle. Subsequent iterations typically run more efficiently, leveraging prior work and aligning with the learning curve.

4. Applying Data Science to Supply Chains Modeling

The DS methods introduced in phase (2.2) represent only a fraction of their potential in supply chain applications. Their full range can be expanded in future iterations as analysts gain expertise, the knowledge base evolves, and new analytical needs emerge. Analysts can leverage specialized tools and libraries in Python, R, Scala, C++, and Julia to implement these methods efficiently without building solutions from scratch.

Framework employs advanced DS techniques tailored for dynamic environments. For instance, clustering groups similar entities (e.g., customers, suppliers, distribution points) based on shared characteristics, while dimensionality reduction methods like PCA extract key performance indicators, allowing decision makers to focus on critical metrics. Regression analysis models relationships between variables to forecast trends such as demand fluctuations and transportation costs, enabling proactive decision-making.

Additional methods include outlier detection to identify anomalies (e.g., irregular delays, unexpected cost increases) and optimization algorithms to solve complex problems like route planning and inventory management. Classification techniques support resource allocation by categorizing SC elements, and scenario simulations test resilience by modeling hypothetical disruptions. Together, these methods form a robust toolkit that effectively addresses the complexities of modern SCs.

Table 2.*Exemplary Applications of Data Science Methods in Supply Chains*

Method Group	Algorithms	Application in the Model
Classification	SVM, nearest neighbors, random forest, neural network	Assigning products and stores to predefined groups
Regression	SVR, nearest neighbors, random forest	Forecasting; defining a function that describes changes in the values of model components
Clustering	K-Means, spectral clustering, mean-shift	Identifying new customer or point-of-sale (POS) segments based on characteristics
Reduction of Dimensionality	PCA, K-Means, feature selection, non-negative matrix factorization	Reducing redundant dimensions; selecting relevant performance measures; identifying features significant for analysis
Model Selection	Grid search, cross-validation, metrics	Choosing the best model from a set of options; optimizing model parameters
Optimization	Nonlinear least-squares, curve fitting, root-finding algorithms	Finding quasi-optimal solutions; supply chain parameterization
Interpolation	Multivariate data interpolation, radial basis function	Improving data quality

Source: Own study.

Table (Table 2) presents a selection of method groups, sample algorithms, and their potential applications within a model. It is important to note that this list is not exhaustive; the specific methods and their applications will depend on the unique requirements. Similarly, the examples provided here are illustrative and may not capture the full scope of potential uses.

5. Conclusions

Observations made during the creation of such a model highlight several critical areas essential for its successful implementation. These include the tools and technologies used, the required skills, human resources, and methods derived from the knowledge base. Table 3 provides a detailed breakdown of these areas across the different phases of the method. The analysis of the table reveals the distinction between technical and business-oriented phases, each requiring different tools and human resources. Data analysis emerges as the pivotal stage, where technical knowledge is translated into actionable business insights.

While SC modeling is not a new concept, it has yet to fully integrate BD technology and DS methods into a cohesive approach. Modern SCs increasingly recognize the potential of these methods, as evidenced by their growing application in both business and research. The widespread adoption of DS underscores its immense potential to transform SC operations.

The development of this method relies on the integration of DS methods and their incorporation into decision-making systems. Achieving this requires not only the right technological infrastructure but also adequately skilled human resources. Dividing the modeling process into distinct phases, each with its unique skill set, ensures the effective allocation of specialized resources.

The proposed incremental SC modeling approach has been successfully implemented in a large retail enterprise, showcasing its practical value in an industry characterized by rapid market shifts and intense competition. By integrating new datasets and analytical methods on an iterative basis, the company can adapt swiftly to changes such as fluctuating demand, evolving consumer preferences, or emerging logistical constraints. Rather than having to rebuild the entire model after each adjustment, the incremental framework allows analysts and decision-makers to incorporate fresh insights into existing structures, significantly reducing both time and cost. This flexibility ensures that the model remains resilient and up to date, even as external factors shift.

Table 3.
Summary of Resources Used in Each Phase

Phase	Tools and Technologies	Skills	Human Resources	Knowledge Base
Data Collection	Data Warehouse; ETL tools, data extraction, data parsers	Data security; Effective large-scale data processing; Data quality improvements; Data mapping	BI architect team; Data governance team; Data management team; Personnel responsible for personal data processing; Legal team	Data manipulation; Data processing methods; Data verification methods
Data Analysis	BI Tools; IDE for programming (e.g., Python, R, Scala)	Soft skills — communicating business requirements, analysis goals, and business relations; Analytical — data warehouse usage; Mathematical; Data visualization	Data Scientists; Data Analysts; Business area owners; Key users knowledgeable about business processes	Basic statistical methods; Data Science methods; AI; Model optimization methods; Supply chain modeling methods; Business process descriptions
Decision-Making	BI tools; Results presentation	Business decision-making; Inference; Results interpretation	Business owners; Data Analysts; Managers	Storytelling; Visualization techniques
Model Enrichment	Checklist; Data Warehouse	Model validation; Control of data flows; Model verification	Data Scientists; Data Analysts; Business area owners; Key business users	Model sensitivity assessment methods; Modeling methods

Source: Own study.

A key strength of this method lies in its emphasis on interdisciplinary competencies. The modeling team typically comprises data scientists, information technology specialists, and supply chain managers who collaborate to translate technical outputs into actionable business strategies. Such synergy leverages the deep domain knowledge of operational staff alongside the advanced analytical skills of data professionals. In addition, the approach recognizes the organizational dimensions crucial to successful implementation: clear communication channels, well-defined decision-making processes, and supportive leadership structures are considered integral to sustaining iterative improvements. By proactively

involving a broad range of stakeholders from different departments, the model not only addresses technical and data-related challenges but also aligns with the strategic and organizational realities of the enterprise. This holistic perspective ensures that the incremental SC modeling framework is both technically robust and readily adaptable to the dynamic conditions of the retail sector.

Future research will focus on expanding the model's applicability, integrating risk management strategies, and providing quantitative performance benchmarks to validate its effectiveness.

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ANALYSIS OF TECHNICAL AND TECHNOLOGICAL SOLUTIONS TO SUPPORT ENVIRONMENTAL MANAGEMENT IN A SMART CITY

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Purpose: The aim of the article is to analyze the trends of contemporary city management and environmental management in the city. The article analyzes the technical and technological tools that can support environmental management in the city against the background of problems related to atmospheric air pollution. Tools for improving social communication in order to increase the comfort of life of city residents were also analyzed. The world literature searched for solutions that could be implemented to the conditions prevailing in Poland, where many urban agglomerations have a carpet structure. In the carpet structure, cities are located close to industrial areas, which significantly affect air pollution in inhabited areas.

Design/methodology/approach: The article analyzes world literature on trends in urban environment management and reports on new technical and technological solutions that support environmental management in the city, especially in the context of polluted air. Foreign solutions were analyzed in search of new solutions to the problems of polluted air in the country (in Poland).

Findings: The article presents technical solutions described in the world literature in the field of monitoring the natural environment and improving communication between city authorities and residents in order to improve their quality of life. Then, an analysis of the possibilities of using new technical solutions supporting the management of the natural environment in the city in Polish conditions was made.

Originality/value: As a result of the analyses, examples of technical solutions were found that could support the management of the natural environment in the city, taking into account the specificity of cities located in the center of agglomerations, which is typical of most Polish cities. Tools were also indicated that could improve communication between city authorities and residents in order to improve their quality of life in the city.

Keywords: environmental management, smart city, urban environment monitoring, air monitoring, ICT solutions.

Category of the paper: literature analysis, review article.

1. Introduction

Globalization, urbanization and the introduction of modern technologies into everyday life, as well as maintaining care for existing resources, mean that the development of urban areas depends on new factors. These include advanced technologies, territorial capital, and tangible and intangible resources that determine the functioning of a given area (Stawasz, Sikora-Fernandez, 2016). This means the need for a comprehensive, integrated approach to city management, based on the existing economic, social, spatial-environmental and institutional potential, with the participation of advanced information and communication technologies (Avveduto et al., 2017, Bacco et al., 2017, Dutta et al., 2017, Szafraniec, 2017).

The above-mentioned activities occur in the process of creating smart cities. World rankings of developed cities are being created, taking into account various criteria, such as: human capital, social cohesion, economy, environment, management, urban planning, internationalization, transport and mobility (Jonek-Kowalska, Wolniak, 2019). The list of the prestigious Forbes magazine, published in 2018, includes the world's largest metropolises as examples of smart cities and assessed according to the above-mentioned criteria. The world leaders include: New York, London, Paris, Tokyo, Reykjavik, Singapore, Seoul, Toronto, Hong Kong and Amsterdam (<https://www.forbes.com/...>). In Poland, smart cities include: Warsaw, Wrocław, Opole, Gdańsk, Rzeszów, Katowice, Kraków and others, which are large agglomerations or regional capitals (Sikora-Fernandez, 2018). Currently, the very large role of cities in the social and economic functioning of economies means that they have a huge impact on the lives of residents and the natural environment (Jonek-Kowalska, 2018, Pichlak, 2018). Due to the continuous increase in the number of residents of large cities at the expense of rural regions, it is necessary to provide city residents with safety and comfort of life.

In 2014, the International Organization for Standardization published the ISO 37120 standard as a tool for measuring the quality of life of city residents. Thanks to the standard (PN-ISO 37120, 2015), it is possible to provide a uniform method for assessing the functioning of cities, their involvement in the services provided to residents (Fijałkowska, Aldea 2017, Komsta, 2016; Midor, Płaza, 2020). The standard defines 100 indicators along with the adopted methodology for calculating them, which can be used by cities of different sizes to measure and control the level of their development from the social, economic and environmental point of view (Wolniak, 2019). The indicators are grouped into 17 thematic areas concerning aspects of the city's functioning. The following areas were distinguished (PN-ISO 37120:2015): economy, education, energy, environment, finance, crisis management, local government bodies, recreation, safety, solid waste, telecommunications, innovations, transport, urban planning, sewage management, water and sewage management. In order to use the standard in cities to report a different range of data, five levels of certification were defined in the standard, which

depend on how many of the listed indicators are subject to monitoring in a given city (Wolniak, 2019).

The subject matter discussed in the article is becoming an increasingly important problem in the face of the effects of civilization development, which often leads to the degradation of the natural environment (including that in densely populated urban areas) and causes increasing traffic. The development of technology for sustainable urban development is a necessity to improve the comfort of life of its inhabitants. The article attempts to analyze available technical and technological solutions that could support city management and improve the quality of life of their inhabitants.

2. The level of intelligence in cities and the management of the natural environment of cities

Various sets of principles for creating smart cities can be found in the literature on the subject (Albino et al., 2015; Kaźmierczak, 2019). The most concise principles are presented in (<http://www.masabi.com/...>), where four rules for creating a smart urban space for a city treated as an entity are proposed. The recommendations are as follows:

- Smart cities should be experience-oriented – citizens receive the necessary experience or service in the urban space.
- Smart cities should be oriented towards necessary practical solutions – the city uses knowledge from the past and applies technology adequate to solve specific problems.
- Smart cities should function on the basis of full digitization of all services, especially infrastructure – optimizing services takes into account digitally excluded people.
- Smart city services and infrastructure are seamlessly connected – city infrastructure and service providers share data with residents via mobile access and use good external practices.

The concept of smart city development also distinguishes three different levels of urban space intelligence development (www.smartcitieslibrary.com/...). At each level (1.0, 2.0, 3.0) of urban intelligence development, the composition of stakeholders is the same and includes: technology providers, city managers – city administration and city residents. However, at different levels of advancement of the intelligence of urban space, a different leader emerges (Kaźmierczak, 2019).

At the Smart City 1.0 level, the role of the project leader falls to a company from the ICT sector, which offers a specific technical and technological solution to be implemented in the smart city space. For this reason, the 1.0 level of city intelligence is referred to as technology-driven. On the other hand, at the Smart City 2.0 level, ICT companies provide technical or technological solutions according to the requirements (expectations) of the administrators of

the urban space, who play the role of a leader and shape the vision of the future of the smart city. This level is called the Technology Enabled project. Finally, at the Smart City 3.0 level, a project called Citizen co-creation appears, in which the role of an equal partner for the city authorities in creating the smart city space is played by its residents (Rożałowska, 2016; Ignac-Nowicka et al., 2019, [www.smartcitieslibrary.com/...](http://www.smartcitieslibrary.com/)).

In the pursuit of creating a friendly city, one of the most important factors is taking into account the needs of its residents and their opinions on the quality of life in the city (Ignac-Nowicka, 2020, 2024), as well as strengthening social activities, which leads to building social capital, especially in the case of projects at the Smart City 3.0 level (Stawasz, Sikora-Fernandez, 2016, Ignac-Nowicka, 2018a, 2019). A friendly (clean) natural environment in the city is one of the most important and basic needs of its residents. Proper management of the natural environment seems to be a basic action in the sustainable development of the city.

3. Directions of development of natural environment management in a smart city

Monitoring the environment in smart cities is a key element of sustainable urban management. It involves using modern technologies to constantly monitor the quality of air, water, soil and other parameters that affect the health of residents and the condition of the urban ecosystem. In detail, it can be said that environmental management in the context of a smart city covers the following areas (Buczaj, Michalak, 2018, Ignac-Nowicka et al., 2020, Prawelska-Skrzypek, Bleharczyk, 2022; Bacco et al., 2022):

- Waste management - the use of advanced technologies to monitor and optimize the collection and processing of municipal waste.
- Green infrastructure - creating gardens on the roofs of buildings (green roofs), creating living wall installations and developing urban agriculture (urban farming) to improve air quality and microclimate.
- Environmental monitoring - implementation of systems monitoring air, water and soil pollution, which allows for ongoing response to ecological threats.
- Energy efficiency - the use of intelligent energy management systems in buildings and urban infrastructure to reduce energy consumption and greenhouse gas emissions.
- Water resources management - implementation of technologies to monitor and optimize water consumption and rainwater retention and recycling systems.
- Urban mobility - promoting ecological means of transport, such as city bikes or electric vehicles, and the development of intelligent traffic management systems.

In smart cities, waste management is based on the use of modern technologies, such as the Internet of Things (IoT), IT systems and data analytics, to optimize the processes of waste collection, segregation and disposal. The aim of these activities is to minimize the negative impact on the environment and increase operational efficiency. Examples of solutions include (Bondar et al., 2023):

- Smart waste containers - equipped with sensors monitoring the fill level, which allows for the optimization of collection routes and reduction of transport costs.
- Waste identification systems - RFID technologies enable tracking and identification of waste, which supports recycling and disposal processes.
- Analytical platforms - analysis of data collected from various sources allows for forecasting the amount of waste generated and planning preventive measures.

Green infrastructure in smart cities is a system of interconnected green areas, such as parks, gardens, green roofs and walls, which integrate natural elements with urban infrastructure. The aim of their creation is to improve the quality of life of residents, increase biodiversity and adapt to climate change. Examples of solutions in this area include the creation of (Szymańska, 2023):

- Green roofs and walls, which reduce the urban heat island effect, improve building insulation and increase the biologically active surface.
- Pocket parks, i.e. small green areas in densely built-up urban areas, which provide places for recreation and improve the microclimate.
- Rainwater retention systems by using green spaces to collect and filter rainwater, which reduces the risk of flooding and relieves the sewage system.

Monitoring the environment in a smart city involves the continuous collection and analysis of data on the quality of air, water, soil and noise levels. Sensor networks, drones and satellite technologies are used for this purpose, which allows for a quick response to ecological threats and making data-based decisions. An example is the creation of a network of air quality sensors that monitor pollutant concentrations and provide information to city residents about the current state of the air. Another example is the use of noise monitoring systems, which allows for the identification of sources of excessive noise and support the planning of reduction measures. In turn, the analysis of satellite data allows for the assessment of changes in land cover, the identification of illegal landfills or monitoring the health of urban vegetation (Bacco et al., 2022).

Energy efficiency is also very important in smart cities, which refers to the optimization of energy consumption in buildings, transport and urban infrastructure through the use of modern technologies and intelligent management systems. The aim of such efforts is to reduce greenhouse gas emissions, reduce operating costs and increase the energy independence of the city. Solutions include (Olszewski, Gotlib, 2023):

- Intelligent building management systems (BMS) - automate lighting, heating and air conditioning control based on the actual needs and presence of users.
- Intelligent energy networks (smart grids) - integrate renewable energy sources, energy storage and dynamic demand management, which increases the stability and efficiency of the energy system.
- LED street lighting with motion sensors - reduces energy consumption by adjusting the intensity of lighting to actual needs.

In the context of smart cities, water resource management includes monitoring and optimizing water consumption, controlling the quality of surface and groundwater, and implementing intelligent water retention and recycling systems to minimize losses, improve distribution efficiency, and provide residents with clean water. Technical solutions in this area include (Orłowski, Rosińska, 2018; Zhu, Zhang, 2023):

- Smart water meters that allow for real-time monitoring of water consumption and leak detection.
- Rainwater management systems that use GIS and IoT technologies to optimize the use of rainwater and prevent flooding.
- Modern filtration technologies for water purification and reuse that allow for the recovery of gray water for economic and industrial purposes.

Sustainable transport in smart cities aims to reduce CO₂ emissions, reduce traffic jams and improve the mobility of residents through the integration of modern technologies and transport systems. An important idea is the development of alternative means of transport that reduce the number of cars in cities (city bikes) and the development of electromobility. A specific solution is the optimization of bus and tram routes based on traffic data - AI-controlled public transport (Geels, Schot, 2023).

In addition, smart cities aim to engage residents in decisions regarding environmental protection through digital platforms, mobile applications and educational campaigns. Digital social participation and environmental education can use city applications (tools for reporting environmental problems, e.g. illegal dumps or sewage failures), programs rewarding ecological habits (e.g. waste segregation, use of public transport) and open data platforms with access to environmental information and statistics related to air quality or energy consumption (Arnstein, 2023).

Environmental management in smart cities covers many aspects, from waste management, through environmental monitoring, water management, transport, to environmental education and social participation. IoT, AI, ICT, GIS and big data technologies play a key role in achieving goals related to sustainable development and improving the quality of life of residents (Strzelecka et al., 2017, Stawiarska, Sobczak, 2020).

4. Technical and technological solutions for monitoring air quality in the city

In most large and medium-sized Polish cities, especially in winter, the permissible air pollution standards are exceeded (Kaczmarczyk et al., 2015, Ignac-Nowicka, 2018a, 2018b). The World Health Organization considers atmospheric air pollution to be the greatest health hazard, which increases the risk of developing lung and/or heart diseases, as well as many others (Soussilane et al., 2017). Gaseous and particulate anthropogenic pollution as a result of human economic activity comes mainly from the combustion of coal, liquid fuels and gases, as well as mechanical or thermal processing of natural resources (Kaczmarczyk et al., 2015). In such a situation, an important goal of urban development is to improve environmental conditions and their control, especially air quality (Rossi, Tosato, 2017).

Protection and monitoring of air quality in cities is based on the implementation of various technical and technological solutions. Currently, attempts are being made to introduce integrated technologies to manage air quality in cities, such as: data collection by unmanned aerial vehicles supported by IoT, the use of Information and Communications Technology (ICT), complex event processing (CEP), and many others.

An interesting application is the use of IoT and drone technology. Integration of the Internet of Things (IoT) with drones enables the creation of mobile monitoring platforms that can collect data from hard-to-reach urban areas. This approach allows for obtaining more detailed and spatially differentiated information on air pollution. The publication (Hu et al., 2018) presents a real-time, detailed and energy-efficient air quality monitoring system based on aerial and ground measurements. The architecture of this system consists of four layers: measurement layer for data collection, transmission layer for enabling bidirectional communication, processing layer for analyzing and processing data, and presentation layer for providing graphical interface for users. In the implementation, three main techniques are studied, given by data processing, implementation strategy and power control. For data processing, spatial matching and short-term forecasting are performed to eliminate the influences of incomplete measurements and data transmission delay. Implementation strategies of ground and airborne measurements are studied to improve the quality of collected data. Power control is further considered to balance power consumption and data accuracy. The solution has been operating at Peking University and Xidian University since February 2018 (Hu et al., 2018).

Another example is an innovative, multidisciplinary and cost-effective ecosystem of ICT (Information and Communications Technology) solutions that enables the collection, processing and distribution of geo-referenced information on the impact of pollutants and microclimatic conditions on the quality of life in smart cities. This system was developed and experimentally evaluated within the framework of the Smart Healthy Environment research project, co-financed by the Tuscany Region (Italy). The system developed an innovative

monitoring network, consisting of fixed and mobile sensor nodes, that provide comparable measurements in stationary and mobile conditions (Bacco et al., 2022). In addition, the sensor data were enriched with data generated by citizens using a dedicated mobile application, using the participatory sensing paradigms of the subjects themselves, i.e. citizens (Bielecka-Prus, 2013) and mobile social networks.

Another example of a technological solution for monitoring air quality is the use of Complex Event Processing (CEP) based on rules and SPARQL queries (Kumar et al., 2024). The use of advanced CEP analytical systems enables real-time analysis of data, e.g. on air quality. In turn, SPARQL queries are used for: searching for information in knowledge bases, processing data in the semantic web, integrating various data sources in the RDF (Resource Description Framework) format. The Semantic Web is an extension of the traditional www network that allows for more intelligent and automated processing of data thanks to their unambiguous description and mutual connections. It is based on a structure in which information is not only presented, but also understandable to machines, which allows for better analysis and integration and the use of artificial intelligence. On the other hand, the RDF format combines data resources into RDF triples, which have the form: subject - predicate - object (e.g.: for testing air quality in a given area, the connection of three elements: air composition (quality), tested area, cause of pollution, e.g.: burning tires). The authors of the publication (Kumar et al., 2024) from the Indian Institute of Information Technology in Allahabad (India) used CEP analytical systems to collect a data set from the Central Pollution Control Board (CPCB) in India and use this data to test the implementation of CEP systems for monitoring air quality in a smart city.

In Poland, a network of ground sensors is used to monitor air quality, data is processed (e.g. in the cloud) and presented in the form of, for example, visual (pollution maps) and alerts (SMS messages) about the air quality in a given area in appropriate applications (including mobile ones), which are available to city residents. The installation of a network of sensors allows for ongoing monitoring of atmospheric pollutant concentrations, such as PM10 and PM2.5 suspended dust, nitrogen dioxide (NO₂) or sulfur dioxide (SO₂). This data is crucial for informing residents about the current state of the air and taking intervention measures. Actions towards the fight for clean air are carried out in Poland, among others, through the development of the Air Quality Monitoring System (www.gov.pl/web/gios/...). Currently, air quality measurements are carried out in Poland at 1,782 measurement stations, including 1022 automatic stations (57% of all stations) and 760 manual stations (43% of all stations). The largest number of measurement stations operating within the State Environmental Monitoring are located in the Silesian Voivodeship (200), Kuyavian-Pomeranian Voivodeship (169), Lower Silesian Voivodeship (162), Lesser Poland Voivodeship (161) and Mazovia Voivodeship (150), in areas with high concentrations of air pollutants (<https://powietrze.gios.gov.pl/pjp/>...).

The fewest stations are located in the Opole province, where in 2025 air quality monitoring was expanded to 62 locations, which was another action aimed at fighting for clean air ([www.opole.pl/dla-mieszkanca/...](http://www.opole.pl/dla-mieszkanca/)). In order to obtain information, among others, on the spatial distribution of concentrations of individual pollutants, measurements can be supplemented with the results of mathematical modeling of the spread of pollutants (pollution forecasts). Data from measurement stations are collected in the national database JPOAT3.0 of the Chief Inspectorate for Environmental Protection (<https://powietrze.gios.gov.pl/pjp/maps/modeling>).

5. Summary and conclusions

Currently, many new technical and technological solutions are being introduced in the world to manage cities and the natural environment in the city, including:

- GIS technology to track pollution in a given area.
- Use of drones to monitor the environment.
- RFID technology, e.g. to track waste.
- Use of the Internet of Things (IoT) – a network of sensors.
- Use of ICT to communicate with city residents.
- Use of complex event processing (CEP) to search and analyze data networks about threats in the natural environment.

The use of these technologies will certainly affect the high development (smart city 3.0) of cities. However, not all cities can currently move towards the use of the most advanced technologies for managing the natural environment in the city. However, in order to improve air quality, it is possible and necessary to expand activities to many areas of action within cities, such as: modernization of heating systems, increasing green areas in urban space, limiting car traffic with combustion engines and ecological education of residents, in particular regarding the combustion of solid fuels in furnaces. If we want to breathe clean air, even the best actions in only one field will not help in the fight against smog, which is why it is necessary to act comprehensively in every area.

Analyzing the technical and technological solutions currently used in the world, it can be seen that some of them have already been implemented in Polish cities, and the further development of these applications will probably concern the dissemination of certain environmental control standards throughout Poland. Drones are successfully used in many Polish cities to monitor the environment and detect illegal emitters of air pollution. The GIS, RFID, Internet of Things (IoT) technologies analyzed in the article, or the use of ICT for communication with city residents are solutions that can be used in Polish cities. The only limitation may be the financial sphere, and therefore the too small range of the solutions used.

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COMPARATIVE ENERGY TRANSFORMATION MANAGEMENT: POLAND AND GERMANY'S PATH TO SUSTAINABILITY

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Purpose: This article examines the approaches to energy transition management in Poland and Germany. Its primary objective is to analyze the lessons that can be derived from each country's experience to inform and guide their respective future transformation processes.

Design/methodology/approach: To initiate the research, a baseline literature review was undertaken, employing a combination of critical review methodologies, online searches, and the exploration of multidisciplinary academic databases such as Scopus and Google Scholar. To gain a comprehensive understanding of the issue under analysis, the study adopted a multi-method research design. This approach integrated various analytical techniques to examine the energy transition processes in both countries, including comparative analysis, secondary data analysis, policy analysis, and case study analysis.

Findings: The research indicates that energy transition governance in Poland and Germany reflects two distinct yet instructive models, shaped by historical legacies, socio-political contexts, and economic priorities. The study seeks to extract lessons from each country's experience that can inform and support their respective future transformation pathways.

Originality/value: This paper contributes to the scientific discourse by offering a comparative analysis of energy transformation management in Poland and Germany, two countries with contrasting historical, socio-political, and economic contexts. It advances existing research by identifying key governance models, policy instruments, and institutional frameworks that shape national energy transitions. By synthesizing lessons learned from both cases, the study provides a nuanced understanding of context-specific and transferable strategies for effective energy governance. This comparative perspective enriches the literature on sustainable energy transitions and offers actionable insights for policymakers navigating similar transformation challenges.

Keywords: Energy Transition in Poland, Energy Transition in Germany, Management, Governance, Transition governance models.

Category of the paper: research paper.

1. Introduction

The energy transition represents one of the most critical challenges of the 21st century, shaping the future of the global climate system, economy, and energy security. Its effectiveness and pace are fundamental in mitigating the adverse effects of climate change and ensuring stable socio-economic development. The shift away from coal and the broader energy transition pose significant challenges for industrialized countries, particularly those whose economies have historically been reliant on fossil fuels. Poland and Germany exemplify this dynamic, as the coal industry has played a fundamental role in their economic development and energy security for decades. The historical trajectory of coal mining in Germany and Poland underscores the sector's crucial role in industrialization, economic stability, and energy security. Throughout the nineteenth and twentieth centuries, both countries structured their economies around coal, shaping their respective industrial landscapes. The coal industry was instrumental in the industrial development of Germany and Poland, with two primary regions—Germany's Ruhr Valley and Poland's Silesia—serving as focal points for this expansion. In Germany, the Ruhr Valley was a cornerstone of the country's industrialization throughout the nineteenth and early twentieth centuries. By the mid-twentieth century, it accounted for more than 80% of Germany's hard coal production, supplying energy for the metallurgical sector, heavy industry, and post-war reconstruction (Wesseling et al., 2017). Similarly, Silesia, located in southern Poland, emerged as the country's industrial hub, with coal mining playing a pivotal role in its economic development. Throughout the twentieth century, Silesia remained at the centre of Poland's extractive sector, contributing the majority of the nation's coal production (Bondaruk, 2023). By the mid-twentieth century, structural inefficiencies within the coal industry in both Germany and Poland had begun to emerge. Increasing operational costs, competition from cheaper coal imports, and the depletion of high-quality coal reserves contributed to the sector's declining profitability. Changing economic conditions, growing environmental concerns, and international climate commitments necessitated structural transformations within the coal industry in both countries. Environmental considerations have played a significant role in shaping the trajectory of the coal sector's transformation. Both the Ruhr Valley and Silesia have experienced adverse consequences due to extensive coal extraction, including land subsidence, water contamination, and deteriorating air quality. The Ruhr Valley has become a centre for post-mining land reclamation initiatives, while air pollution levels in Silesia remain among the highest in Europe, generating increasing societal and political pressure to accelerate the energy transition. Germany and Poland have adopted distinct approaches to restructuring their coal industries. The German energy transition has been embedded within a broader energy and climate policy framework. The *Energiewende* program (Jacobsson, Lauber, 2006) has encompassed economic diversification through the development of new industrial sectors, investments in renewable energy—particularly wind and solar power—programs for the

retraining and reintegration of former coal workers, and large-scale environmental reclamation projects aimed at revitalizing former mining areas. Poland's energy transition has been more gradual and remains ongoing. Between 1994 and 2005, 38 coal mines were closed, financed by the Liquidation Fund and the state budget. However, Poland continues to face significant social and political resistance to coal phase-out, coupled with a slower expansion of renewable energy sources. Coal remains the dominant component of the country's energy mix, delaying the transition toward a more sustainable energy system. This paper undertakes a comparative analysis of the governance models of energy transition in Poland and Germany, examining the historical context of the transition, the legal framework and legislative initiatives governing coal phase-out, the timeline for fossil fuel reduction in both countries, financial mechanisms supporting the transition, public consultation and stakeholder engagement efforts, and broader governance structures facilitating the transition process.

2. Materials and methods

To initiate the research, a baseline literature review was conducted using a combination of critical literature review methods, online literature searches, and an examination of multidisciplinary academic databases, including Scopus and Google Scholar. The search strategy employed key terms such as "Energy Transition", "Energy Transition Governance in Poland", and "Energy Governance Transition in Germany" to ensure a broad yet focused collection of relevant sources. For the mapping the methodology of VOS-viewer has been used. VOS-viewer is a special tool that uses the software for visualizing and constructing bibliometric networks, which include for example journals, researchers, or individual publications, and they can be constructed based on citation, bibliographic coupling, co-citation, or co-authorship relations. The literature review identified energy transition as a systematic shift towards clean and sustainable energy sources. Furthermore, it highlighted significant differences in Energy Transition Governance between Poland and Germany.

Source: VOS viewer.

decline significantly in the longer future. The green section of the graph marks the contribution of renewable energy sources, such as wind and solar. Although Poland has taken steps to promote renewables, their overall share remains modest. The literature indicates a slow and incremental increase in the adoption of renewables, aligning with the national goal of reaching 32% renewable electricity by 2030. Compared to countries like Germany, Poland's progress is slower due to its entrenched reliance on coal and the political and economic complexities of energy reform. Natural gas, typically shown in yellow, is gaining significance as a transitional energy source in Poland's strategy. It is viewed as a temporary solution that can help reduce carbon emissions while maintaining energy security during the coal phase-out. The graph likely shows a steady rise in natural gas use, particularly with investments in new gas-fired power plants. However, some sources caution that this may prolong the transition to a fully renewable system if over-relied upon. Other energy types, such as nuclear power and hydropower, are represented by blue or light grey. Poland is in the process of developing its first nuclear power plants and expanding offshore wind capacity, indicating a broader diversification of the energy mix. The literature suggests that these sources, while still limited in share, are projected to grow steadily and play a more substantial role post-2030. The graph reflects this by showing a gradual increase in their presence. Key policy goals and transition milestones are usually emphasized using red. Notable markers include the target of reducing coal-based electricity to 30% by 2030 and the strategic timeline set out in the Energy Policy of Poland until 2040 (PEP2040). These milestones are crucial indicators of progress and are visually accentuated in the graph to track Poland's advancement—or delays—in achieving its energy goals. Overall, Poland's energy transition graph visually encapsulates the country's cautious but determined shift toward sustainability. Despite significant reliance on coal, gradual diversification efforts and policy milestones signal a growing momentum for change, albeit at a more conservative pace than seen in some of its European counterparts.

To develop a more comprehensive understanding of the analysed issue, the study employed a multi-method research approach, integrating several analytical techniques to examine the energy transition in both countries:

- Comparative Analysis was employed to systematically assess the policies, strategies, and outcomes of the energy transition in Poland and Germany. This approach encompassed political, economic, and social dimensions, allowing for a holistic evaluation of transformation processes.
- Secondary Data Analysis supplemented the research by reviewing existing reports, government documents, national and regional energy strategies, and statistical data from authoritative sources such as Eurostat, the International Energy Agency (IEA), and the BP Statistical Review of World Energy. This data-driven approach facilitated an empirical evaluation of key trends and policy impacts.

- Policy Analysis was conducted to evaluate the effectiveness of governmental strategies in Poland and Germany, with particular attention to regulatory frameworks and climate policies. This analysis included an assessment of legislative measures such as the European Commission's "Fit for 55" package, Germany's *Energiewende*, and Poland's Energy Policy 2040. The objective was to examine the broader policy implications for energy sector transformation and long-term sustainability goals.
- Case Study Analysis focused on a comparative examination of two post-mining regions: Silesia in Poland and the Ruhr Valley in Germany. This analysis provided insights into regional adaptation strategies, socio-economic restructuring, and the challenges associated with transitioning away from coal-dependent industries.

By integrating these methodological approaches, the study aimed to develop a nuanced and evidence-based understanding of the energy transition in both national and regional contexts. To compare the models of energy transition management in Poland and Germany, the following key factors were taken into consideration:

- The historical context of the energy transition in both countries.
- The legal framework and legislative initiatives governing coal phase-out.
- The role of public consultation and stakeholder engagement efforts in shaping energy policies.

This comparative framework enabled a structured assessment of the governance models shaping the energy transition in Poland and Germany, providing valuable insights into policy effectiveness and implementation challenges.

3. Energy Transformation Management in Poland and Germany

Historical context of the transition in Poland and Germany

The historical trajectory of coal mining in Germany and Poland highlights the sector's critical role in industrialization, economic stability, and energy security. Both nations heavily relied on coal throughout the 19th and 20th centuries, shaping their respective economic landscapes. However, as global economic and environmental priorities shifted, coal-dependent economies faced significant challenges, leading to restructuring and an eventual decline in coal production. While Germany pursued an early transition in response to economic pressures and environmental concerns (Renn, Marshall, 2020). Poland's transition—particularly in the Silesian region—has been more gradual due to the continued socio-economic reliance on coal (Grudziński, Olkusi, 2019). Two key regions stood at the forefront of the economic and industrial expansion in both Germany and Poland: the Ruhr in Germany and Silesia in Poland. In Germany, the Ruhr region was the backbone of the country's industrialization in the 19th

and early 20th centuries. By the mid-20th century, it accounted for over 80% of Germany's hard coal production, supplying energy for steel manufacturing, heavy industries, and post-war reconstruction (Matthes, 2017). The economic dominance of coal mining transformed the Ruhr into an industrial giant, with cities like Essen, Dortmund, and Bochum emerging as key centers of mining and steel production (Cheung et al., 2017). Similarly, Silesia, located in southern Poland, became the country's industrial core, with coal mining playing a decisive role in economic development. Throughout the 20th century, Silesia was the centre of Poland's mining sector, responsible for the vast majority of the country's coal extraction (Cappellano et al., (2024). At its peak in 1990, Poland operated 71 coal mines, employing nearly 400,000 workers, and most of these mines were concentrated in Upper Silesia. Both regions developed strong economic identities around coal, but their transitions away from coal have followed different paths. By the mid-to-late 20th century, structural inefficiencies in coal mining became evident in both Germany and Poland. Rising operational costs, competition from cheaper imports, and the depletion of high-quality coal deposits led to increasing financial strain on domestic coal industries (Weidner, Mez, 2008). The Ruhr region faced mounting economic constraints in the 1960s, exacerbated by competition from cheaper imported coal, particularly from the United States and Australia (Wigand, Amazo, 2017). The discovery of alternative energy sources such as nuclear power and natural gas further reduced the economic viability of coal mining (Wirth, Schneider, 2015). Additionally, Germany's commitment to international climate agreements, including the Paris Agreement, accelerated efforts to phase out coal (Eloy, 2016). In Poland, similar economic inefficiencies emerged, particularly in Silesia. The sector struggled with overproduction, high operational costs, outdated infrastructure, and reliance on state subsidies (Fischer et al., 2016). Environmental concerns also played a crucial role in shaping the coal transition. Both the Ruhr and Silesia suffered from severe ecological damage, including land subsidence, water contamination, and deteriorating air quality (Jungjohann, Morris, 2014). The Ruhr region became a focal point for environmental restoration efforts, with large-scale land rehabilitation projects and investments in alternative industries. Meanwhile, in Silesia, pollution levels remained high due to continued coal dependence (Rogala, Cieřlik2020). The region is home to some of the most polluted cities in Europe, including Katowice and Rybnik, where air quality concerns have led to growing public and political pressure to accelerate the energy transition (Rogall, 2020). Despite these concerns, resistance to coal phase-out remains strong due to its economic significance in Poland (Topaloglou et al., 2024).

4. Legal Context and legislative initiatives on transition in Poland and Germany

The transition from coal dependency to a low-carbon economy is one of the most significant energy transformations in Europe. Both Poland and Germany have adopted structured policies to phase out coal, aligning their strategies with European Union climate targets. However, these two countries face distinct economic, political, and social challenges in implementing their energy transitions. While Germany has established a comprehensive legal framework for coal phase-out, with a clear timeline and strong economic compensation mechanisms, Poland's transition remains gradual, balancing energy security concerns, economic stability, and EU climate commitments (Agora Energiewende, 2015). Both Poland and Germany have implemented national policies and legislative frameworks to guide their coal phase-out processes. However, Germany's legal approach is characterized by legally binding phase-out dates and financial compensation mechanisms, whereas Poland's strategy is more flexible, accommodating the ongoing reliance on coal for energy security.

Germany has implemented a series of ambitious legislative and policy frameworks to drive its energy transition and achieve climate neutrality such as:

- **Federal Climate Protection Act (2019)**

Known as the Bundes-Klimaschutzgesetz, this act legally binds Germany to meet both national and EU climate targets. It affirms Germany's pledge to pursue greenhouse gas neutrality by 2050, as announced at the UN Climate Summit in 2019. The act provides a roadmap for emissions reductions across sectors and guides the country's Climate Action Programme to 2030. This groundbreaking act of legislation establishes a legally binding framework for Germany's climate policy, anchoring the country's national and EU climate obligations into law. It reflects Germany's commitment to achieving greenhouse gas neutrality by 2050.

The act sets sector-specific annual emission reduction targets for areas such as energy, industry, transport, buildings, agriculture, and waste management. These targets are monitored and enforced by an independent Council of Experts on Climate Change, which evaluates annual emissions reports and advises on corrective measures if targets are missed.

Key features of the Act include:

- A binding reduction path for greenhouse gas emissions up to 2030, aiming for a 55% reduction compared to 1990 levels.
- Annual reporting and transparency mechanisms to ensure accountability across all sectors.
- Empowerment of federal ministries to take responsibility for emissions in their sectors and implement necessary actions.
- Legal recourse and mandatory adjustments if sectors fail to meet their targets.

The Federal Climate Protection Act also supports Germany's broader Climate Action Programme 2030, which includes investments in renewable energy, public transport, energy-efficient buildings, and sustainable mobility. Overall, the act not only strengthens climate governance in Germany but also provides long-term policy certainty for stakeholders involved in the energy transition.

- **Coal Exit Act (2020)**

Officially named the *Gesetz zur Reduzierung und zur Beendigung der Kohleverstromung*, the Coal Exit Act lays out a legally binding roadmap for the complete phase-out of coal-fired power generation in Germany by 2038. This law represents a cornerstone of Germany's broader climate strategy, signalling a decisive move away from fossil fuels toward a more sustainable and renewable-based energy system. The act stipulates a gradual reduction of coal capacity, with intermediate targets and milestones. It includes differentiated timelines for phasing out hard coal and lignite (brown coal), the latter of which is more carbon-intensive and concentrated in specific regions like Lusatia and the Rhineland.

Key components of the Coal Exit Act include:

- €40 billion support package for the most affected coal-dependent regions. This funding is aimed at:
 - Economic restructuring and job creation in new industries.
 - Infrastructure development and education initiatives.
 - Attracting innovation and clean technology investments.
- Compensation mechanisms for utility companies and workers affected by early plant closures.
- Auction schemes to incentivize power plant operators to voluntarily shut down coal capacity in a cost-effective and competitive manner.
- Modernization and transition support for combined heat and power (CHP) systems to convert them to more climate-friendly technologies.
- Legal commitments to review the coal phase-out timeline by 2026, with the possibility of bringing forward the 2038 deadline, particularly in light of evolving EU climate targets and Germany's own energy market developments.

Importantly, the act also ensures that the coal exit is aligned with energy security and grid stability, especially during the transition period when Germany is also decommissioning its nuclear power plants. The scale of the transition—reflected in the allocation of nearly 11% of the federal budget in 2020—underscores the socio-economic and political significance of this policy.

- **Renewable Energy Sources Act (EEG 2023)**

The *Erneuerbare-Energien-Gesetz (EEG)*, originally enacted in 2000, has long been the legislative backbone of Germany's renewable energy expansion. Over the years, it has been revised multiple times to adapt to changing market conditions, technological advancements, and climate policy goals. The 2023 amendment of the EEG marks one of the most ambitious

iterations to date, reflecting Germany's intensified commitment to accelerating the energy transition.

The EEG 2023 sets a bold new target: by 2030, 80% of Germany's electricity consumption must be covered by renewable energy sources, such as wind, solar, biomass, and hydroelectric power. This is a critical milestone on the path to achieving greenhouse gas neutrality by 2045.

Key features and objectives of the EEG 2023 include:

- Accelerated expansion of wind and solar power, with legally defined annual capacity addition targets (e.g., 10 GW/year for onshore wind and up to 22 GW/year for solar PV).
- Simplified permitting procedures to remove bureaucratic barriers and speed up project development, especially for wind farms and rooftop solar installations.
- Grid modernization and digitalization measures to ensure that renewable energy can be efficiently integrated into the public electricity grid and distributed nationwide.
- A shift from fixed feed-in tariffs to market-based premiums, promoting cost-efficiency and competition among energy producers.
- A strengthened focus on citizen participation and community energy, allowing local cooperatives and individuals to benefit more directly from renewable energy projects.
- Support for innovative technologies and flexibility solutions, such as energy storage, smart grids, and hydrogen production from surplus renewables (power-to-x technologies).
- Integration of climate justice and social equity principles, including mechanisms to limit energy costs for consumers and provide support for low-income households.
- **Energy Policy of Poland until 2040 (PEP2040)**

The *Polityka Energetyczna Polski do 2040 roku (PEP2040)* represents Poland's most comprehensive and strategic approach to energy planning in over a decade. Officially adopted in 2021, it sets the foundation for a long-term, gradual transformation of Poland's energy sector in alignment with European Union climate and energy goals.

At the heart of PEP2040 lies the principle of a just and inclusive energy transition, ensuring that no region or social group is left behind. This is particularly relevant for Poland, a country historically reliant on coal, where large parts of the workforce and regional economies are still deeply embedded in fossil fuel industries.

Key pillars of the PEP2040 include:

1. Diversification of the Energy Mix

PEP2040 charts a clear shift away from coal and towards low- and zero-emission energy sources. By 2040, coal's share in electricity generation is expected to fall significantly, replaced by:

- Offshore wind energy, with a planned capacity of up to 11 GW by 2040.
- Onshore renewables, including solar PV and biomass.

- The commissioning of Poland's first nuclear power plant in 2033, with further units to follow, forming a stable low-emission energy backbone.

2. Energy Security and Supply Stability

The strategy prioritizes the reliability and resilience of Poland's energy system, especially in the context of growing energy demand and shifting geopolitical conditions. This includes:

- Modernizing and expanding the electricity grid.
- Building energy storage capacity and smart grid infrastructure.
- Enhancing gas infrastructure as a transition fuel.

3. Economic Competitiveness and Innovation

PEP2040 underscores the importance of a competitive energy sector that supports economic growth and job creation. It promotes:

- Investment in research and innovation, particularly in clean technologies.
- The development of domestic supply chains for renewable energy components.
- Support for energy-intensive industries in reducing their carbon footprint while maintaining global competitiveness.

4. Just Transition for Coal Regions

Recognizing the socio-economic challenges of moving away from coal, the policy includes targeted support for coal-dependent regions like Silesia. This includes:

- Retraining programs for workers.
- Support for small and medium enterprises (SMEs).
- Investments in education, infrastructure, and alternative industries.

5. Energy Efficiency and Consumer Empowerment.

Improving energy efficiency across all sectors is a key goal. The policy aims to:

- Reduce primary energy consumption.
- Promote energy-saving technologies in buildings and industry.
- Increase consumer participation in energy production through prosumer initiatives (e.g., rooftop solar).

• **National Energy and Climate Plan (NECP) 2021–2030**

Poland's Updated National Energy and Climate Plan (NECP) for 2021-2030 is a strategic framework designed to align national energy and climate policy with the broader European Green Deal and EU climate targets, while carefully considering Poland's unique economic and energy landscape. It builds on the original NECP of 2019, strengthening ambitions across key areas in response to the European Union's increased climate targets for 2030.

This updated NECP sets forth a comprehensive set of targets and policy measures to drive the green transformation of Poland's economy, modernize the energy system, and ensure energy sovereignty. It provides a blueprint for decarbonization, energy efficiency, and a just transition over the next decade.

Key Goals and Commitments:

- 50.4% reduction in greenhouse gas emissions by 2030 (vs. 2020 levels). Poland plans a significant emissions cut through the phasing out of coal, scaling up of renewables, and enhanced energy efficiency measures. This marks a substantial step forward, given Poland's traditionally coal-dependent energy mix.
- 56% share of renewables in electricity generation. The plan anticipates rapid growth in solar PV, onshore wind, and offshore wind, as well as a larger role for biomass and biogas in the energy mix. Offshore wind is projected to be a game-changer, with multi-gigawatt scale projects planned in the Baltic Sea.
- 16.7% reduction in primary energy consumption. Efficiency improvements will span across sectors—particularly in residential buildings, transport, and heavy industry—with incentives for retrofitting, energy management systems, and smart metering.
- ~PLN 792 billion (€170+ billion) investment in the energy transition. This unprecedented investment will be channelled into:
 - Clean energy infrastructure (generation, transmission, and distribution).
 - Grid modernization and digitization.
 - Renewable energy deployment and innovation.
 - Support for new green technologies and manufacturing capabilities.
- Strengthening energy security and resilience. The NECP addresses Poland's reliance on fossil fuel imports and promotes a more self-sufficient energy system, bolstered by renewables, modern grid infrastructure, energy storage, and diversified energy sources.
- Support for coal regions and social cohesion. Through a just transition strategy, the plan ensures that communities affected by the decline of coal receive financial, technical, and institutional support. This includes retraining programs, job creation in clean industries, and targeted regional development initiatives.
- Promotion of clean tech and innovation. The plan recognizes the crucial role of innovation in decarbonization, emphasizing R&D in areas like green hydrogen, energy storage, electromobility, smart grids, and carbon capture. It also aims to foster domestic innovation ecosystems and public-private cooperation.

Table 1.*Key legal initiatives on transition in Poland and Germany*

Country	Policy/Legislation	Year	Objectives and Key Features
Germany	Federal Climate Protection Act (Bundes-Klimaschutzgesetz)	2019	<ul style="list-style-type: none"> - Legally binding climate neutrality by 2050. - Sector-specific emission reduction targets (55% by 2030 vs. 1990). - Independent oversight and annual reporting. - Legal recourse for missed targets. - Supports Climate Action Programme 2030.
Germany	Coal Exit Act	2020	<ul style="list-style-type: none"> - Complete coal phase-out by 2038 with interim milestones. - €40 billion for regional transition support. - Compensation for affected companies/workers. - Auction mechanisms for plant closures. - Review possibility to expedite exit by 2026.

Cont. table 1.

Germany	Renewable Energy Sources Act (EEG 2023)	2023	<ul style="list-style-type: none"> - Target of 80% renewable electricity by 2030. - Defined annual capacity additions (wind 10 GW, solar up to 22 GW). - Simplified permitting procedures. - Shift to market-based incentives. - Emphasis on citizen participation and community energy. - Support for innovative technologies and social equity.
Poland	Energy Policy of Poland until 2040 (PEP2040)	2021	<ul style="list-style-type: none"> - Just transition from coal, diversified energy mix (offshore wind up to 11 GW by 2040, nuclear from 2033). - Energy security and grid resilience improvements. - Economic competitiveness and innovation. - Targeted regional support for coal regions. - Enhanced energy efficiency and consumer participation.
Poland	National Energy and Climate Plan (NECP) 2021-2030	2021	<ul style="list-style-type: none"> - 50.4% GHG emissions reduction by 2030 (vs. 2020). - 56% renewable electricity by 2030 (solar, onshore/offshore wind, biomass). - 16.7% primary energy consumption reduction. - PLN 792 billion (€170+ billion) energy transition investment. - Enhanced energy security, grid modernization, and support for coal regions. - Promotion of innovation (hydrogen, storage, electromobility).

Source: Own study.

While both Germany and Poland have established legislative frameworks for coal phase-out, the effectiveness of policy implementation varies considerably between the two countries, influenced by political will, institutional capacity, and socio-economic dynamics. Germany has made substantial progress in operationalizing its coal exit strategy. The Coal Phase-Out Act and the Climate Protection Act provide a robust legal foundation, ensuring policy continuity and investor confidence. The €40 billion allocated for regional development has enabled some coal regions, like the Ruhr, to pivot towards service industries and renewable energy. Moreover, the share of coal in Germany's electricity mix has steadily declined, with renewables contributing over 50% to electricity generation as of 2023. However, implementation gaps remain. Critics argue that financial compensation has disproportionately favored large energy companies, with insufficient direct support for workers and small communities. Additionally, recent energy security concerns triggered by the war in Ukraine led to the temporary reactivation of some coal plants, raising questions about the resilience of the transition. Poland, on the other hand, faces more structural challenges. Despite policy commitments in the Energy Policy of Poland until 2040 and the National Energy and Climate Plan, coal remains a dominant energy source, contributing over 70% to electricity generation in 2023. While EU-funded programs under the Just Transition Mechanism have begun to support workforce retraining and renewable energy projects in Silesia, progress has been slow and uneven. Delays in regulatory reforms, limited infrastructure for renewables, and a strong coal lobby have hindered effective implementation. Furthermore, Poland's reliance on gas as a transitional fuel may prolong dependence on fossil fuels rather than accelerating the shift to a low-carbon economy. Germany's implementation approach is more structured and measurable, though not without flaws. In contrast, Poland's transition is constrained by political and economic dependencies, making implementation less predictable and slower in pace. Evaluating effectiveness reveals

that legal mandates and financial instruments alone are insufficient without equitable social outcomes and consistent political commitment.

The outbreak of the war in Ukraine in 2022 demonstrate how external geopolitical shocks can rapidly reshape national energy priorities and governance frameworks, reinforcing the importance of flexible, adaptive transition strategies that balance long-term climate goals with short-term energy security imperatives. For Germany, the sudden loss of Russian gas imports—previously accounting for over half of its supply—prompted emergency measures including the temporary reactivation of coal-fired power plants, expedited construction of LNG terminals in Brunsbüttel and Wilhelmshaven, and a short-term recalibration of its decarbonization timeline. Although the long-term goals of the *Energiewende* remain intact, the crisis exposed vulnerabilities in Germany’s energy system and underscored the need for greater resilience and diversification, including increased investment in hydrogen and energy storage technologies. Poland, on the other hand, had already pursued partial diversification through infrastructure projects such as the Świnoujście LNG terminal and the Baltic Pipe, which became vital strategic assets in the post-2022 context. However, the crisis further solidified coal’s role as a “reliable fallback”, slowing down short-term decarbonization efforts. At the same time, it spurred intensified efforts to accelerate nuclear deployment and expand offshore wind, positioning energy sovereignty as a key driver of transition policy. Both countries also aligned with the European Commission’s REPowerEU plan, which emphasized the urgent need to reduce fossil fuel dependence from Russia while accelerating the rollout of renewables.

5. Consultations & Public Engagement Efforts in Poland and Germany

The role of public engagement in the transition away from coal in both Germany and Poland underscores the complexities of balancing economic, social, and environmental considerations in large-scale energy transformations. The effectiveness of stakeholder participation is crucial in ensuring a just and inclusive transition; however, challenges persist, particularly in regions where coal has historically been an economic mainstay (Matthes, 2017). In Germany, the Commission on Growth, Structural Change, and Employment (Jurca, 2014) played a pivotal role in formulating a consensus-driven approach to coal phase-out. The structured involvement of key stakeholders, including industry representatives, labour unions, and environmental organizations, facilitated a broad-based agreement that incorporated economic, environmental, and social considerations (Morris, 2013). The commission conducted over 100 expert hearings and received input from more than 500 stakeholders, ensuring an inclusive decision-making process (Agora *Energiewende*, 2019). Despite this, tensions remained, particularly concerning the timeline of coal phase-out and the adequacy of compensation measures for affected industries and workers. Similarly, Poland has adopted a consultative approach, notably through expert committees and roundtable discussions, to address the concerns of various stakeholders.

Public consultation mechanisms, mandated by law, provide communities with opportunities to voice their concerns regarding energy projects (Tol, 2023). However, questions remain regarding the extent to which these consultations influence policy adjustments that adequately address local economic impacts. The 2021 Social Agreement on the Transformation of the Coal Mining Sector, which includes employment guarantees and financial mechanisms for coal companies, represents a significant step in ensuring a fair transition. Nevertheless, the agreement's timeline, which extends coal mining operations until 2049, has been met with criticism from environmental groups advocating for a more ambitious decarbonization strategy (European Climate Foundation, 2022). Public forums and citizen assemblies have played a crucial role in fostering social acceptance of the coal phase-out process in Germany. The inclusion of local communities in transition planning has been shown to increase trust and reduce opposition to policy changes. According to the German Federal Environment Agency (BMWi, 2017), while 72% of respondents supported the transition to renewable energy, concerns over job security and economic instability in coal-reliant regions persisted. The introduction of regional engagement platforms helped mitigate resistance by increasing transparency and enabling affected communities to participate actively in decision-making processes. In Poland, social acceptance of the coal phase-out remains a contentious issue. While stakeholder engagement initiatives, such as workshops and community dialogues, have provided a platform for discussion, the effectiveness of these efforts varies across regions (Ember, 2024). The Social Agreement of 2021 attempts to address these concerns through financial compensation and social protection measures, including mining leave, severance pay, and employment guarantees (Soboń, 2021). However, public perception remains mixed, with ongoing fears of economic marginalization in coal-reliant regions (Mazurkiewicz, 2019). Recurring challenge in both Germany and Poland is the need for greater transparency and accountability in the allocation of financial resources for the energy transition. Germany's €40 billion transition fund, aimed at regional economic development and infrastructure investments, has faced scrutiny over the prioritization of projects and the equitable distribution of funds (Groba, Breitschopf, 2013). Research indicates that ensuring transparency in fund allocation is critical to maintaining public trust and mitigating perceptions of political favouritism (Hager, Stefes, 2016). In Poland, similar concerns exist regarding the implementation of the Silesia Transformation Fund and the extent to which financial support will effectively reach the most affected communities. While the agreement provides a structured framework for transition, the dependency on European Union negotiations to finalize support mechanisms presents an additional layer of complexity and potential delays. Moreover, while public awareness campaigns in Germany have successfully increased support for renewable energy, Poland's engagement strategies have been more reactive, addressing stakeholder concerns primarily through legal consultation requirements and negotiated agreements. This discrepancy highlights the varying political and economic factors influencing each country's energy transition strategy (UNECE, 2023).

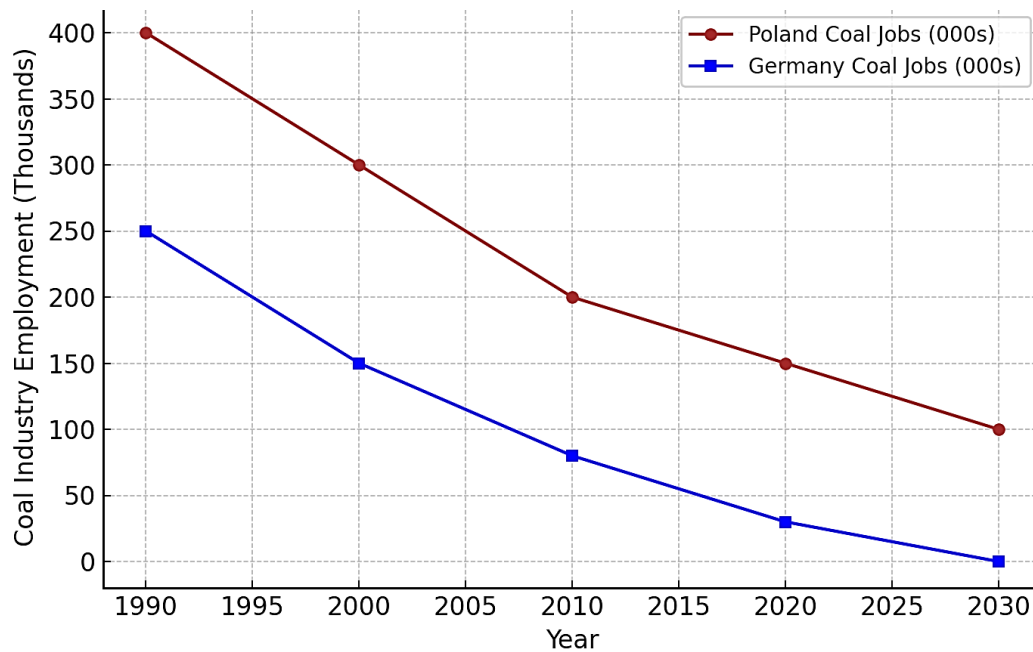


Figure 3. Decline in coal Employment in Poland and Germany.

Source: (European Commission, 2021).

6. Transition governance models in Poland and Germany

Germany and Poland are both undergoing significant energy transitions, moving away from coal toward renewable and low-emission energy sources. However, their approaches differ due to governance structures, economic strategies, and regional socio-political considerations. Germany's coal phase-out governance follows a multi-level approach, involving federal, state, and municipal authorities. The Federal Government sets overarching policies, while state and local governments implement region-specific strategies to mitigate socio-economic impacts. Key legislation, such as the Federal Climate Protection Act (2019), Coal Exit Act (2020), Renewable Energy Sources Act (EEG, 2023), provides a legal framework for this transition. Additionally, the Coal Exit Act (2020) allocates substantial financial aid for economic restructuring and workforce reskilling. In contrast, Poland's transition is guided by a combination of regulatory and market-based mechanisms. The Energy Policy of Poland until 2040 (PEP2040) outlines a long-term vision based on three pillars:

- Just Transition – ensuring that affected regions and communities receive financial and developmental support.
- Zero-Emission Energy System – transitioning through nuclear power, offshore wind energy, and increased distributed energy production.
- Good Air Quality – investing in district heating, electrification of transport, and zero-emission housing.

While Germany emphasizes direct government intervention and public-private collaboration, Poland relies on market-driven solutions, including the Polish Power Exchange for renewable energy trading. Germany's transition has been supported by significant public and private investments in renewable energy, digital industries, and workforce retraining. The Ruhr region serves as a prime example of economic diversification through business incentives, infrastructure modernization, and research investments. Germany also promotes public-private partnerships to create innovation hubs and green business incubators that stimulate entrepreneurship and job creation. Poland, on the other hand, integrates economic modernization within its broader energy policy goals. The Energy Policy of Poland until 2040 (PEP2040) aims to create up to 300,000 new jobs in sectors such as renewable energy, nuclear power, electromobility, and digital infrastructure. Unlike Germany, where workers transition into green energy sectors, Poland's model includes support for individual energy consumers, shielding them from rising energy costs while encouraging participation in the energy market. Germany's transition heavily involves major energy companies, such as RWE and Uniper, which have committed to early coal plant closures and investments in wind, solar, and hydrogen-based energy solutions. Research institutions like the Fraunhofer Institute (Fraunhofer ISE, 2023) and Agora Energiewende (Agora Energiewende, 2015) contribute policy recommendations and technological insights to guide the transition. Environmental NGOs, including WWF Germany (WWF Germany, 2023), advocate for stronger climate policies and social justice in the transition process. In Poland, private sector engagement is growing, driven by tax incentives, subsidies, and feed-in tariffs. The government promotes energy efficiency through public-private collaborations and energy trading platforms. While Germany's transition model integrates environmental NGOs in policy discussions, Poland's transition places greater emphasis on ensuring energy security and modernizing industrial energy. Germany's coal phase-out has resulted in substantial reductions in greenhouse gas emissions, improved air quality, and land restoration. Former coal mining sites have been repurposed into green spaces, cultural centres, and renewable energy farms, contributing to biodiversity conservation and sustainable urban development. Poland's transition also prioritizes air quality improvements, particularly through investments in district heating, transport electrification, and energy-efficient housing. Unlike Germany, which has already made significant progress in reducing coal dependency, Poland still relies on coal but aims for long-term decarbonization with the implementation of nuclear energy and offshore wind projects.

Germany's main challenge is maintaining energy supply stability while rapidly transitioning to renewables. Ensuring continued economic growth and job security in former coal-dependent regions remains a priority. Poland, meanwhile, faces the challenge of balancing energy security with climate commitments. The gradual approach in PEP2040 (Ministry of Climate and Environment, 2021) allows Poland to transition while maintaining stable electricity production. However, reliance on gas as a transitional fuel poses long-term sustainability concerns.

7. Discussion

The historical trajectory of coal mining in both Germany and Poland reveals its foundational role in national industrialization, economic stability, and regional development. For decades, coal was not only a dominant energy source but also a key pillar of employment and economic activity—particularly in the Ruhr Valley of Germany and the Silesian region of Poland. However, the contemporary global shift toward low-carbon development has necessitated a reassessment of coal's long-standing centrality in energy systems. The divergent approaches taken by Germany and Poland in phasing out coal offer valuable insights into the complex, multidimensional nature of energy transitions and provide transferable lessons for other fossil fuel-dependent economies. Germany embarked on a relatively early and structured transition away from coal, underpinned by a robust legal and institutional framework. The adoption of the political regulations provided clear timelines and targets, including a legally binding commitment to cease coal-fired energy production by 2038. This legal certainty has been instrumental in attracting investment in renewable energy and facilitating the gradual transformation of the energy sector. Central to Germany's approach was the establishment of the Commission on Growth, Structural Change and Employment (Kohlekommission), which brought together diverse stakeholders, including government bodies, industry representatives, trade unions, environmental NGOs, and civil society (Kohlekommission, 2019). This participatory mechanism ensured that the transition strategy was informed by a broad consensus and reflected a balanced integration of economic, environmental, and social priorities. Significant financial allocations have accompanied Germany's coal exit strategy, with federal and regional governments pledging billions of euros to support structural transformation, workforce retraining, and environmental rehabilitation in former coal regions. However, despite this comprehensive approach, Germany has encountered notable challenges. Critics have pointed to disparities in the distribution of transition funds, with concerns that large energy corporations have disproportionately benefited, while local communities have seen comparatively fewer direct gains (Agora Energiewende, 2015). Furthermore, the accelerated pace of the coal phase-out, while aligned with international climate commitments, has raised concerns about energy supply stability and overreliance on natural gas as a transitional fuel—issues that have become more pronounced in the context of recent geopolitical uncertainties and volatile energy markets.

Poland, by contrast, has adopted a more gradual and adaptive approach, shaped by its substantial socio-economic dependence on coal. Coal continues to account for a significant share of Poland's electricity generation, and the sector remains a critical source of employment in certain regions. The absence of a legislated coal exit date has provided policymakers with greater flexibility but has also introduced uncertainty for investors and stakeholders. The country's primary strategic document, the **Energy Policy of Poland until 2040 (PEP2040)**, sets out broad decarbonization goals, including a reduction in the share of coal in the energy mix and a planned increase in renewables. However, natural gas remains central to

Poland's transition plans, reflecting both infrastructural realities and political preferences for a fuel perceived as more controllable and secure in the short term. While Poland has initiated social dialogue processes—most notably the 2021 Social Agreement on the Transformation of the Coal Mining Sector—these efforts have often been reactive rather than anticipatory. The agreement includes provisions for employment guarantees, compensation, and retraining programs, but its long-term impact remains uncertain due to limited institutional capacity and persistent mistrust among affected communities (European Commission, 2021). Moreover, environmental degradation, particularly air pollution in coal-intensive regions such as Silesia, continues to pose serious public health and sustainability concerns, undermining efforts to attract green investment and stimulate broader economic diversification. The comparative experiences of Germany and Poland in transitioning away from coal offer several critical bilateral lessons for managing energy transitions in fossil fuel-dependent contexts:

Table 2.

Bilateral Lessons for Poland and Germany in energy transformation context

Institutional and Legal Clarity Facilitates Predictability	Germany's structured, legally binding roadmap has provided a clear framework for both public and private actors. This contrasts with Poland's more flexible, but less predictable, strategy. Legal certainty can enhance investor confidence, reduce market risk, and promote sustained policy implementation over time.
Socio-Economic Realities Must Shape Transition Pathways	Poland's slower approach reflects the embeddedness of coal in local economies and the potential social fallout from rapid disengagement. A key takeaway is that energy transitions must be context-sensitive and calibrated to avoid socio-economic disruption. Gradualism, while slower, may be necessary where coal underpins regional livelihoods.
Stakeholder Participation Enhances Legitimacy and Consensus	Germany's stakeholder engagement mechanisms, particularly the Kohlekommission, highlight the value of inclusive policy processes. Broad-based participation can improve policy legitimacy, enhance public trust, and reduce resistance. Poland's experience points to the need for more proactive and meaningful community engagement to ensure local buy-in.
Financial Support Must Be Equitable and Targeted	Transition-related funding must be distributed transparently and fairly. While Germany has mobilized substantial financial resources, concerns about corporate capture highlight the importance of designing compensation schemes that prioritize affected workers and communities.
Public Awareness and Communication Are Critical	Germany's investment in public education campaigns has helped normalize the transition and increase support for renewables. Poland's more limited communication efforts have contributed to persistent scepticism, suggesting that effective transitions must include sustained efforts to inform, educate, and empower the public.
Balancing Energy Security with Climate Goals Remains Challenging	Both countries illustrate the tension between decarbonization and energy security. Germany's pivot to natural gas and Poland's continued reliance on coal and gas raise important questions about the sustainability of transitional fuels. Diversification of energy sources and accelerated investment in renewables are essential to reduce dependency on fossil-based energy and ensure long-term stability.

Source: Own Study.

8. Conclusion

The comparative analysis of energy transition governance in Poland and Germany reveals two distinct yet instructive models shaped by historical legacies, socio-political dynamics, and economic priorities. Germany exemplifies a structured, legally codified approach rooted in multi-level governance, stakeholder inclusivity, and long-term planning. This model emphasizes legal certainty, stakeholder consensus, and integrated regional development, offering a replicable framework for managing energy transition in post-industrial economies. In contrast, Poland's transition reflects a more cautious, adaptive strategy shaped by continued dependence on coal for energy security and economic stability—particularly in regions like Silesia with long-term decarbonization goals, the absence of a legally binding coal exit date, reliance on transitional fuels like natural gas. While Poland has initiated efforts toward just transition—such as the 2021 Social Agreement—public trust and policy coherence remain challenges due to delays in funding, inconsistent stakeholder influence, and uneven regional development. Despite their differences, both countries face common challenges: ensuring social justice, economic resilience, and environmental sustainability during the energy transition. Germany and Poland exemplify two distinct yet instructive models of energy transition in coal-reliant economies. Germany's legally anchored, consensus-driven approach offers a potential blueprint for structured decarbonization, while Poland's gradualism underscores the importance of aligning climate ambitions with socio-economic realities. Both experiences affirm that successful energy transitions require a holistic strategy—balancing environmental imperatives, economic resilience, and social justice. As the European Union moves toward deeper decarbonization, mutual learning between member states will be essential. By drawing on each other's strengths and addressing shared challenges collaboratively, countries like Germany and Poland can pave the way for a more just and sustainable energy future.

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POLISH CONSUMERS' PREFERENCES IN VEGETABLE CONSUMPTION

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Purpose: This study aimed to analyze changes in the consumption of vegetables in Poland and assess consumer preferences for their consumption.

Methodology: In the article, the results of macroeconomic analyses of changes in the consumption of fresh and processed vegetables in Poland in 2015-2022, by category, developed based on CSO data, are presented. The main part of the paper is based on the analysis of data from surveys conducted among 255 respondents from all over Poland. Statistical analyses used the Mann-Whitney U test and the Kruskal-Wallis ANOVA test.

Findings: From 2015 to 2022, the consumption of vegetables and processed foods in general showed a slight decreasing trend. The highest growth rate was recorded for processed and frozen vegetables and the group of other vegetables, indicating that consumers are increasingly opting for processed or pre-processed foods, which reduce meal preparation time. In turn, the positive growth rate in the consumption of fresh vegetables from the group of other vegetables indicates that consumers are seeking more and more new flavors, expanding the range of vegetables they consume.

The survey showed that despite the increase in the price of vegetables, caused by high inflation in Poland, more than half of the respondents did not reduce their consumption of vegetables, which proves that the amount of vegetables consumed is due to certain eating habits of consumers and that the price increase contributed to their search for substitute products that are more favorable in terms of price. Among the most consumed vegetables were tomatoes, as well as cucumbers and carrots, while the key factor in deciding whether to buy vegetables was their freshness, and quality, and only in third place was price. Noteworthy is the fact that just over half of the respondents consume vegetables daily, which is what the nutritional standards indicate. This proves that there is still a lot of work to be done in terms of nutrition education for the public, especially since the average consumption of vegetables in Poland is far from the European average.

Originality/value: The significance of the research conducted lies in a better understanding of consumers' vegetable consumption behaviour, their response to changing market conditions (e.g., price increases or inflation) and the impact of eating habits on consumer choices. This is important information for both the agricultural sector and vegetable trading companies, which can better adjust sales and marketing strategies based on this information. The research can also help formulate health and education policies to promote healthy eating habits in society.

Keywords: vegetables, consumer preferences, vegetable consumption.

Category of work: research work.

1. Introduction

Vegetables and fruits are fundamental components of a healthy diet. In 2016, the Food and Nutrition Institute released the latest version of the nutrition and physical activity pyramid, which emphasizes that fruits and vegetables form the foundation of proper nutrition. Notably, in the previous version, these foods were positioned on the second tier, below grain products. Fruits and vegetables are rich sources of essential nutrients and health-promoting components, including antioxidants. Therefore, it is crucial to incorporate an adequate supply of these foods into our daily diets. Key dietary antioxidants include vitamin C, vitamin E, carotenoids, exogenous coenzyme Q10, and polyphenolic compounds (Kałedkiewicz, Lange, 2013). Additionally, fruits and vegetables are low in fat and calories, with vegetables also being low in sugars (Wawrzyniak et al., 2011; Gronowska-Senger, 2015). Regular consumption of fruits and vegetables can significantly reduce the risk of stroke, heart disease, type II diabetes, and certain types of cancer. They also enhance the immune system, improve digestive health, and lower the likelihood of being overweight or obese (Ostrowska et al., 2003; Kazimierczak, 2004; Devirigliis et al., 2024). Despite the vital role of fruits and vegetables in our diet, their consumption in the Polish market remains insufficient.

Recommendations from the WHO and various EU national agencies suggest that fruits and vegetables should form the basis of our diet, with a recommended daily intake of around 400 grams. However, research and Eurostat data indicate that actual consumption levels are significantly lower than these recommendations. The amount of fruits and vegetables people consume varies widely and is influenced by factors such as gender, income level, education, and place of residence. Generally, women, individuals with higher income and education levels, and residents of southern European countries tend to consume more fruits and vegetables (Bieniek-Majka, 2022). Alarming, low consumption rates are particularly evident in low- and middle-income countries, where over 80% of individuals over the age of 15 consume less than the recommended amount of fruits and vegetables (Frank et al., 2019).

The demand for vegetables is increasing as consumers are becoming more aware of their importance in a healthy diet. People are focusing not only on the basic functions of food but also on the nutritional benefits of vegetables, which are rich in vitamins, minerals, and fiber (Przybysz et al., 2016; Olewnicki et al., 2016). The consumption of both vegetables and fruits is fundamental to maintaining a healthy lifestyle (Mikulec et al., 2023). Additionally, informed consumers are seeking foods that meet functional criteria (Grębowiec, 2018), which has led to the growth of vegetable and fruit production and their processing into new forms. In Poland, the past decade has seen a shift in the structure of vegetable consumption. The share of spending on potatoes and unprocessed vegetables has decreased, while expenditures on processed vegetables in various forms have increased (Murawska, 2016). Despite a long-term upward trend in the consumption of fruits and vegetables (Goryńska-Goldmann, 2024), Engel's law indicates that the overall share of food spending in Poland, including for vegetables, has been declining. However, the proportion of vegetable spending has remained fairly constant at around 10% of total food expenditures (Murawska, 2016).

The progressive development of vegetable processing techniques and modern packaging has made it possible to offer consumers vegetables with a longer shelf life, while preserving their sensory qualities (Domagała et al., 2021). Studies indicate that traditional marketplaces are no longer the primary places for purchasing vegetables, as the share of big-box stores has significantly increased (Grzybek, Szopinski, 2016; Lubańska, 2009). These changes have posed a considerable challenge for vegetable distribution, as products must now be processed more extensively, with larger batch sizes to meet the increased demands of retail supply logistics. Participating in large-scale retail supply often requires additional investments in pre-preparation, packaging systems, and production certification (Lubańska, 2009).

Poland's entry into the European Union, along with a significant concentration and improvement in vegetable production, led to an expansion in exports (Jäder, 2012; Pawlak, 2014; Bugała, 2016; Jäder, 2017; Kapusta, 2017). This situation required not only an increase in the concentration of vegetable production and processing but also an enhancement in production quality and the implementation of certification systems mandated by international buyers (Kurek, 2007; Chernyshevich, 2011). In this context, producer groups played a crucial role, as their involvement was essential for achieving short-term changes (Chlebicka, 2020; Olewnicki et al., 2021). Consequently, vegetables became a significant component of Polish agri-food exports (Zelazowska, 2012; Pawlak, 2014).

Additionally, differences in pricing between Poland and other EU countries have also contributed to this export growth (Sobczak, Jablonska, 2015). It is important to note that a positive balance in foreign trade was mainly achieved through exports of processed vegetables, while trade in fresh vegetables remained negative (Filipiak, 2010). The increased demand for processed products for export has led to a rise in the share of processing within Polish agribusiness from 40% to 56% between 2000 and 2022 (Wicka, Wicki, 2024). Thus, foreign trade has become one of the key factors driving the development and

transformation of Polish agriculture since 2000, in addition to domestic demand (Runowski et al., 2023). However, there is a consensus that new markets must continually be sought due to escalating competition (Bulkowska, 2024). Significant fluctuations in vegetable market prices remain a negative factor in production development planning (Sobczak, Jablonska, 2015), a challenge that persists despite improvements in market organization.

The study aimed to analyze changes in vegetable consumption in Poland and to assess consumer preferences based on survey results.

The information presented in the study can become useful to various stakeholder groups. First of all, producers and farmers will be able to adjust their production strategies to changing consumer preferences and market conditions, such as price increases and inflation. Vegetable traders, both retail and wholesale, will use the data to optimize their offers and select appropriate sales channels. Companies marketing and distributing food products will be able to better align their campaigns with current consumption trends. In addition, public authorities and public health organizations can use the results to formulate health and education policies that promote appropriate eating habits.

2. Material and methods

The study presents as a background for the study of consumer preferences the results of macroeconomic analyses of changes in the consumption of vegetables, both fresh and processed, by their respective categories, in Poland over the years 2015-2022. The primary source of information for macroeconomic analyses was data from the survey of household budgets, conducted by the Central Statistical Office. The year 2015 was taken as 100%, from which the basic parameters statistical parameters giving a summary description of the analyzed phenomenon were calculated, including fixed-base indices, with the help of which changes in the size of absolute data in the last analyzed year about the base year were analyzed. By calculating chain indices (with a variable base), the average annual rate of changes under study was determined, the measure of which in the period under study (t_0 , t_1) was the difference between the average chain index of the period and unity (Gorczynski, 2004). The coefficients of variation, which are the quotient of the standard deviation and the arithmetic mean of the values studied, were also calculated.

The main part of the paper is the analysis of primary data from surveys conducted using the CAWI method, on a group of 255 respondents, nationwide, in 2023. Women accounted for the largest share of the surveyed population, i.e. 60.0% of the total, taking part in the research. Men, on the other hand, accounted for 40.0%. The survey also established four age groups of respondents, i.e. 18-30 years old, 31-45 years old, 46-60 years old and over 60 years old. The largest group, 116 people (45.5%), were respondents aged 18-30. The percentage of respondents aged 31-45 was 30.2%, while those aged 46-60 and over 60 were 15.7% and 8.6%, respectively. Another factor characterizing the survey population was the place of residence. The largest group of study participants were residents of cities with a population of less than 50,000 (30.2%). The second smaller group among the survey participants were residents of cities with more than 250,000 residents accounting for 27.5%. The share of rural residents was 26.7%, while the smallest group, only 5.9% of people lived in a city with a population of 52,000 to 99,900.

Taking into account the monthly disposable income per person in the household, the largest number, 44.7%, of respondents had incomes above PLN 3000. The second largest group, in terms of numbers, were respondents with incomes between 2001 and 3000 PLN. The least numerous group of respondents (6.3%) were those with per capita incomes of up to PLN 1000.

The next aspect characterizing the surveyed population was their socioeconomic situation. The largest group of respondents were those employed in a company or office (47.8%) and students (25.9%). No farmers took part in the survey. The smallest group, only 3.14%, were people not working anywhere.

Considering the number of people in the household, the largest group was two people in the household, with 32.2%. In contrast, the smallest groups were six and seven people in the household. They accounted for 2.0% and 0.4% of the total surveyed population, respectively.

Analyses were performed using Statgraphics plus 4.1. Due to the lack of normal distribution and unequal groups, the significance of differences was tested with non-parametric tests statistical Mann-Whitney U test for two grouping variables for gender and Kruskal-Wallis ANOVA test for questions where there were more than three grouping variables. A significance level of $\alpha = 0.05$ was used in the analyses.

When interpreting the survey results, it should be kept in mind that in surveys, various factors can limit the results and affect the quality of the data. This can include errors resulting from difficulties in recalling information or the phenomenon of social desirability, when survey respondents provide answers according to the public's expectations rather than their own beliefs or experiences, as in the case of answers regarding a healthy lifestyle, such as eating organic vegetables. When creating the survey questionnaire, the authors made every effort to ensure that the form of the survey was conducive to providing reliable answers, which is facilitated by, among other things, the anonymity of the survey or the use of questions with a time reference to the event, which could help respondents recall specific activities more accurately.

3. Analysis of vegetable consumption based on CSO data

The analysis carried out showed that the consumption of vegetables, mushrooms and preserves excluding potato preserves including mushroom preserves in households in 2022 was 54.4 kg/person, which was 6.2% lower than in 2015 (Table 1). It is noteworthy that in the case of fresh and refrigerated vegetables and mushrooms in 2022, consumption fell compared to the first year of the period under review. There was a clear decrease in the consumption of beets by 30.0% from 2.4 kg/person in 2015 to 1.7 kg/person in 2022. Also, there was a decrease in the consumption of cabbage by 20.0%, cauliflower vegetables by 11.8%, tomatoes by 11.9%, cucumbers by 17.6% and carrots by 14.9%. The smallest decrease was in onions by 4.4%. Noteworthy is the increase in consumption of frozen vegetables including mushrooms from 1.8 kg/person in 2015 to 2.0 kg per person in 2022 by 13.3%, as well as processed vegetables excluding processed potatoes, including processed mushrooms by 16.2%.

In general, it should be pointed out that the overall consumption of vegetables, mushrooms and preserves excluding potatoes showed a downward trend, with an average annual rate of decline of 0.9%, and the coefficient of variation was 2.8%. There was an average annual decrease in consumption of vegetables such as cabbage by 3.1%, cauliflower vegetables by 1.8%, tomatoes by 2.7%, cucumbers by 2.7%, carrots by 2.3%, beets by 5.0% and onions by 0.6%. The coefficient of variation was 9.6%, 4.8%, 4.0%, 8.3%, 8.4%, 15.0% and 2.6%, respectively. Frozen vegetables including mushrooms saw a 1.8% increase in the average annual rate of change, and processed vegetables excluding processed potatoes including processed mushrooms by 2.2%.

Table 1.*Vegetable consumption in households in Poland from 2015 to 2022*

Specification	2015		2016		2017		2018		2019		2020		2021		2022		The average annual rate of change	Coefficient of variation
	kg/person	%	kg/person	%	kg/person	%	kg/person	%	kg/person	%	kg/person	%	kg/person	%	kg/person	%		
Vegetables, mushrooms and preserves*	58.0	100.0	59.0	101.9	58.2	100.4	56.4	97.3	55.2	95.2	56.8	97.9	55.9	96.5	54.4	93.8	-0.9	2.8
Fresh and refrigerated vegetables and mushrooms	47.9	100.0	48.6	101.5	47.6	99.5	45.8	95.7	44.0	92.0	44.9	93.7	44.2	92.2	42.8	89.5	-1.6	4.6
cabbage	5.4	100.0	5.3	97.8	5.0	93.3	4.7	86.7	4.3	80.0	4.4	82.2	4.3	80.0	4.3	80.0	-3.1	9.6
cauliflower	2.0	100.0	1.8	88.2	1.9	94.1	1.8	88.2	1.8	88.2	1.8	88.2	1.8	88.2	1.8	88.2	-1.8	4.8
tomatoes	10.1	100.0	10.0	98.8	9.6	95.2	9.7	96.4	9.5	94.0	9.6	95.2	9.2	91.7	8.9	88.1	-1.8	4.0
cucumbers	6.1	100.0	6.4	103.9	5.9	96.1	5.8	94.1	5.6	92.2	5.3	86.3	5.2	84.3	5.0	82.4	-2.7	8.3
carrot	5.6	100.0	5.9	104.3	6.0	106.4	5.3	93.6	4.9	87.2	5.2	91.5	5.0	89.4	4.8	85.1	-2.3	8.4
beets	2.4	100.0	2.5	105.0	2.4	100.0	2.2	90.0	1.9	80.0	1.9	80.0	1.8	75.0	1.7	70.0	-5.0	15.0
onion	5.4	100.0	5.4	100.0	5.4	100.0	5.2	95.6	5.0	93.3	5.3	97.8	5.3	97.8	5.2	95.6	-0.6	2.6
other vegetables and mushrooms	10.8	100.0	11.4	105.6	11.4	105.6	11.3	104.4	10.9	101.1	11.4	105.6	11.5	106.7	11.2	103.3	0.5	2.3
Frozen vegetables**	1.8	100.0	1.9	106.7	1.9	106.7	1.9	106.7	2.0	113.3	2.2	120.0	2.2	120.0	2.0	113.3	1.8	6.4
Vegetable preparations***	8.2	100.0	8.5	104.4	8.6	105.9	8.6	105.9	9.1	111.8	9.7	119.1	9.6	117.6	9.5	116.2	2.2	6.4
sauerkraut	2.0	100.0	2.0	100.0	1.9	94.1	1.9	94.1	1.9	94.1	1.9	94.1	1.8	88.2	1.7	82.4	-2.7	6.2
Vegetable and vegetable-fruit juices	1.7	100.0	2.2	128.6	1.9	114.3	1.9	114.3	1.9	114.3	1.9	114.3	1.8	107.1	1.7	100.0	0.0	8.3

* without potatoes,

** including mushrooms,

*** excluding processed potatoes, including processed mushrooms.

Source: own compilation according to IERiGŻ PIB study based on unpublished CSO data.

4. Survey results

Grocery shopping is one of the basic activities performed almost daily. It was therefore important to determine, the frequency of purchasing vegetables during such activities. The survey showed that the vast majority of respondents purchased conventionally grown vegetables very often and frequently. In the case of vegetables, very frequent and frequent purchases were indicated by 48.6 and 44.3% of respondents, respectively. Respondents, on the other hand, rarely bought vegetables labelled BIO, as indicated by 32.5% of respondents, respectively. It is worth noting that one-fifth of the survey participants did not purchase these products at all (Fig. 1). Also, a study conducted by Zmarlicki (2010) on a group of Skierniewice students proved that the willingness to purchase organically grown vegetables more than a decade ago was also negligible. The implication is that despite the passage of years, consumers' attitudes toward buying this type of food are still incidental. Most respondents indicated that they would be able to purchase BIO vegetables if their price was similar to conventionally grown products. Another issue of lack of interest in organic products indicated by the above author was often their unattractive appearance, which did not encourage consumers to purchase them.

The above proves that it would be worth investigating the relationship between the level of consumption of organic food and consumer awareness of healthy eating, including food safety, as well as the perception of this type of food, including its proper labeling. However, a literature review has shown that consumer awareness does not go hand in hand with an increase in the consumption of organic products. As Borychowski (2023) cites, spending on organic products in Poland was estimated at only 4 euros per year per citizen. Although public awareness of environmental issues and the negative consequences of conventional agriculture, which is mainly focused on maximizing profits, is growing, the price of organic products is the factor that largely limits consumers' purchasing choices. Many authors share this opinion, including Grzybowska-Brzezińska (2018), Trokhymchuk (2022), as well as Smoluk-Sikorska et al. (2024), who prove in their research that the most important barrier to the growth of organic food consumption is undoubtedly its high price, and to a lesser extent the quality or availability of this type of food. Therefore, when looking for the reasons for the high prices of organically produced food, it would be worth examining the reasons for the low popularity of organic farming in Poland. According to Borychowski (2023), “in Poland, the only EU country, the area of organic land fell from 655.5 thous ha to 509.3 thous ha between 2012 and 2020, i.e. by 22%. On average, the area of organic land in the EU as a whole increased by more than 55% during this period”. However, as the author states, it should be mentioned that in 2020, the area of organic farming in our country accounted for only about 4% of the agricultural land.

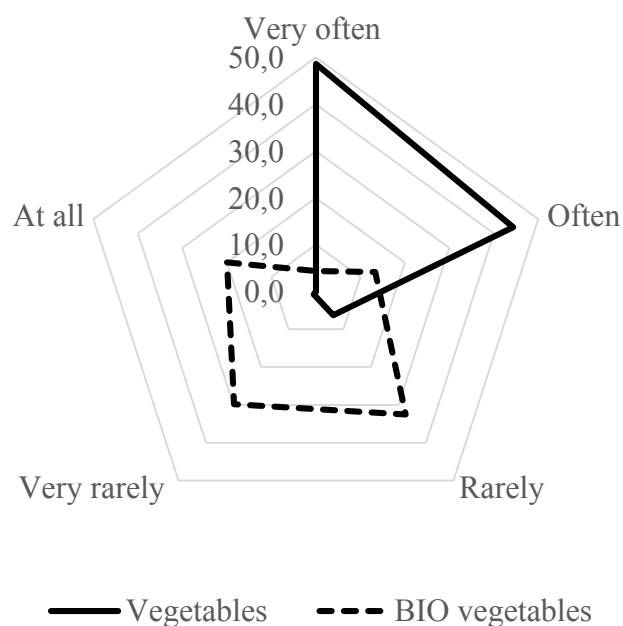


Figure 1. Frequency of vegetable purchases by respondents (in %).

Source: own research.

The analysis shows that the vast majority of respondents consumed vegetables daily, as indicated by 55.3% of respondents. Several times a week vegetables were consumed by 38.0% of respondents. Vegetables were consumed only once a week by 6.3% of opinion leaders. None of the respondents indicated that they consumed vegetables less than once a month (Figure 2).

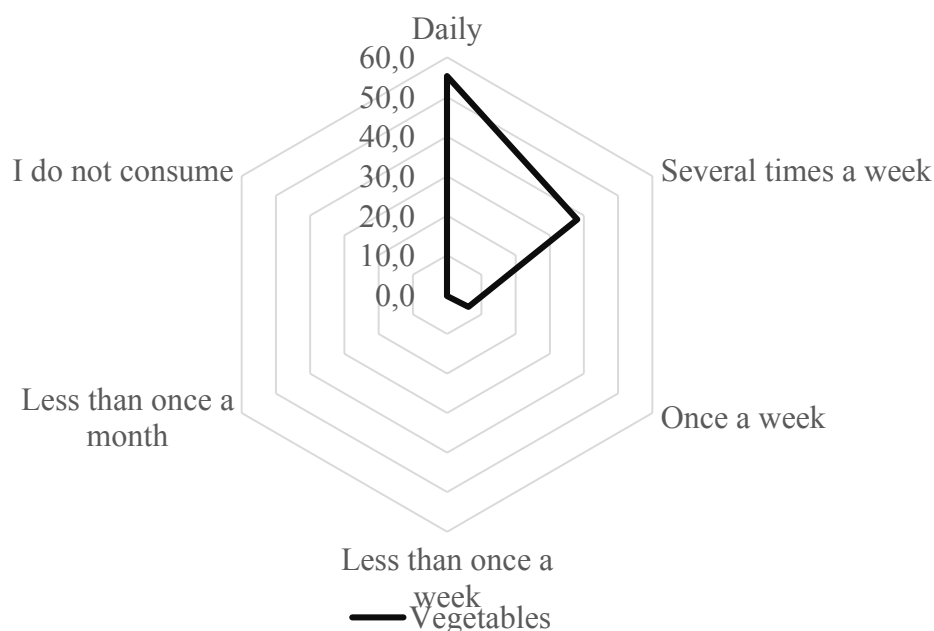


Figure 2. Frequency of vegetable consumption according to respondents (in %).

Source: own research.

Among the most frequently purchased vegetables were tomatoes and cucumbers. Purchases of these vegetables were indicated by 62.4 and 51.0% of respondents, respectively. Vegetables such as carrots, potatoes, lettuce and peppers were frequently purchased by 22.4 to 44.3% of respondents. Other frequently purchased vegetables, whose purchases were indicated by a total of 66.3% of survey participants, include onions, cabbage, broccoli, cauliflower, mushrooms, etc. (Figure 3). In a study conducted by Iowa et al. (2011), respondents indicated similarly, i.e. tomatoes, cucumbers and lettuce were their most frequently consumed vegetables.

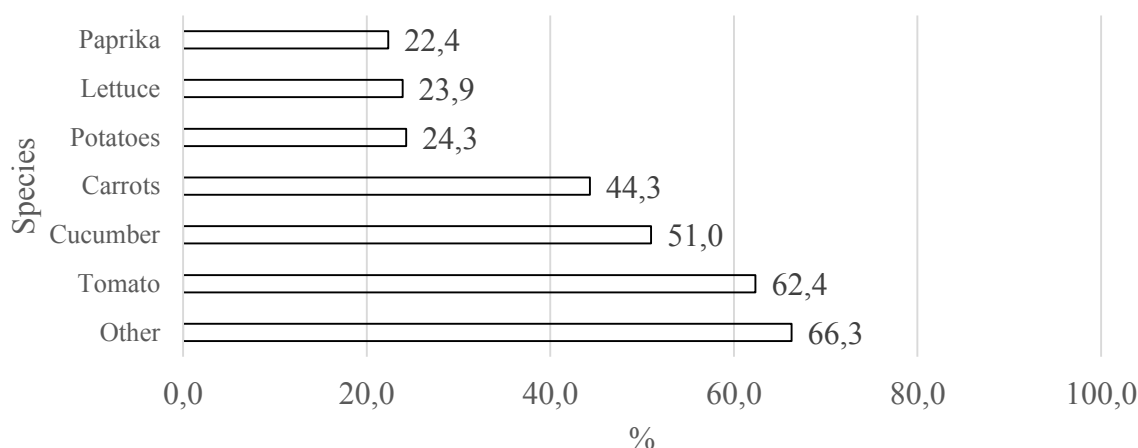


Figure 3. Most frequently purchased vegetables according to respondents (in %).

Source: own research.

According to the survey questionnaire, most consumers purchased vegetables very often (46.3%) and often (30.6%) from large grocery stores (i.e., hypermarkets, and discount stores). In contrast, respondents very rarely bought vegetables in small grocery stores (28.6%) and from street sales (27.8%). On the other hand, 31.0 and 25.5% of survey participants did not purchase there at all, respectively (Figure 4).

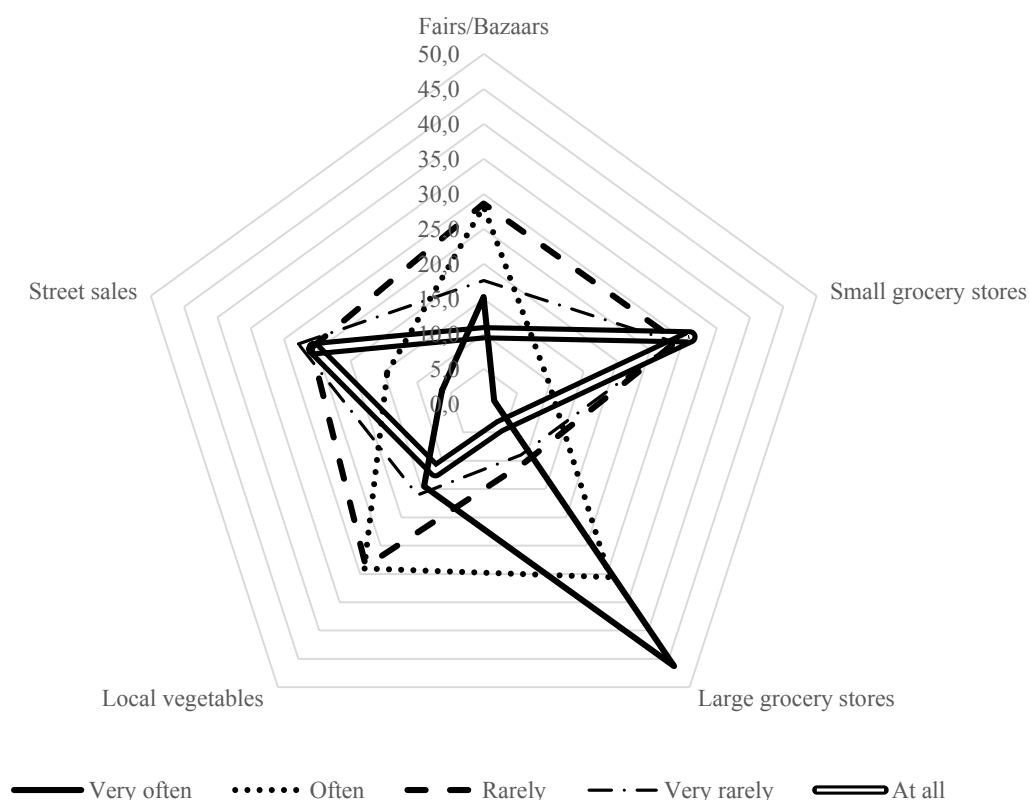


Figure 4. Frequency and location of vegetable purchases by respondents (in %).

Source: own research.

When buying vegetables, freshness and quality were the most important factors for 86.7 and 78.0% of respondents, respectively. Price was also an important factor for almost half of the respondents. Factors considered unimportant when buying vegetables turned out to be brand name and producer name. A study conducted by Kuren et al. (2022) on a group of 20-39-year-olds showed that respondents' opinions showed a positive attitude towards the health-promoting values of vegetables, despite the low frequency of consumption. The study showed that a higher frequency of vegetable consumption was associated with greater knowledge among respondents about their positive effects on health (Figure 5).

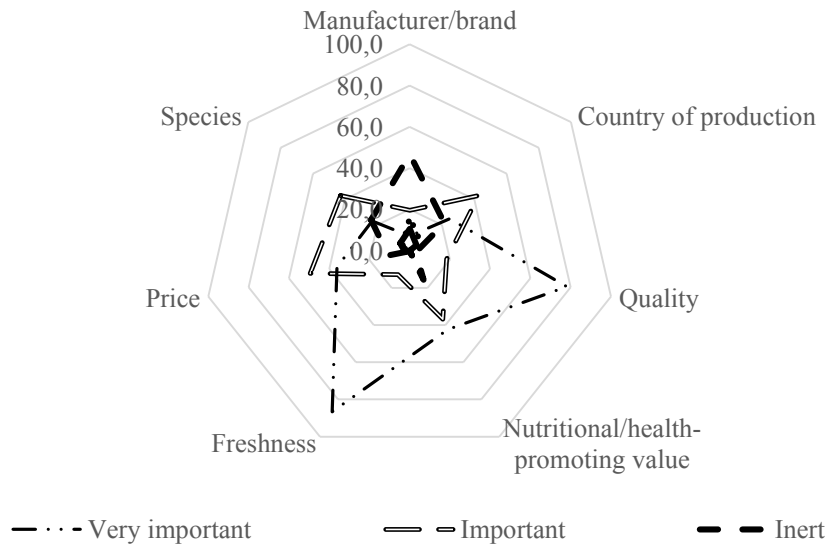


Figure 5. Factors influencing the purchase of vegetables by respondents (in %).

Source: own research.

The survey showed that of all the factors determining the choice of where to buy vegetables, the most important for respondents was the location near their place of residence, which was indicated by more than 70% of respondents. It is worth pointing out that this factor was more than 80% most often indicated by those over 60 years of age. It is noteworthy that low prices at the point of sale ranked only fourth among the factors for choosing where to buy vegetables, although it was indicated by more than 50% of respondents. More than 60% of respondents, concerning the purchase of vegetables, when choosing where to buy, were guided by the high quality of the products (65.9%) and the wide assortment of sales. On the other hand, the cleanliness of the store, discounts offered, helpful staff and advertising are factors that influence consumers' decisions to a lesser extent as to where to buy (Figure 6).

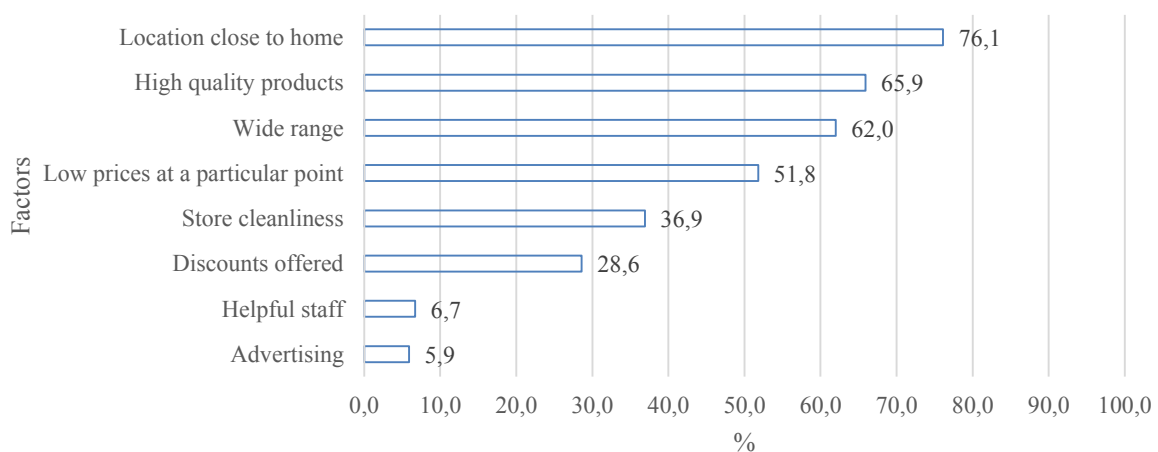


Figure 6. Factors influencing respondents' choice of where to buy vegetables (in %).

Source: own research.

The survey revealed that 34.1% of respondents spent between PLN 11 and PLN 20 on vegetable purchases in a single transaction. When analyzing the gender of the respondents, it was found that nearly 60% of both women and men allocated between PLN 11 and PLN 30 for their vegetable shopping at one time (see Table 2). Notably, 45.5% of respondents over the age of 60 spent between PLN 11 and PLN 20 for single purchases. In terms of income groups, a clear trend emerged: the higher the participants' income, the more they tended to spend on one-time vegetable purchases. Over 10% of individuals with incomes exceeding PLN 3,000 spent more than PLN 60 on vegetables in a single purchase, while among the other income groups, only 2.0% to 6.3% allocated such an amount.

The statistical analyses conducted did not reveal significant differences among specific groups of respondents, such as age, place of residence, and the frequency of spending money on vegetables. This conclusion is supported by the values obtained from the Z statistic, as well as the H statistic from the Mann-Whitney U tests and the Kruskal-Wallis ANOVA, along with the corresponding p-values. This suggests that, regardless of factors like age or place of residence, vegetables can be prioritized in grocery shopping.

Table 2.

One-time amounts that respondents spend on buying vegetables (in %)

Specification		Respondents' indications (in %)							Number n	Value of statistics	
		PLN 1-10	PLN 11-20	PLN 21-30	PLN 31-40	PLN 41-50	PLN 51-60	above 60 zł		p-value	Z or H*
Total		9.4	34.1	31.4	12.6	3.9	2.4	6.3	255		
Gender	K	7.2	37.3	31.4	15.0	2.6	2.6	3.9	153	0.4593	0.4593
	M	12.7	29.4	31.4	8.8	5.9	2.0	9.8	102		
Age	18-30 years	12.9	33.6	31.0	12.9	2.6	0.9	6.0	116	0.2645	3.9723
	31-45 years	7.8	32.5	32.5	14.3	5.2	1.3	6.5	77		
	46-60 years	2.5	32.5	40.0	7.5	5.0	5.0	7.5	40		
	Over 60 years old	9.1	45.5	13.6	13.6	4.5	9.1	4.5	22		
Education	Medium	11.0	31.9	27.5	16.5	3.3	1.1	8.8	91	0.1690	5.0392
	Professional	37.5	12.5	50.0	0.0	0.0	0.0	0.0	8		
	Higher	7.1	36.8	32.3	11.0	4.5	3.2	5.2	155		
	Village	5.9	38.2	30.9	16.2	1.5	0.0	7.4	68		
Place of residence	City of up to 50 t. inhabitants	11.7	29.9	29.9	15.6	3.9	1.3	7.8	77	0.9045	1.0349
	City of 51 to 99 t. inhabitants	0.0	33.3	53.3	0.0	0.0	6.7	6.7	15		
	City of 100 to 250 t. inhabitants	8.0	32.0	32.0	16.0	8.0	0.0	4.0	25		
	City of more than 250 t. inhabitants	12.9	35.7	28.6	7.1	5.7	5.7	4.3	70		
Monthly disposable income	Up to PLN 1000	37.5	37.5	6.3	12.5	0.0	0.0	6.3	16	0.0657	7.2037
	PLN 1001-2000	10.2	34.7	36.7	10.2	4.1	2.0	2.0	49		
	2001-3000 PLN	7.9	30.3	39.5	11.8	5.3	2.6	2.6	76		
	Pow. 3000 PLN	6.1	36.0	27.2	14.0	3.5	2.6	10.5	114		
Socio-economic situation	Student	12.1	34.8	39.4	12.1	0.0	0.0	1.5	66	0.2674	5.1996
	Self-employed	10.3	23.1	25.6	17.9	7.7	2.6	12.8	39		
	Company/office employee	6.6	36.1	32.0	11.5	4.9	2.5	6.6	122		
	Pensioner	10.0	45.0	15.0	15.0	5.0	10.0	0.0	20		
	Currently not working anywhere	25.0	25.0	25.0	0.0	0.0	0.0	25.0	8		

*Z for Mann-Whitney U, H for Kruskal-Wallis.

Sources: Own research.

Based on the analysis, it can be indicated that 63.5% of all respondents consumed the same amount of vegetables compared to the previous year. Considering the gender of the respondents, both women (64.1%) and men (62.7%) said they consumed the same amount of vegetables (Table 3). Considering age groups, each of the groups 18-30, 31-45, 46-60, and over 60 also bought the same amount of vegetables in 2023 compared to 2022. This was indicated by 56.9% to 81.8% of opinion leaders. For income groups, place of residence, and socioeconomic situation, no clear differences were observed in attitudes toward vegetable consumption compared to the previous year. A study conducted by Jäder (2015) shows that the highest consumption of vegetables was in the households of pensioners, married couples with no children, and those with the highest income. However, it is worth pointing out that 50.0% of students consumed the same amount of vegetables compared to the previous year, but almost 40% indicated that they consumed more.

In contrast, the statistical analyses carried out showed no significant differences, across groups characterizing the respondents and the one-time use of money to buy vegetables, as indicated by the values of the Z statistic and H of the Mann-Whitney U tests and Kruskal-Wallis ANOVA and p-value.

Table 3.

Amount of vegetables consumed by respondents compared to the previous year (in %)

Specification		Respondents' indications (in %)			Number n	Value of statistics	
		Read more	Less	As much		p-value	Z or H*
Total		24.3	12.2	63.5	255		
Gender	K	24.2	11.8	64.1	153	0.8393	0.2028
	M	24.5	12.7	62.7	102		
Age	18-30 years	33.6	9.5	56.9	116	0.0807	6.7403
	31-45 years	16.9	11.7	71.4	77		
	46-60 years	20.0	22.5	57.5	40		
	Over 60 years old	9.1	9.1	81.8	22		
Education	Medium	18.7	12.1	69.2	91	0.3656	3.1735
	Professional	25.0	0.0	75.0	8		
	Higher	27.7	12.9	59.4	155		
	Village	27.9	8.8	63.2	68		
Place of residence	City of up to 50 t. inhabitants	20.8	14.3	64.9	77	0.7343	2.0077
	City of 51 to 99 t. inhabitants	40.0	6.7	53.3	15		
	City of 100 to 250 t. inhabitants	12.0	12.0	76.0	25		
	City of more than 250 t. inhabitants	25.7	14.3	60.0	70		
Monthly disposable income	Up to PLN 1000	18.8	12.5	68.8	16	0.3468	3.3061
	PLN 1001-2000	28.6	18.4	53.1	49		
	2001-3000 PLN	22.4	11.8	65.8	76		
	Pow. 3000 PLN	24.6	9.6	65.8	114		
Socio-economic situation	Student	39.4	10.6	50.0	66	0.0949	7.9109
	Self-employed	28.2	12.8	59.0	39		
	Company/office employee	18.9	13.1	68.0	122		
	Pensioner	5.0	10.0	85.0	20		
	Currently not working anywhere	12.5	12.5	75.0	8		

*Z for Mann-Whitney U, H for Kruskal-Wallis.

Sources: Own research.

Based on the analysis, it can be indicated that as many as 74.9% of all respondents spent more cash on vegetable purchases compared to the previous year. A greater amount of cash than last year was spent on vegetable purchases by 77.8% of women and 70.6% of men (Tab. 4). Noteworthy are the age groups, each of which allocated a greater amount of cash for vegetable purchases. For income groups, place of residence, and monthly disposable income, no clear differences were observed in the allocation of cash for vegetables. Each of these groups allocated more compared to the previous year. It is noteworthy that for those currently not working anywhere more than 60% indicated that they allocated the same amount of cash for vegetable purchases than in the previous year and nearly 40% indicated that they allocated more.

The statistical analyses conducted showed significant differences in respondents' education, socioeconomic situation monthly disposable income per person in the household and the amount of cash allocated for vegetables about 2022, as indicated by the values of the Z statistic and the H of the Mann-Whitney U and Kruskal-Wallis ANOVA tests and p-values. The differences are that those with vocational and secondary education allocated the same amount of cash in the past year, while the vast majority of those with higher education, allocated more cash to purchase vegetables compared to the previous year. In the case of monthly income, those in the income group from PLN 1001 to 2000 stood out from the other income groups in that, the vast majority of them (85.7%) allocated more cash for the purchase of vegetables compared to the previous year, while the same amount of cash was allocated by only 24.1% of the opinion leaders in this group. Also, 77.0% of the employed and 71.8% of the self-employed allocated more cash for the purchase of vegetables compared to the previous year, while only 5.7% of the employed and 5.1% of the self-employed respondents allocated less.

Table 4.

The amount of money allocated to the purchase of vegetables by respondents compared to the previous year (in %)

Specification		Respondents' indications (in %)			Number n	Value of statistics	
		Read more	Less	As much		p-value	Z or H*
Total		74.9	6.3	18.8	255		
Gender	K	77.8	5.9	16.3	153	0.4974	-0.6785
	M	70.6	6.9	22.5	102		
Age	18-30 years	75.9	6.0	18.1	116	0.9071	0.5529
	31-45 years	75.3	6.5	18.2	77		
	46-60 years	72.5	5.0	22.5	40		
	Over 60 years old	72.7	9.1	18.2	22		
Education	Medium	67.0	4.4	28.6	91	0.0011	16.0734
	Professional	62.5	0.0	37.5	8		
	Higher	80.6	7.7	11.6	155		
	Village	73.5	4.4	22.1	68		
Place of residence	City of up to 50 t. inhabitants	75.3	6.5	18.2	77	0.7785	1.7671
	City of 51 to 99 t. inhabitants	93.3	0.0	6.7	15		
	City of 100 to 250 t. inhabitants	72.0	12.0	16.0	25		
	City of more than 250 t. inhabitants	72.9	7.1	20.0	70		

Cont. table 4.

Monthly disposable income	Up to PLN 1000	62.5	12.5	25.0	16	0.0035	13.6088
	PLN 1001-2000	85.7	10.2	4.1	49		
	2001-3000 PLN	68.4	2.6	28.9	76		
	Pow. 3000 PLN	76.3	6.1	17.5	114		
Socio-economic situation	Student	77.3	7.6	15.2	66	0.0320	10.5588
	Self-employed	71.8	5.1	23.1	39		
	Company/office employee	77.0	5.7	17.2	122		
	Pensioner	75.0	10.0	15.0	20		
	Currently not working anywhere	37.5	0.0	62.5	8		

*Z for Mann-Whitney U, H for Kruskal-Wallis.

Sources: Own research.

Based on the survey, 46.3% of all respondents definitely felt that the price of vegetables has increased compared to 2022. Considering gender, 56.2% of women felt the price increase very strongly and 51.0% of men felt the price increase only strongly (Table 5). Considering age groups, more than 80% of survey participants from all groups felt very strongly or strongly about the increase in vegetable prices compared to 2022. The same is true, respondents felt very strongly or strongly about the increase in vegetable prices regardless of where they lived, their monthly disposable income and even their socioeconomic situation.

The statistical analyses conducted, however, showed no significant differences, across groups characterizing respondents and perceptions of an increase in vegetable prices compared to 2022, as indicated by the Z-statistic and H values of the Mann-Whitney U tests and Kruskal-Wallis ANOVA and p-value.

Table 5.

Respondents' feelings were caused by the increase in vegetable prices compared to the previous year (in %)

Specification		Respondents' indications (in %)				Number n	Value of statistics	
		I feel very strongly	I feel strongly	I feel slightly	I don't feel		p-value	Z or H*
Total		46.3	40.0	12.2	1.6	255		
Gender	K	56.2	32.7	9.8	1.3	153	0.1083	-1.6057
	M	31.4	51.0	15.7	2.0	102		
Age	18-30 years	42.2	43.1	12.9	1.7	116	0.6185	1.7835
	31-45 years	51.9	37.7	9.1	1.3	77		
	46-60 years	55.0	30.0	12.5	2.5	40		
	Over 60 years old	31.8	50.0	18.2	0.0	22		
Education	Medium	46.2	36.3	17.6	0.0	91	0.4568	2.6038
	Professional	25.0	62.5	12.5	0.0	8		
	Higher	47.1	41.3	9.0	2.6	155		
	Village	44.1	44.1	10.3	1.5	68		
Place of residence	City of up to 50 t. inhabitants	46.8	37.7	14.3	1.3	77	0.4689	3.5597
	City of 51 to 99 t. inhabitants	40.0	46.7	13.3	0.0	15		
	City of 100 to 250 t. inhabitants	68.0	20.0	12.0	0.0	25		
	City of more than 250 t. inhabitants	41.4	44.3	11.4	2.9	70		
Monthly disposable income	Up to PLN 1000	62.5	25.0	12.5	0.0	16	0.1630	5.1226
	PLN 1001-2000	53.1	44.9	2.0	0.0	49		
	2001-3000 PLN	41.0	43.6	11.5	1.3	78		
	Pow. 3000 PLN	43.9	36.8	16.7	2.6	114		

Cont. table 5.

Socio-economic situation	Student	36.4	53.0	10.6	0.0	66	0.0603	9.0337
	Self-employed	46.2	28.2	25.6	0.0	39		
	Company/office employee	53.3	35.2	8.2	3.3	122		
	Pensioner	35.0	50.0	15.0	0.0	20		
	Currently not working anywhere	50.0	37.5	12.5	0.0	8		

*Z for Mann-Whitney U, H for Kruskal-Wallis.

Sources: Own research.

The above survey results are confirmed by a report by the Center for Public Opinion Research (CBOS) published in 2022 (Omyla, 2022), according to which Poles have been greatly affected by inflation. The most severe was the increase in food prices. According to the research published in this report, respondents reduced their daily purchases and used substitutes.

5. Summary and conclusions

Vegetables, like fruits, are among one of the basic and most important foods. Hence, according to the latest dietary recommendations, these products have been ranked first in the pyramid of human nutrition. Demand for vegetables is increasingly linked to the increase in consumer awareness of their health-promoting properties. Hence, it is assumed that a change in consumption patterns should contribute to an increase in the consumption of this food group. In addition, the progressive development and introduction of innovations in manufacturing techniques, modern supply chains and new types of packaging have resulted in the possibility of offering consumers vegetables with a longer shelf life, without losing their sensory qualities, and, through their processing and foreign trade, their availability practically throughout the year.

Changes in the structure of vegetable consumption in Poland have been recorded throughout the studied multi-year period. The macroeconomic analyses carried out showed that although the consumption of vegetables and processed vegetables, in general, showed a slight downward trend from 2015 to 2022, the highest growth rate was recorded for processed and frozen vegetables and the group of other vegetables. While a negative rate of change was recorded for all other categories of the vegetable groups analyzed.

Research results show that consumers are consuming more and more processed vegetables and frozen vegetables that are suitable for direct consumption or whose pre-processing significantly reduces meal preparation time. Thus, it is a food of convenience for the consumer. In turn, the positive growth rate in the consumption of vegetables from the group of other vegetables shows that consumers are looking for more and more new flavors, expanding the

range of fresh vegetables consumed, which are often available all year round, despite high prices.

According to the survey, the most frequently consumed vegetables among respondents were tomatoes, cucumbers and carrots. Most respondents purchased vegetables very often. Purchases were mainly made at hypermarkets and discount grocery stores. Slightly less important were markets and local vegetable stores. In addition, the most important factor in respondents' choice of where to buy vegetables was the location near their place of residence, which was indicated by more than 70% of respondents. A significant proportion of respondents chose places that offered a wide assortment and high-quality produce. When shopping, respondents paid particular attention to the freshness and quality of vegetables, while only in third place was the price.

Based on the analysis, it can be pointed out that nearly half of all respondents were very much affected by the increase in vegetable prices caused by high inflation in Poland. Although they allocated more funds for the purchase of vegetables compared to the previous year, this did not translate into an increase in their consumption. This indicates that the amount of vegetables consumed is due to certain eating habits of consumers, and the price increase contributed to their search for more affordable substitute products. Thus, the study also shows that the price is not the most important factor determining the level of vegetable consumption, but largely influences the assortment of vegetables consumed, or their preparations.

Particularly noteworthy is the fact that only a little more than half of the respondents consume vegetables every day, that is, as indicated by nutrition standards. Which proves that there is still a lot of work to be done in terms of nutrition education of the public, especially since the average consumption of vegetables in Poland is far from the European average.

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THEATRE MANAGEMENT IN THE CONTEXT OF THE DEVELOPMENT OF NEW GENERATION TECHNOLOGIES – MANAGEMENT IMPLICATIONS ARISING FROM THE IMPACT OF TECHNOLOGY ON THE SHAPING THEATRE FUNCTIONS

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Purpose: The aim of the study is to determine how experts perceive the impact of technology on the shaping of theatre functions from a management perspective, and to identify possible management implications arising from this impact.

Design/methodology/approach: The study is qualitative. Empirical data was collected during an expert panel (4 experts) and individual interviews (8 experts). The study is international - the sample includes experts from 5 countries.

Findings: The experts' perceptions of the impact of technology on the theatre's functions (culture-forming, economic, entertainment, educational, promotional) from a management perspective were determined. A number of management implications were identified as a result of the impact of technology on the functions of the theatre. Revision is required in the areas of availability management, repertoire management, human resources policy, financial management, aesthetic contact management, image management and relationship management with organisers, among others. At the same time, in addition to digital and technological competences, political and change management competences need to be developed.

Research limitations/implications: First, the study focused on only five functions of theatre. It can be expected that an increase in the sample size and depth of the study would reveal other functions of theatre that are influenced by technology. It should also be remembered that the study used a purposive sample, so caution should be exercised when trying to generalise the research to the whole population. The research results obtained can form the basis for other art institutions.

Practical implications: The results of the study can be taken into account by theatre managers who want to consciously shape the function of the theatre with the help of new technologies.

Originality/value: To the authors' knowledge, this is the first research address to the management implications of the impact of technology on the theatre's function. The added value of the study lies in its international scope, which allows for a wider range of analysis. The results of the research can be useful for theatre managers, cultural organisers and providers of new technologies for culture.

Keywords: Theatre management, arts management, technology, theatre's functions, theatre's meaning.

Category of the paper: Research paper.

1. Introduction

Over the years, theatre has performed various social, political and economic functions in shaping collective identity and national culture. This is evidenced by the achievements of the avant-garde in Central and Eastern European countries, which were a kind of response to what was happening in the social, economic and political environment at the time. The literature also points to the importance of theatre in the creation of intellectual and creative capital. In times of geopolitical instability, the problem of maintaining and recognising one's own subjectivity in political, cultural and economic terms is extremely current. From a theatre management perspective, the functions of theatre have a dual significance. Firstly, they can determine selected processes of theatre management. Secondly, theatre managers can influence the shape of these functions locally through appropriate theatre management.

The dynamic development of new technologies determines the transformation of the functioning of contemporary organisations (Bukvić, 2024, p. 6; Nocoń, 2024, p. 36). Due to the nature of their activities and objectives, this also applies to cultural institutions (Kaczmarek, 2024, p. 72; Kwiecień, 2024, p. 8; Xiaojuan, 2023, p. 4), including theatres (Karcz-Ryndak, 2024a; Plebańczyk, 2023). Next-generation technologies have a significant impact on transforming the traditional functions of the theatre and creating new ones (Tonkoshkura, 2022; Damiano et al., 2020).

The diversity of ownership (public, private, non-profit), the type of theatre (including drama, music, puppetry, dance), its size (including the building in which it is located and the number of people employed there, the stage) are some of the many factors that determine the functions of a theatre. Consequently, the functions of a theatre can be different for each situation in which the theatre finds itself. For example, in a public theatre, social functions may be more important. This means that the manager of a contemporary theatre should be aware of the functions of the theatre and, through proper management, should shape these functions. This is particularly important in the context of the possibilities offered by modern technologies (including artificial intelligence, computer vision, the Internet of Things, etc.) (Izsak, 2022, p. 11; Modliński, Pinto, 2020; Pizzo, Lombardo, Damiano, 2019).

The functions that theatre provides change over time; for example, the function of creating a national identity will have a much greater impact in times of turbulence for a nation, such as during a war. As time and technology progress, new functions of theatre are created (Auslander, 2023; Tajtáková, 2014). Due to the development of social competences, the economic importance of theatre is growing.

As one of the oldest art forms, theatre must evolve in response to changing social, political and economic conditions. The modern digital age brings with it significant changes that have a major impact on theatre management and its functions in society. Digitalisation and technological innovation are not only changing the way theatres are managed, but also influencing their social, political and economic roles. In the context of rapidly developing technology, theatre faces new challenges (Karcz-Ryndak, 2024b, pp. 101-103), but also unique opportunities. Digital tools and platforms enable theatres to extend the reach of their activities, to innovate their presentation formats and to find new ways of 'attracting' audiences, which in turn affects their place in the cultural and economic structure of a given region.

In light of the above, the purpose of this study is to determine how experts perceive the impact of technology on the design of theatre functions from a management perspective, and to identify possible management implications arising from this impact. The research questions formulated for this purpose are 1) How do experts perceive the impact of next generation technology on the design of theatre functions? 2) What are the management implications of the impact of next generation technology on theatre functions? Obtaining information in these areas is particularly important from the perspective of theatre directors who want to consciously shape the functions of the theatre through next-generation technologies and who are therefore faced with the challenge of adapting existing management practices.

Although the question of how technology influences the shaping of an institution's functions applies to cultural institutions in general and is a broader trend, the authors recommend industry-specific analyses due to differentiating factors. One example is the nature of cultural assets and their accessibility. Galleries or museums are dominated by tangible cultural goods, which are therefore in principle available without restrictions (the organiser only regulates the place and time of access to these goods). In the case of theatres, on the other hand, a performance has the characteristics of an intangible good, i.e. it is only available during the performance. In addition, the reception of a performance can vary due to the variability of conditions (e.g. changes in the cast, audience structure, change of scene, etc.), which limits its repeatability, unlike museum exhibits, books or films.

It is also worth highlighting the limitations of the diffusion of some innovations between different cultural sectors. It can be assumed that some of the technologies used in theatres (e.g. in terms of stage movement or sound direction) have little application in libraries. Theatres are definitely closer to other arts institutions focusing on the performing arts. However, even here there are differences, e.g. at the level of the core product of the activity. For philharmonic, for example, the musical level of a performance is of primary importance. For theatres other than musical theatres, other aspects will be dominant, e.g. the text of the work in dramatic theatres. It can be seen that the type of performance is reflected in the functions of the institution. In the case of concerts, the role of the entertainment function is increasing. In some theatres, the educational function is more obvious (e.g. puppet theatres specialising in performances for children).

2. Methods

The research presented in this article is based on a qualitative analysis of interviews with experts and theatre managers who share their experiences and insights into the role of theatre in the contemporary world. The empirical data used in the article were obtained within the framework of the research project "Managing contemporary theatre under progressive technological change in an international perspective - Part II" conducted at the Krakow University of Economics and the expert panel "Management of Contemporary Theatre: Challenges, Threats, Perspectives" held during the 14th International Scientific Conference "Knowledge - Economy - Society" CMQ 2022 at the Krakow University of Economics. Based on these, it is possible to show how theatre management in the context of digitalisation and the growing importance of innovation affects its role as a social, political and economic tool, and to identify the challenges and opportunities perceived by theatre industry experts. An important aspect of this study is the combination of experts' perspectives and theatre directors' management practices.

This study was conducted based on a qualitative approach (Busetto, Wick, Gumbinger, 2020; Flick, 2010; Jemielniak, 2012; Kaczmarek, 2013; Lune, Berg, 2017). The proposed research approach based on qualitative methods is a response to the problems associated with the quantitative research strategy in the case of theatres, including the reluctance of the theatre community to participate in this type of research, which can be seen in other research (Karna, 2007), or negative phenomena related to the self-assessment elements included in the questionnaire, e.g. a tendency to present oneself in a positive light.

The research sample was purposively selected based on the authors' knowledge of the theatre industry. This approach reduced the time needed to recruit respondents by shortening the administrative path, e.g. in public theatres.

The research is international in nature - the sample includes experts from 5 countries. The empirical material used in this study was obtained through qualitative interviews (Fontana, Frey, 2009; Kvale, 2023) conducted individually with a group of selected experts (8 experts) and a focused group interview (Gillham, 2000) conducted with a sample of experts during an expert panel (sample included 4 experts). The experts interviewed included 8 theatre managers.

The research was conducted on the basis of an interview script containing questions related to the area outlined in the introduction. In addition, the research (both in individual interviews and in the expert panel) allowed for the possibility of deepening the issues raised by specifying them with additional questions.

During the panel, the experts took turns presenting their opinions, listening to each other's opinions and asking each other questions. The individual interviews and the panel were recorded, and the material was transcribed, anonymised, coded and analysed. The coding was

open (Bingham, 2023) and the snowball method was used to generate a list of codes (Kirchherr, Charles, 2018). In addition, the results obtained were validated according to the state of the art in qualitative research.

3. Functions of modern theatre

Theatre, as one of the oldest art forms, functions in economic terms as an institution, foundation/association or commercial enterprise that fulfils a range of functions at different levels. This section of the article will cite statements from experts who share their experiences and opinions on the function of theatre in the light of changing social, economic and political processes due to the dynamic development of new technologies.

Theatre has the ability to influence the behaviour of individuals and groups of people. As a complex structure (including elements such as acting, directing, set design, sound, dance, etc.) that also collaborates with external stakeholders (organiser, supervisory body, programme and artistic board, audience, etc.) to create unique artistic experiences, it has fulfilled a number of important functions for society, politics and the economy since ancient times. The activities of theatres contribute to the development of creativity, the acquisition of the ability to critically evaluate reality and the analysis of complex problems. It also influences the development of cultural behaviour and contributes to the identification of a person with his or her nation, generation and region (Trzeciak, 2011, p. 12).

Due to the nature of its activities, the theatre can be divided into two types of functions: external, i.e. oriented towards society, and internal, i.e. those that favour the creation of conditions for the survival of the theatre as an institution, as well as the introduction of innovations that contribute to its development (Wilk, 2015, p. 155).

In the literature on the subject, the external functions of the theatre include the following: educational, cognitive, cathartic, entertaining and ceremonial. Their characteristics are summarised in Table 1.

Table 1.
External/social functions of the theatre

Functions	Description
Educational and cognitive (Guzy-Steinke, 2002, pp. 272-273)	Theatre helps to shape sensitivity and creativity, and by stimulating the imagination, it contributes to a fuller understanding of human destiny through the use of archetypes.
Cathartic (purifying) (Duvignaud, 1976; Hausbrandt, 1983, p. 93)	Identifying with the character in the play allows the audience to experience these fictional events as if they were real, which brings relief in terms of satisfying emotions and states, the so-called 'thirst for experience'.

Entertainment (Brecht, 1965, p. 65)	Theatre fulfils the need for fun and pleasure, not only in terms of humour, but also in terms of intellect - it initiates the process of independent thought and judgement.
Ceremonial (Hausbrandt, 1983, p. 93)	Theatre adds a special festive character to both private and public events, acting as an embellishment to the occasion.

Source: Own elaboration.

The social functions of theatre are emphasised by respondents, who point to the importance of theatre in 'educating' audiences, in shaping attitudes and in the emotional development of younger audiences:

„A very important (purpose - explanation by the authors) aim of our theatre is to 'educate' the theatre audience for the future (...). Our performances are 'ready/complete', they can see a 'painted' play, there is music, there is drama, there is acting, so a lot of art in one place. So different senses are stimulated. They have everything in one place. So they can develop their interests (...). And I must say that in our theatre we don't only have cheerful performances - we also perform plays with difficult subjects, for example death in children's plays. This is not unusual for our theatre. We try to show how justice and injustice work. Sadness is also a 'good' feeling (to get to know it - explanation by the authors)” [E2].

„(...) even my children came here for workshops and they learned how to be good people, they learned values. To develop different senses and an approach to what is good and what is bad, how to communicate with people” [E10].

„(...) we are taming sadness and fear and the performances, which will be aimed at young audiences (...) will present the characters with which our young audiences can identify in such difficult and critical and borderline moments. We are not trying to frighten them (...), these are still performances for young audiences and they are presented in a beautiful artistic form. Because quality and artistic value are, of course, the most important thing for us, and we stick to that, and we make sure that young viewers who are raised in this theatrical spirit, which is (...) extremely important to us, are also surrounded and imbued with certain values, so that we accustom them to values such as art, but also aesthetic values, which we want young viewers to build their perception of what they will one day see and hear themselves (...). For the time being, we, his teachers and his parents, choose for him, but soon he will be an independent viewer of art, and we want to prepare him as well as possible for that” [E7].

Contemporary theatre plays an important role in shaping the culture-forming - experts point to the influence of theatre on changes in society and consider theatre as a 'prestige medium':

„(...) they also play an incredibly important role in culture-forming, being, as they say, "centres of prestige distribution" and an extremely important place for social contact, for the public's contact with the art of theatre. It is also worth noting that theatre is one of the most popular forms of cultural education, which we often forget because we talk about theatre as a public institution, but theatre practice, theatre education, seems to be extremely important as well and is the most used form of cultural education in general” [E4].

Theatre is currently a driving force for change in society; it uses its identity to show, describe and encourage these changes:

„(...) Culture, theatre and theatre institutions are the place where social change can be described, can be, well, named. We can find out if the direction in which change is taking place is the direction in which we want to go. Theatre productions, individual performances and, above all, the processes of their creation and reception are precisely the kind of social test that names change, defines it, parametrises it qualitatively, without being a causal factor in the sense of (...), mechanical or sociological (...). And here the theatre has really returned to the basics of calling a spade a spade: evil is evil, but also of rebuilding a purifying experience” [E6].

„Theatre (...) goes beyond mere entertainment; it is a cornerstone of cultural identity, reflecting the rich tapestry of a country's history, art and social values. Historically, theatre has been a mirror of society, reflecting the vitality of life, its dilemmas and its triumphs. This deep-rooted tradition continues to influence the role of theatre today, making it a powerful tool for comment and reflection on contemporary issues” [E1].

The statements made by the experts in the study show that, despite significant changes, theatre is still an important part of social life, regardless of the country in which it operates.

The researchers also point to a group of therapeutic functions that theatre fulfils in relation to society (Table 2). In addition, the positive impact of theatre in rehabilitation practice is indicated, where the main goal of creative rehabilitation treatments is to stimulate the development of new social competences (Konopczyński, 2007, p. 13).

Table 2.
Therapeutic functions of theatre

Functions	Description
Entertainment	Theatre allows people to take their minds off everyday matters by immersing them in the world of fictional adventure. It provides a positive experience, improves mood and refreshes the mind, which has a positive effect on work undertaken and attitudes towards the environment.
Compensatory	Theatre activities (e.g. workshops with actors) help to release inner tensions, get to know oneself and one's talents, and overcome feelings of inferiority.
Preventive	Thanks to theatrical activity, people satisfy their needs (e.g. movement, expression or contact with other people), which helps to prevent the emergence of certain negative social phenomena.

Source: Own elaboration based on Kulczycki (1990).

In the literature on the subject, authors also point to other functions of the theatre:

- Artistic - theatre as an art form allows the expression and exploration of emotions, ideas and various topics through acting, set design or directing (Bonet, Schargorodsky, 2018, pp. 77-78);

- Shaping the consciousness of the country's inhabitants - it regulates the social mechanisms of society, influences its attitudes and actions, and opens a discourse between society and the country's authorities (Dobrowolski, 2019, pp. 33-34);
- Economic - in economic terms, theatre is considered a direct generator of jobs and other economic effects, such as the creation of added value in other sectors, the level of employment (Staszek, 2016, p. 63);
- Promotional - the theatre is a place to learn about regional and national culture (Frey, Pommerehne, 1989, p. 19). Theatre activities are reflected in the tourism industry. Due to the educational and promotional functions of the theatre, there is an increase in understanding and knowledge of the culture of a particular country, which contributes to the development of cultural tourism (Rohrscheidt, 2016), which in turn leads to an increase in income in other industries, such as the hotel industry. In this context, theatre tourism becomes a key issue, where the potential tourist decides to travel based on the availability of theatre performances in a given place.

The experts surveyed recognise the impact of technology on the functions of the theatre. They point to the evolutionary nature of the functions performed by the theatre. At the same time, they point out that the theatre industry will not be able to avoid the impact of technology (e.g. due to the changing profile of the audience). They emphasise the key role of the theatre manager in ensuring artistic quality:

„Functions (...) they determine everything, the whole intention. Traditional functions are constantly changing, technology is creating new functions. Moving in this direction is a necessity” [E12].

„Yes, it is crucial for theatres - technology affects the fundamentals of theatre, the functions that theatre fulfils (...) because theatre exists for something and for someone, which is the audience. As technology develops, the audience changes, and theatre makers cannot ignore these changes if they want a full house” [E8].

„Theatre has always been subject to metamorphosis - that is its nature. The same will happen in the age of ever-present technology. I don't think that technology will dominate the art, but it will contribute to giving us a new face of theatre. The role of a conscious theatre manager is to make this transformation without compromising the artistic level” [E3].

Considering the functions presented and the statements made by experts, it is easy to conclude that the traditional functions of the theatre are still relevant. In recent years, new technologies have been developed and increasingly used in theatres. As a result of the deepening relationship between theatre and technology, the function of the theatre is evolving. The technologies that are being introduced offer new opportunities to shape these functions (e.g. by changing the way we communicate or by providing a source of new stage stimuli). This situation presents a challenge to theatre management. Theatre managers who wish to influence the technological shaping of the theatre's functions, or who wish to manage efficiently

those functions that have already undergone technological processes, need to rethink each area of management and introduce appropriate improvements.

4. The impact of technology on selected theatre functions and related management implications

The content analysis of the interviews conducted provides information about the potential impact of technology on selected theatre functions. Table 3 summarises examples of areas of influence relating to the culture-forming, economic, entertainment, educational and promotional functions of the theatre. At the same time, it should be emphasised that this catalogue contains only a fraction of the possibilities offered by technology in shaping the functions of the theatre.

Table 3.
Selected areas of technology's impact on theatre functions

Function	How technology affects the function of the theatre	Description
Culture-forming	New forms of expression	New technologies are important in terms of shaping the message of the content conveyed during a performance. For example, music created using artificial intelligence rather than music created by the artist offers a different avenue for creativity and audience engagement through the way the work is created (e.g. as a result of interaction with the audience) and received.
	New methods for shaping the cultural competences of audiences	Digital means of reaching audiences are another form of cultural dissemination and thus have an indirect impact on the development of their cultural competences.
	Interactivity	Interactive technologies, such as mobile apps or voting systems, allow the audience to influence the performance. Such interaction changes the role of the audience from passive observer to active participant, changing the approach to experiencing art.
Economic	New sources of income for the theatre	Technology can help increase audiences, especially younger audiences, which will have a measurable economic impact on theatres. In addition, it is possible to create digital products for audiences who prefer mobile access to the arts. One example is online performances, which can generate additional income by removing capacity constraints.
	Economic benefits to other industries	The increased visibility of the theatre as a result of technology, which leads to larger audiences, translates into economic benefits for other industries such as catering and hospitality. A larger audience means a greater increase in demand for these types of services.
	Optimisation, automation and autonomisation of processes	Technologies can improve the efficiency of selected processes (e.g. administration), resulting in measurable economic benefits.

Cont table 3.

Entertaining	Introduction of new stimuli during the performance	The introduction of new stimuli allows the audience to become more involved in the performance experience. The conscious use of technology in a stage setting also offers a wider range of creative possibilities for the manager and the acting ensemble.
	Reaching the 'mass' audience	Technology can help to attract new audiences and to implement mass audience strategies. On the other hand, it can contribute to the need to adjust the level of performance, i.e. to lower the level of art.
Educational	New ways of learning	This includes both new methods of developing cultural competences and new forms of expression, as described earlier in the context of the culture-forming function. An example is the development of creativity through the co-creation of performances with an audience.
	Increasing accessibility	Technology provides opportunities to reach excluded audiences (e.g. people with disabilities who cannot get to the theatre). As a result, these people can benefit from the educational value of theatre.
Promotional	Support for theatre tourism	Technology makes it possible to increase the reach of the theatre and to create an offer geared towards theatre tourism, which is a special case of cultural tourism.
	New ways to promote culture	By contributing to the image of the theatre, technology indirectly contributes to the promotion of culture and ultimately the country, region or city itself, depending on the scale of the action.

Source: Own elaboration.

The analysis of the collected empirical material also reveals managerial implications that are valuable for both the theory of arts management and the practice of managing these organisations.

Shaping the contemporary functions of the theatre with the use of modern technologies is a key challenge for theatre managers, partly due to the paradox known as 'Baumol's cost disease' (Baumol, Bowen, 1966; Nierenberg, 2015), which is characteristic of artistic organisations. One of the reasons for this paradox is that, despite technological advances, it is impossible to increase the productivity of artistic institutions. However, according to experts, new technologies can partially solve these problems. While experts confirm that productivity gains in the work of artistic teams in theatres will be rather limited, they see technology as a way to increase the productivity of technical and administrative staff. In addition, experts see an opportunity for automation and autonomisation of selected processes, which will change the way theatres function:

„(...) there is a lot to do. It is hardly surprising that our industry is somewhat ossified when it comes to organisational matters. But those who automate the elements that make up the organisational framework for art will win the competition, (...) become more efficient and be able to devote more resources to artistic production” [E11].

„(...) in many areas, a lot of aspects are becoming autonomous. It is more than just automation. I can't imagine this in the context of art itself, but an autonomous programme that we allow to handle certain processes, for example administration and accounting, or

the promotion of performances, would be something that would facilitate the functioning of the theatre on many levels” [E12].

„I manage a music theatre. Dance and music performances have already undergone several technological transformations, e.g. from analogue to digital systems. I think we are now entering the era of systems making decisions for people” [E5].

At the same time, experts point out that the implementation of new technologies by theatres is usually associated with high costs. Theatres, regardless of their form of ownership, usually have limited and inflexible budgets, which severely limits the motivation of managers to implement technological innovations solely out of a desire to create new functions for the theatre:

„(...) theatre functions on their own may not be enough to motivate change. Investing in technology is a long-term process, and in discussions with the organiser, tangible quick wins carry more weight” [E12].

„The funding structure in our country is a problem. The budget at my disposal is inflexible and, above all, too small. I think that the national theatres, which are under the direct control of the ministry, have a better chance, and arguments about the evolution of the theatre's function can have more impact (...). Although in their case the problem will be the extent of the changes needed. In my opinion, however, there is no going back - change will come sooner or later” [E11].

„Public theatres will not necessarily have the motivation to implement new solutions, even though they have more resources than theatres like ours (private - authors' explanation). On the one hand this can be an opportunity for non-institutional theatres, on the other hand it can be a competitive factor” [E3].

In view of the arguments presented, it seems crucial to introduce new mechanisms for financial management. Dedicated funds for the technological development of the theatre or greater activity by theatres in raising external funds for these purposes are needed. Changes in the management of the relationship with the organiser seem necessary, leading to the involvement of bodies that directly fund theatres' activities in the implementation processes. It is clear, therefore, that consciously shaping the function of the theatre through technology requires highly developed political and change management skills on the part of theatre managers. In addition, experts consider technology to be a factor of competitiveness that is directly linked to the economic function of the theatre. It can be considered at two main levels. Technology that increases the efficiency of theatres, for example by automating selected processes, leads to an increase in the competitiveness of the theatre at an organisational level. On the other hand, on an artistic level, technology can be a generator of new stimuli or new art forms - examples are Annie Dorsen's algorithmic theatre (2012) or robotic theatre:

„By definition, a theatre that uses technological innovations must be open to new trends in art (...) by applying technologies extensively, they develop them themselves to a certain extent. For example, there is talk of robotic theatre. In my opinion, it does not yet look very attractive, but the development is visible” [E3].

The theatre manager who wants to use technology on stage is therefore faced with the challenge of changing the approach to managing the aesthetic contract with the audience - this is implied, among other things, by new impulses. It also affects the whole process of managing a theatre production, from the planning stage to the stage management during the premiere.

Technology supports theatre management and facilitates the documentation and analysis of performances, which in turn encourages artistic criticism and reflection on the form and content of art. Digital platforms and social media allow for discussion and exchange of opinions, enriching the discourse on theatre and its role in society, and enabling theatre to become a space that responds to the needs of contemporary society. As a result, theatre managers need to rethink their approach to managing the image of the theatre and the manager himself:

„(...) Theatre happens on stage, which is where stage technology plays a key role. It is important to realise that the desire to see Macbeth or Romeo on stage is not the only reason for visiting the theatre. It may simply be a desire to relax or be entertained. This is where technology has a special role to play. However, this approach requires a change in the way the theatre is perceived, towards an entertainment centre rather than a house of art” [E5].

„(...) I see technological theatre as original theatre with a well-planned image. But it is important that it is authentic” [E12].

„(...) the promotional function of a theatre is based on its image. On what it brings (...), what its message is, how it is perceived by its surroundings. In the theatre business, however, the image is built over many years, mainly through the artistic value of the work, and this can only be guaranteed by outstanding theatre personalities - actors, directors, theatre managers. Ultimately, their image is the image of the theatre (...). Times have changed, technology has advanced, and so must the approach to image building through the active use of technological advances. Please also remember that the risk to the image has also increased due to technology” [E8].

Experts also point to the negative impact of new technologies on some of the theatre's functions. It is becoming increasingly difficult to mobilise audiences to go to the theatre, the culture-forming function is being reshaped and the focus is shifting to the entertainment function:

„(...) the theatre has been transformed into a kind of 'entertainment machine'. Only a few theatres offered the opportunity to see important dramas, but now television, especially social networks and artificial intelligence in general, have entered people's lives and changed their mentality and the way they 'use' the theatre (...). Now in Italy young

people go to the theatre because it is part of the school or university programme and they have to go to the theatre, but it is not really a need for them” [E9].

This can have consequences for repertoire management. Technology makes it possible to take the performance out of the theatre building, but:

„Theatres need to be aware of the changing profile of the cultural participant. Taking into account technology and the impact that the viewer can have on art, I would even venture to say that we are dealing with a user of culture and art, not just a participant. This approach should be reflected in the programming offered by theatres” [E11].

It is clear, therefore, that theatre managers face choices in shaping theatres' repertoires in the context of 'mass audiences' and the general change in the profile of cultural participants towards cultural users.

The areas of impact identified also include the need for a new approach to availability management. In particular, this is the result of the impact of technology on the cultural and educational function, through new channels for reaching audiences and the possibility of reaching people excluded from participation in theatre performances. This issue is also linked to the economic function of the theatre - increased accessibility can lead to increased income for the theatre.

„The stage is slowly becoming less of a barrier (...) there is an audience that cannot get to the theatre for various reasons (...) sometimes it is because of where they live, sometimes it is because of health restrictions - this is a challenge for technology. All the functions we are discussing today take on a new meaning if we give all those who are excluded the chance to participate in culture” [E5].

New generation technologies allow the theatre to collaborate with creators and artists from different parts of the world, enriching the local perspective with new styles and international perspectives. At the same time, it should be emphasised that the internationalisation of the theatre is closely linked to its promotional function, which should ultimately translate into its economic function:

„The promotional function of the theatre benefits the tourism industry in the broadest sense. This is a consequence of its culture-forming function, as a highly developed culture is more interesting. It should be noted that international theatre festivals and guest performances have a direct impact and can interest potential visitors in culture. This is local action. In turn, the shaping of local audiences has a long-term impact on culture” [E8].

In the context of tourism, as mentioned by the E8 expert, an interesting issue is theatre tourism, which also has a direct impact on the finances of theatres. This phenomenon needs to be taken into account in theatre management at the level of repertoire management and pricing policy:

„(...) please note the paradox of tourism. I would no longer speak exclusively of cultural tourism, but of personalised theatre tourism. Here, technology plays a huge role in the delivery of the theatre's programme or in the formatting of the offer, e.g. in the form of

ticket packages for performances. The modern theatre manager needs to manage repertoire policy with these factors in mind” [E11].

The relationship between technology and the theatre's function is also reflected in the way theatres manage their human resources. New technologies require specific competences, in particular digital and technological ones:

„(...) the resource needed to implement new technology is a competent employee. The choice is not easy - either training or hiring additional staff (...), and in many cases both” [E5].

„(...) we are talking about theatre functions and technologies. Activities at the interface of these two subjects require competence. My team is made up of theatre people, not computer scientists (...) or technologists. So we will need knowledge and skills, but I think that creating new jobs can only be a temporary solution. I believe that my team will develop the technological competences to a level that will enable them to meet the challenges - they are extremely talented people” [E8].

The experts quoted above indicate that in developing the necessary competences of staff, theatres may decide to train existing staff or to recruit specialists with the desired competences. Each of these options can be problematic because of the financial outlay required. The development of technology requires a flexible approach that allows for quick adjustments, and grant-based funding does not fully allow for this. Funds for possible training need to be planned well in advance. On the other hand, in the context of additional staff, the problem may be the level of remuneration for specialists with appropriate qualifications. This means that the theatre organiser, who is responsible for the level of funding, plays an increasingly important role in this process. In addition, when it comes to hiring additional staff, it can be difficult to find people with the right competences, i.e. people who are digitally, technologically and artistically competent.

The survey focused on the formation of functions in which the respondents did not explicitly refer to the ethical use of new technologies (Sypniewska, Gołębiewski, 2023). Only indirect conclusions can be drawn from the information obtained during the interviews. However, the ethical aspects of the application of selected technologies, e.g. a robotic actor or a play written by a language model, need to be taken into account in management processes already at the conception stage of the implementation of a new technology. This is necessary because of the controversies that such applications raise, as well as legal issues such as copyright. In view of the potential implementation risks, theatres should raise awareness of possible risks, define internal policies, in particular with regard to applications of artificial intelligence, robotics (Coeckelbergh, 2022; Liao, 2020; Tribelli et al., 2024) and autonomous systems, and develop control mechanisms (Kosiak, 2023, p. 348).

The findings presented in this paper complement earlier research conducted by one of the authors on perceptions of the impact of technology on key aspects of theatre management (Karcz-Ryndak, 2024a, 2024b), which revealed, among other things, the relationship between

technology and theatre functions, as well as the limitations of implementing new technologies in theatres. The research conducted is part of a more general narrative about the cultural sector. Modlinski and Pinto (2020), in their research, note the adoption of new technologies by the cultural sector, both at the level of complementary technologies (reinforcement of employees) and substitutive technologies (elimination of human labour) in the context of the mission carried out in the units studied. Compared to the studies cited, this study provides a contribution oriented towards a cultural sector, analysing technologies from the perspective of the functions of cultural institutions that are inseparable from their mission.

The results obtained confirm the findings of researchers on the changing form of cultural participation in the context of digital transformation (Kaczmarek, 2024; Plebańczyk, 2023). Moreover, the results obtained are in line with the findings of Kaczmarek (2024, pp. 74-75) regarding the need for self-diagnosis of employees' digital competences. At the same time, it should be noted that the authors extend this perspective to technological competences. On the other hand, with regard to the study by Plebańczyk (2023), the results obtained are consistent with regard to the accessibility of culture.

In relation to the impact of technology on the strategy of cultural organisations, Kaczmarek (2024) points out that the digital strategy of a cultural institution should be consistent with its mission and the organisation as a whole. Another finding of the authors, that theatres should be wary of adopting a copycat strategy, is in line with this view.

Researchers also address the relationship between technology and the image of the organisation (Kaczmarek, 2024, p. 75; Wróblewski, 2017, p. 176). The present study complements these findings with issues of possible image crises, by linking them to the authenticity of change indicated by theatre managers.

The research conducted clearly separates the relationship between technology and theatre functions into two perspectives. On the one hand, the impact of technology on theatre functions creates challenges for theatre managers. On the other hand, it is possible to create these functions through the use of appropriate technologies. The research also has the added value of taking a broad perspective of theatre functions rather than focusing on a selected one. This makes visible the differences at the level of dominant functions and the related distinctiveness of different cultural departments. For example, in the case of the broader music industry (Sojecka, 2024, p. 70) and concerts (Fira, 2024, pp. 51-52), the importance of their entertainment function increases, which is not necessarily the case for the theatre industry.

5. Conclusion

Modern technologies influence the way theatres are managed, affecting their functions and their ability to reach audiences. Theatre managers should be aware of the changing functions of the institution and adapt management skilfully to dynamic conditions in order to fully exploit the potential of technology. Theatre has a significant impact on cultural education, developing the social sensitivity and creativity of audiences, as well as supporting rehabilitation processes. Contemporary theatre faces challenges such as changing perceptions of artistic quality through the prism of actors' popularity on social media.

The research contributes to both management theory and practice. The added value in the theoretical context is the new knowledge about the relationship between technology, theatre functions and management. The research shows the impact of technology and the possible management consequences in relation to the culture-forming, economic, entertainment, educational and promotional functions. In practical terms, the research is useful for theatre managers who wish to influence the design of the theatre function through the use of selected technologies, or who are taking steps to adapt theatre activities to functions that have already undergone technological evolution. In addition to theatre managers, the knowledge acquired may be useful to theatre organisers in the context of financial support for the solutions implemented, as well as to researchers dealing with the topic of technology management in cultural institutions. The research conducted may also be a starting point for research on other cultural sector entities in the context of shaping their functions through new generation technologies.

At the same time, it is important to bear in mind certain limitations of the research carried out. Firstly, the research focused on only five functions of theatre: culture-forming, economic, entertainment, educational and promotional. It can be expected that a larger sample size and more in-depth research would reveal other functions of theatre that are influenced by technology. Secondly, even with regard to the five functions of theatre mentioned, a wider impact of technology than has been revealed can be expected. As before, the solution might be to conduct more in-depth research or a quantitative study. In using the results of the study, one should also bear in mind the typical problems of qualitative research using the interview technique, e.g. the possible tendency of respondents to self-presentation. It should also be remembered that the study used a purposive sample, so caution should be exercised in attempting to generalise the research to the whole population.

When considering further research directions, it is worth adopting a different research perspective, e.g. that of an artistic theatre team, a theatre employee or an organiser. It may also be beneficial to expand the catalogue of theatre functions and to conduct quantitative research. In a broader context, further research can focus on analysing the implementation processes of

new technologies in theatres, taking into account the context of theatre functions and identifying specific cases that can be a source of knowledge for management practitioners.

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PROCESS ORIENTATION IN PROJECT MANAGEMENT IN COMPANIES OF THE INSTALLATION AND ASSEMBLY INDUSTRY

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Purpose: The purpose of this paper is to provide an overview of the current situation in the management of companies in the installation and assembly industry in the context of process orientation.

Design/methodology/approach: The scope of the article relates to the literature search and the analysis of the situation conducted in companies in the industry. Key aspects in the approach to project management processes that occur in companies in the installation and assembly industry were presented.

Findings: Conclusions on the prospects of using the process approach in companies in the installation and assembly industry were presented. Current solutions and proposals for new implementations were also mentioned. The benefits of introduction and application of process orientation in project management at companies in the above-mentioned industry were indicated.

Practical implications: The article outlines assumptions and the essence of process orientation, and presents practical application in companies

Originality/value: The article focuses on the installation and assembly industry, which is relatively little researched scientifically. The paper is addressed primarily to practitioners implementing projects in the industry and the scientific community dealing with this issue.

Keywords: management, process orientation, project.

Category of the paper: Viewpoint.

1. Introduction

Process orientation is an approach to management in which processes, i.e. activities aimed at achieving specific results, are an essential element (Marciszewska, Nowosielski, 2011). In project management, process orientation focuses on ensuring the smoothness of activities, effective cooperation between teams and optimization of processes to achieve project goals (Gudelj, Delic, Kuzmanovic, Tesic, Tasic, 2021). In the traditional approach to project management, the focus is on completing tasks and meeting specific requirements. Process

orientation emphasizes the importance of the management process itself - the flow of information, standardization of procedures and streamlining of activities. This approach makes it possible to improve the work of project teams and increase the efficiency of goal achievement. Companies in the construction industry, and the installation and assembly are part of such a group, are organizations in which project management is the most important element of functioning in both business and financial contexts. Therefore, appropriately adapted to the specifics of the company, processes are an essential element affecting the achievement of business success by these organizations (Gąsowska, 2022). Issues of potential problems encountered in implementing such an approach were also noted. The material presented in the paper is original and addresses issues that are not often focused in the installation and assembly industry. It should be noted that from a scientific point of view, the industry is relatively little studied, and the available literature and scientific studies are rather limited.

2. Research methods and an overview of process orientation and characteristics of the industry

Presented research focuses on an overview and analyzes the role of process orientation in project management. During the research, the attention was focused on conducting theoretical examinations using methods such as analysis and synthesis, among others. The purpose of the review was to determine the current state of processes within project management and their impact on the achievement of business success for companies in the installation and assembly industry (Shamim, 2022). Process orientation generally spotlights on the processes occurring in an organization, rather than on organizational units or functions (Prudzienica, 2011). The overriding goal of this approach is to optimize and standardize activities so that they are as efficient as possible and the organization can achieve its goals with fewer resources. Process orientation plays an important role in the management of organizations, and its application is particularly evident in companies seeking to innovate and adapt to a changing environment.

The origins of process orientation can be traced to the history of production management and labor optimization in factories. Its development was closely related to the evolution of management theory, as well as to the growing importance of efficiency and quality in the activities of enterprises. Many concepts in the field of process orientation have emerged, with various sources of process orientation, including Total Quality Management, Business Process Reengineering and Six Sigma (Czyż-Gwiazda, Burka, 2011). Process orientation assumes that in any organization there are many interrelated processes that affect the final outcome of activities. It should be noted that management maturity is important in the processes occurring in organizations, which, by increasing the flexibility of the organization, directly improves business performance (Sliż, Szelągowski, 2023). In order to effectively manage

an organization in a process-oriented manner, it is necessary to understand and allocate the processes that occur in a company. These include the following activities:

1. Identify key processes to determine which are most critical to achieving the organization's goals.
2. Carry out optimization and standardization to minimize the poor use of resources (time, money, materials) and develop uniform procedures that can be applied across projects.
3. Introduce continuous improvement through regular analysis and enhancement.

The pursuit of improved quality, lower costs and higher productivity are key elements of a process orientation in terms of the management approach. The above determinants also apply to project management processes and relate to the concept of a process organization, in which processes are identified, related, measurable and purposefully managed (Bitkowska, 2013).

Process orientation – overview

Process orientation is based on the following key principles:

1. Introduce process standardization by identifying and implementing best practices that can be replicated across projects.
2. Implementation of activities in which regular analysis and improvement of processes to eliminate unnecessary activities will lead to optimization.
3. Smooth and efficient flow of information between all departments of the organization.
4. Monitoring of processes for their compliance with established quality standards.

Maintaining the above requirements leads to a number of benefits for the organization related to achieving greater efficiency, higher quality of products or services, transparent and understandable to all, and faster and often proactive response to change or innovation. The relationships between the processes, as well as their interpenetration, are shown in Figure 1.

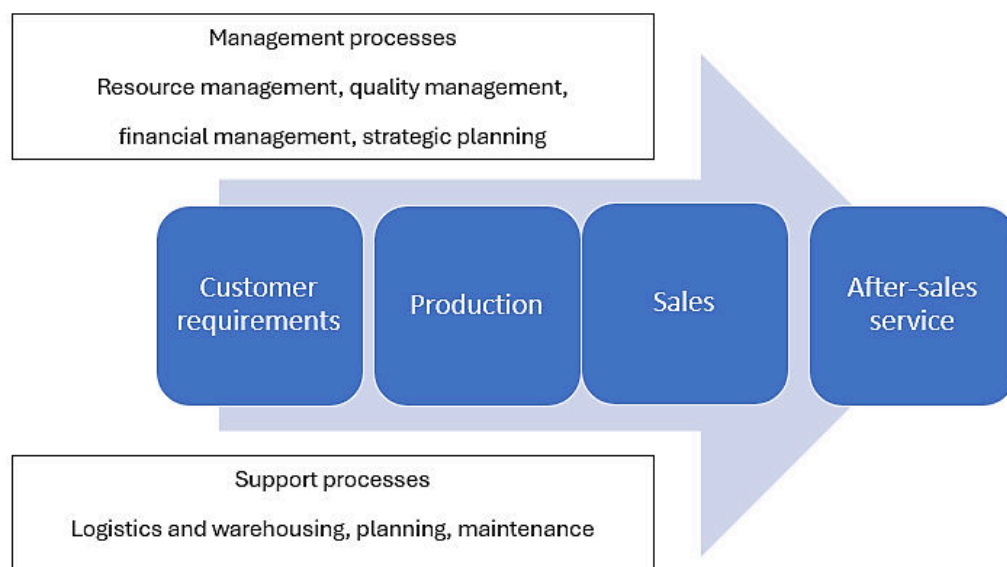


Figure 1. Process breakdown diagram.

Source: <https://akademijakosci.com/zarzadzanie-procesowe/>

Process orientation derives from the drive for efficiency and optimization that accompanied the development of management. Due to developed methodologies and tools, modern companies can effectively manage their processes, which translates into greater competitiveness, better quality of products and services, and the ability to adapt faster to a rapidly changing market. Today, process orientation is the foundation of modern management, which focuses on continuous improvement and optimization of organizational activities. Process orientation in project management is an approach that focuses on optimizing processes, standardizing procedures and improving information flow (Biesok, 2019). This makes it possible to increase the efficiency, quality and fluidity of project implementation. Implementing this approach allows organizations not only to better manage projects, but also to develop their ability to carry out increasingly complex tasks. As a result, companies can become more competitive on the market, take on more complex tasks for implementation, and optimize costs, resulting in possible price reductions for customers.

Project management – a key area in installation and assembly companies

Project management is one of the key areas of activity of modern companies in the installation and assembly industry. Projects are an essential tool for realizing the long-term strategic goals of the company, and the ability to manage them effectively is indispensable in a dynamically changing business environment and effective and rapid adaptation to market expectations. An important aspect remains the assumption that projects can be implemented as a response to changes in the business environment, allowing the organization to adapt to new conditions. They can also involve changes in organizational structures (Boguszewicz-Kreft, Gmińska, Sokołowska, 2015). The installation and assembly industry is generally characterized by the use of a narrow and duplicated group of solutions in the field of project management methods and methodologies, which is primarily due to the fact of high specialization in terms of personnel and technologies used. The above determinants additionally affect the low ability of most companies in the industry to significantly change their business profile, as this involves a series of decisions and changes of a financial nature.

Project management is a major revenue item in companies in the installation and assembly industry, since projects and their implementation are the basic financial foundation of companies in this industry. It also plays a decisive role in achieving strategic goals and adapting to market changes. Also, the selection of personnel, as well as improvements in other resources, run in close correlation with the projects carried out in the organization. Therefore, the importance of project management in companies in the installation and assembly industry is primarily related to the optimization of resources through their effective use in the planning and allocation processes, as well as the minimization of risks. It also involves striving for precise definition of objectives, which allow the implementation team to predetermine the needs and define the most important elements of the project. The next important stage of project

management is planning, which involves defining the scope of the project, the schedule of activities, the budget and the resources that will be needed to carry out the project. This stage also identifies potential risks and develops strategies to manage them. Throughout the project management process, companies must also focus on effective team management project using various competencies and skills, monitoring and controlling progress, checking any deviations, or making adjustments. The final activity remains the evaluation of the project, during which all stages and elements of this activity should be analyzed, which allows for the improvement of management processes in the future. Meeting the above requirements, as a rule, should increase the operational efficiency of the organization, though, among other things, the expedient use of resources, more effective management of change or the propensity for innovative activities.

There are numerous challenges when it comes to project management for companies in the installation and assembly industry. The more complex the project, the more difficult it is to manage it effectively. Due to the coexistence of many aspects related to technology, projects in the industry require both technical knowledge, as well as coordination skills and practical risk and resource management skills (Knauf, 2015). Most projects in the industry are often carried out under time and budget pressure, and short timelines in schedules or insufficient resources can lead to delays, financial overruns or reduced quality. Within project management activities, the industry is characterized by a large number of stakeholders - clients, investors or employees. Managing their expectations, as well as communication between them, can be a challenge, especially if stakeholders have conflicting goals or expectations (Morgan, 2005).

It should be noted that project management is a major area of activity in companies in the installation and assembly industry. It has a significant impact on efficiency, innovation and adaptability of the organization to market changes. Effective project management in a company allows better use of resources, minimizes risks and leads to the achievement of the organization's strategic goals. For companies in the installation and assembly industry, project management is a business foundation without which organizations cannot function. Therefore, it remains extremely important to adequately use both the appropriate tools and methodologies for project management, as well as to understand the need to use processes. Meeting these conditions undoubtedly however, it enhances companies' operational capabilities, especially in terms of how they respond to the changing business environment.

3. Conclusions

Process orientation in project management is an approach that emphasizes understanding and optimizing processes that make up a project (Bitkowska, Weiss, 2017). Thus, a project is treated not as a set of isolated activities, but more as a workflow, interdependence and continuous improvement. Project management has traditionally focused on task and resource management, while process orientation introduces a more structured approach to managing the various stages of project execution (Szczepaniak, 2017). At the core of this approach is the identification of processes, their analysis, optimization and monitoring. The application of process orientation enables systematic and more efficient project management, with an emphasis on harmonious flow of activities. In projects, processes can be understood as a sequence of steps that lead to the achievement of a specific goal. Each project can therefore be broken down into a series of processes, such as planning, resource allocation, risk management, communication or quality control. With a process orientation, projects become more transparent and their implementation more efficient.

In terms of project management, the key steps in line with the process orientation are:

1. Process mapping which involves identifying all activities in a project, determining their sequence and interdependencies. These steps provide a better understanding of how different activities affect each other and which steps are critical to the success of the overall project.
2. Standardization of processes implemented through the introduction of repeatable procedures and methodologies for project implementation, which is an important element of process orientation ensuring implementation in accordance with best practices.
3. Workflow management, i.e. focus on the optimal flow of activities and resources within the project, automation of some processes, which implies reduce project time, reduce errors and improve communication between team members.
4. Continuous process improvement using optimization tools.
5. Risk management by systematically identifying, analyzing and managing risks at the process level, which allows rapid response to potential risks and minimizing their impact on the project.
6. Quality control to identify problems and eliminate them early in the project, minimizing the risk of errors and corrections in the final phase.

The key elements of process orientation in project management are shown on Fig. 2.



Figure 2. Key elements of process orientation in project management.

Source: https://mfiles.pl/pl/index.php/Podej%C5%9Bcie_procesowe/

In terms of implementation, attention should be paid to tools that support process orientation in project management (Romanowska, 2004). An important role is played by BPM (Business Process Management) systems, which allow modeling, automation, monitoring and optimization of processes within a project. Their importance is particularly important in terms of automating repetitive tasks, managing resources and responding more quickly to changes in the project. Workflow diagrams (flowcharts), on the other hand, provide a visual representation of the processes in a project. They make it easier to understand the sequence of activities and identify critical points that are crucial to project success. Agile and Scrum methodologies significantly support process orientation. Their approach involves regular and systematic monitoring, evaluation and improvement. This allows project teams to respond quickly to changes and improve task completion processes. Modern IT tools play a key role in process orientation. Project management tools make it possible to monitor progress, manage resources and assignments, communicate internally and externally, and automate certain processes. With them, you can better control the course of the project, including by tracking the performance of individual processes, which affects the efficiency of implementation (Trzecieliński, Adamczyk, Pawłowski, 2013).

The benefits to the installation industry of using process orientation in project management are primarily transparency and control over the course of implementation. This is because process orientation makes it possible to track progress, as well as identify bottlenecks. It also has a positive impact on the organization's knowledge management by applying procedures to

protect intellectual property (Ha, Lo, Suaidi, Mohamad, Razak, 2021). Process optimization improves efficiency and saves resources, so organizations can execute projects faster and more efficiently. Automating and standardizing processes also reduces the risk of wasting time and resources, which is especially important in large projects with limited budgets. Processes that have been optimized and organized in a logical way allow tasks to be performed more efficiently, while the reduction of redundant steps and better organization of teams contribute to shorter project times and lower costs. Through quality checks at each stage of the process, projects implemented with a process orientation tend to be more compliant, while regular process analysis makes it possible to quickly identify errors and implement appropriate changes related to the customer requirements, market conditions or internal problems. Companies in the installation and assembly industry are particularly sensitive in terms of potential risks. Therefore, risk management, especially through process identification and monitoring, allows for earlier detection of potential risks. This approach allows the implementation of appropriate preventive or corrective actions. This allows a more proactive approach to problems and a faster response to potential difficulties (Bitkowska, Sobolewska, 2020). The use of the process approach in project management in companies in the installation and assembly industry can therefore lead to an increase in the operational efficiency of these organizations, thereby achieving more business and financial goals.

4. Summary

Process orientation in project management is an approach that allows better understanding and optimization of project activities (Orieno, Ndubuisi, Eyo-Udo, Ilojiana, Biu, 2024). It also allows the application of numerous optimizations within the operation of companies. The analysis presented was based on a literature search of the topic and case studies of companies in the industry were used. In companies in the installation and assembly industry, the main benefit of introducing and applying process orientation remains faster and more flexible response to change, greater efficiency and optimization of resources, as well as more effective risk management. These aspects of project management also make it possible to carry out more complex tasks, where traditional management would require more effort and resources. They therefore provide real benefits both operationally and financially. Through process mapping, continuous improvement, automation and standardization, organizations can execute projects more efficiently, respond more quickly to changes and deliver services or products that are more customized to the customer's needs. It should be noted that the introduction of process orientation in companies in the installation and assembly industry also brings particular benefits of scalability, which flows into replication in other projects. Standardized procedures allow in new tasks for faster execution with more precisely defined

risks. This makes organizations more flexible and ready to manage more projects simultaneously. It should be noted that the implementation and subsequent use of a process approach to project management is fraught with numerous difficulties. Particularly common difficulties include financial factors, including the cost of implementation and staff training, as well as personnel factors related to team members' attitudes toward new solutions or changes. The presented overview of applied process-orientation solutions in the management of installation and assembly companies can provide guidance for application in companies in the industry with the aim of improving operational efficiency, thereby influencing the improvement of the performance of these organizations. The most important limitations to using such solutions are related to the human factor, including resistance or reluctance to implement changes and the additional costs associated with implementation (Castro, Dresch, Veit, 2020). The review identified the direction of the current status in the industry's companies, as well as the benefits of potentially implementing process orientation solutions. Despite the numerous limitations, the balance of benefits of such solutions argues in favor of implementing the methods in the practice of companies in the industry. The information obtained and recommendations for application can be applied to companies in the industry to improve the operational efficiency of companies, which indirectly improves the business performance of these organizations.

Acknowledgements

Materials, results and considerations presented in this article are a prologue to the future empirical studies and will be included in later deliberations.

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THE SIGNIFICANCE OF ECONOMIC INNOVATION IN THE CONDITIONS OF THE PANDEMIC CRISIS AND RELATED GOVERNMENT ACTIONS

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Purpose: The aim of the article is to analyse the significance of innovation during the pandemic crisis and related government actions. The implementation of social distancing rules and the closure of public spaces by countries became key measures to combat the spread of the SARS-CoV-2 virus (COVID-19).

Design/methodology/approach: The study is based on the analysis of scientific literature, including empirical research, from the period of 1 January 2020 to 31 December 2023. The research process involved systematising knowledge in the area of the research problem. Key economic mechanisms that emerged during the pandemic crisis were identified, and it was demonstrated how governments responded to the effects of the pandemic, aiming to prevent the consequences of COVID-19.

Findings: The analysis revealed that the pandemic crisis exposed both the potential and the limitations of enterprise innovativeness. At the same time, differences in government support strategies significantly influenced the speed and effectiveness of businesses' adaptation to the changes that occurred in the economy.

Research limitations/implications: The study is limited to the analysis of literature and the discussion of research findings from a selected period, which may not account for the full long-term effects of the pandemic crisis. Further research may focus on a detailed assessment of sectoral and regional differences in the creation of innovation during the crisis.

Practical implications: The results show the necessity of building enterprise resilience to crises through investment in innovative technologies and business models. These conclusions can assist policy-makers in designing effective support mechanisms for companies in crisis situations.

Social implications: The study highlights the importance of cohesive public policies that support innovation, which can positively impact quality of life and economic stability during crises. It is also possible to highlight the need for corporate social responsibility in addressing global challenges.

Originality/value: The article demonstrates the significance of innovation during a crisis and emphasises the substantial impact of government actions and legal regulations on the development of innovative solutions. It includes conclusions relevant to enterprises in terms of preparation and response to future global crises.

Keywords: Innovation, Government Action, Coronavirus Crisis, Policy, Corporate Sector.

Category of the paper: literature review, research paper.

1. Introduction

The coronavirus pandemic (SARS-CoV-2) and its rapid spread forced countries to take decisions aimed at curbing the mobility of communities, which in turn translated into changes in the economy. Those government decisions became an exogenous shock for a considerable number of business entities. The coronavirus pandemic brought changes to many industries, characterised by both benefits and losses. However, it is a well-known fact that states of danger such as wars, plagues, cataclysms and crises induce people to come up with unconventional solutions to problems, and above all, intensify creativity and innovation.

The aim of this article is to review and critically analyse the literature, including empirical studies, on the significance of innovation amid the pandemic crisis, as well as the actions taken by governments to counteract this crisis, both from a social and economic perspective. The question is whether such studies have already been carried out, and what their conclusions were? To answer the main question, we should address three auxiliary questions: (1) what happens to the economy, i.e. what changes are taking place in business practices during a pandemic crisis and why innovation is necessary? (2) What were the government actions aimed at supporting the innovativeness of enterprises during the coronavirus crisis? (3) what innovative measures have been taken by companies to sustain business?

In view of the above, by observing real-world conditions and reviewing the literature, a research gap was identified, highlighting the need to systematise knowledge about the significance of innovation amid the pandemic crisis and the related government actions. An analysis of the existing knowledge on this topic can serve as an introduction to broader areas of research. It summarises the current state of knowledge, which can facilitate the understanding of theories and research findings.

In light of the above, the research hypothesis assumes that innovation plays a significant role amid the pandemic crisis, both from a social and economic perspective. It accelerates the implementation of new technologies and business models, as well as reveals human potential in adapting to dynamically changing economic conditions.

The research focuses on illustrating the scale of the coronavirus crisis and the condition of enterprises, consumer behaviour and the ways companies deal with the government restrictions imposed as a consequence of the COVID-19 pandemic. The persisting situation inclined society to reconsider its views on consumption and brands that became less important. At the same time, the DIY idea emerged, which involved unconventional methods of doing things for one's own use, without the assistance of professionals. Individual and social identities have changed, which beyond any doubt affected people's and corporate innovation in a new situation.

2. The Research Method and Analysis of the Scale and Effects of the COVID-19 Pandemic

The research method was based on an analysis of national and international subject literature. Significant scientific publications covering the period of the pandemic and its conclusion (2020-2023) were selected for analysis, describing the economic phenomena occurring within this time frame. The changes that took place in economic practices during the pandemic crisis conditions clearly indicate the importance of innovation in adapting to new challenges.

COVID-19 is not the first disease that affected people's health. Over the last decades, virus outbreaks such as SARS (also known as SARS-CoV-1), MERS, swine flu, Zika and yellow fever posed a threat to people's lives globally (Buheji, Ahmed, 2020). Unlike other threats, COVID-19 became a pandemic, requiring global mobilisation and cooperation to bring it under control.

It can be observed that the coronavirus pandemic is one of the largest health crises in modern history. The COVID-19 epidemic has had a profound and potentially lasting impact on all social and economic aspects (Basu, Swaminathan, 2021). The pandemic revealed the consequences of the public health crisis and also showcased public policy programmes (Paananen et al., 2023). Apart from a humanitarian tragedy caused by the COVID-19 pandemic, there is also a threat to local economies as well as the whole, global economy. As documented in history, the time of a crisis brings far-reaching changes within the whole society and economy, and most crisis situations stimulate innovation and technological development.

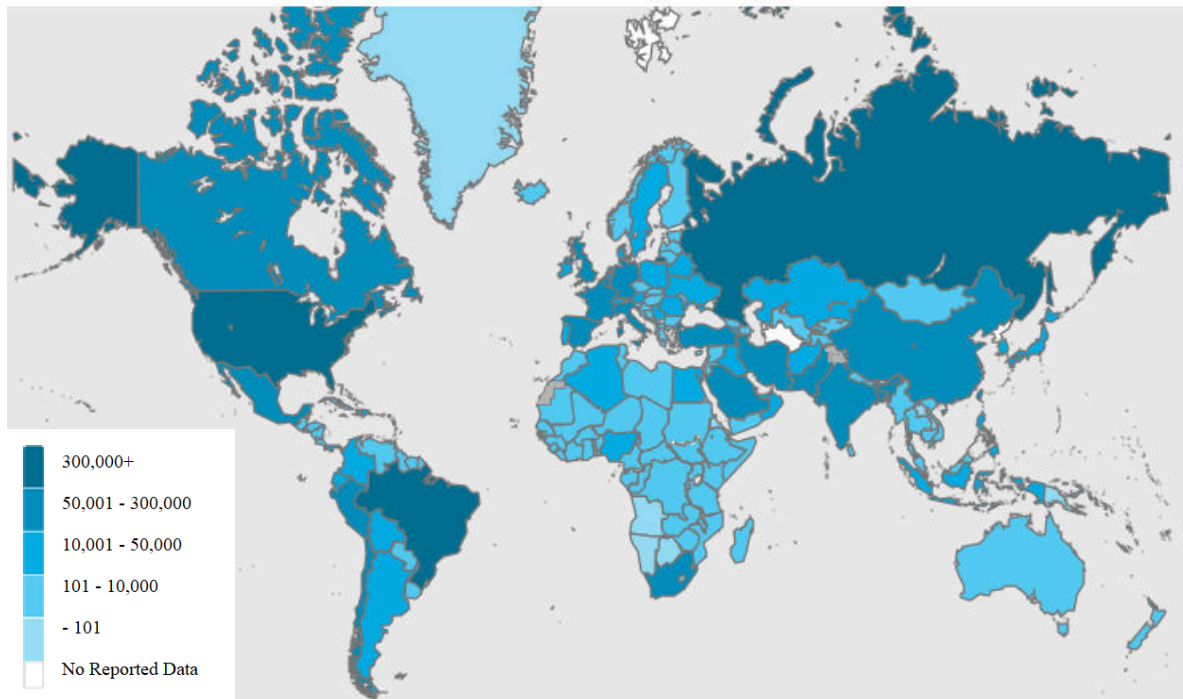
It can also be observed that its conclusion was not clearly defined, as it dissolved and became intertwined with other crises, including the emergence of the Russian-Ukrainian war (Paananen et al., 2023). This conflict contributed to the deepening of economic and political instability worldwide, affecting many sectors of the global economy. As a result, the boundaries between individual crises began to blur.

This phenomenon creates an opportunity for research and, over time, for the systematisation of knowledge about social and economic challenges in the conditions of the pandemic crisis. In such a situation, broadly understood innovations introduced in business organisations are of particular importance. At the same time, social innovations include adaptive measures enabling the resolution of social and economic problems in such circumstances.

Since 2020, the world struggled with the coronavirus (COVID-19) caused by SARS-CoV-2, which suddenly reached pandemic status. The new situation rapidly changed the global economy; almost concurrently, all the countries in the world noted an economic slowdown and a recession. The global economy lost its potential, and the question arose of how businesses should operate to survive in the changed market and new reality. Societies and

economies, including businesses worldwide, experienced an external shock, dealing with an unpredictable situation.

To illustrate this phenomenon, statistical data showing the scale of the phenomenon can be presented. In the second week of June 2020, there were over seven million COVID-19 infections reported worldwide. On 9th June 2020, WHO registered 7,039,918 reported infections, with over 400 thousand deaths due to this illness (on 9th June 2020, the official number of deaths reached 404,396 (WHO, 2020)). The range of coronavirus infections is shown on the map in Figure 1.



Data from: June 09, 2020.

Figure 1. The Map of Coronavirus 2019-nCoV (COVID-19) Infections at the Onset of the Pandemic.

Source: Author's own elaboration on the basis of: (WHO, 2020).

For the first time, the World Health Organisation (WHO) announced the strain of coronavirus (SARS-CoV-2) to cause a global pandemic on 11 March 2020 (Yang, Yu et al., 2020). On 14 March 2020, the Polish Republic declared the state of epidemic emergency due to SARS-CoV-2 infections that was lifted on 20 March 2020 by the ordinance of the Minister of Health of 20 March 2020 (Journal of Laws of 2020, section 440). Then, pursuant to the ordinance of the Minister of Health of 20 March 2020 on the announcement of epidemic within the territory of the Polish Republic (Journal of Laws of 2020, sections 491, 522 and 565) from 20 March 2020 until further notice, the state of epidemic was announced due to SARS-CoV-2 infections.

The first observations that were made after announcing a pandemic were on the consumer behaviour. The shopping spree at the end of February and the beginning of March 2020 swiftly turned into panic buying, increasing the expenditure of households. Purchases of toilet paper

skyrocketed by a staggering 845% in comparison to the previous month, household cleaning agents surged by 766%, paper towels by 536%. The buyers swept the shelves clean of toilet paper, disinfectants and cleaning agents, or even drinking water (NCSolutions, 2020). In time, the buyers got used to new conditions and stopped worrying about the deficit of products. It should be noted that such a situation was observed in the developed countries.

Hoarding was attributable to the fear of the unknown, and the information spread by the media was perceived as “preparation for survival in extreme conditions” (Austin, 2020). The emergence of health risks and economic risks began to shape consumer behaviour (Basu, Swaminathan, 2021).

Another phenomenon concerned commerce and production, as many European manufacturers transferred their production to China. Therefore, as emphasised by Yigit Kazancoglu, Esra Ekinici et al. (2023), the degree of global supply chain structures of countries and sectors affected by the pandemic crisis is significant. The most appropriate solutions for managing them can be identified by considering a systems thinking approach.

Global chains of supply are of great importance for the world economy, and production comes mostly from the nascent economies. Shutdown of plants in China affected many industries such as computers and iPhones as well as the automotive industry (Ajami, 2020). In 2019, Asia contributed 35.3% of global export and 33.8% of global import. The industries greatly dependent on Chinese supplies included global production of computers, household appliances and electronics, optical ware, textiles and clothing (Wprost, 2020).

The tourist industry became the fastest and most extensively affected by the COVID-19 pandemic. Many tourists were forced to cancel their trips as public space was shut down by the local authorities. This sector is closely linked to the hospitality industry, which also significantly felt the effects of the pandemic crisis. As noted by Justyna Łukomska-Szarek, Agnieszka Wójcik-Mazur et al. (2023), during the COVID-19 pandemic, many governments imposed strict restrictions on travel and mobility, as well as temporary bans on accommodation providers. Lockdowns, the necessity to close hotels, or guest occupancy limitations resulted in a decline in bookings or the cancellation of already agreed-upon stays. The financial situation of many operators deteriorated significantly, and some entities were forced to cease operations as they could no longer run profitable businesses.

In order to contain the pandemic COVID-19 and ensure safety to their staff, some companies, where possible, transitioned to remote work (work from home–WFH). That made an impact on the hotel industry and transportation (Hadi, 2020). This change led to a decline in demand for services related to business travel. As Toshihiro Okubo (2022) observed, telework was occasionally used before the coronavirus pandemic to enable better working styles. However, as COVID-19 infections spread, telework became a necessity for most companies across various industries. The government requested that employees exercise self-discipline by staying at home and actively sought to promote telework. Some entities were forced to shut down because they could no longer operate profitably.

Transport turned out to be the industry most vulnerable to the coronavirus crisis. Airlines grounded 75% of their fleet due to domestic and international air travel limitations, following the decisions of governments striving to contain the virus. In line with the information provided by the International Air Transport Association (IATA), it was forecasted that the revenue of this sector would decrease by one-third of a trillion dollars USD, with 25 million possible redundancies (Kotoky, Stringer, Saxena, 2020). Tourism, as an industry “most vulnerable to a pandemic”, came to a grinding halt due to social distancing restrictions and a halt in travel (Jamal, Budke, 2020).

3. Research Results

3.1. Government Actions Amid the Pandemic Crisis

Due to the threat to health and life of COVID-19, the governments decided to ban the movement of people, which slowed down the global economy and put many companies out of business. The imposed restrictions on mobility and the closures of service sectors significantly affected the operations of tourism, gastronomy, hospitality, and transportation companies. At the same time, many enterprises had to adapt to the existing situation by investing in information and communication technologies (ICT), which enabled them to conduct business under conditions of social isolation.

In view of the high contagion rate of SARS-CoV-2, enforcing social distancing proved to be the only effective solution to limiting infections within the communities (Fong, Gao et al., 2020). It should be noted that while government decisions aimed at increasing security improved well-being for people, they resulted in unpredictable results for the economy. In view of the current crisis of the world economy and the impact made by COVID-19 on innovation, keen attention should be brought to the impact made by government actions on companies. Again, Keynesian economics makes sense by calling for state intervention. A free-market mechanism does not provide any solutions to complex problems that emerge in the economy.

At this point, it is possible to attempt to answer the posed questions: What happened to the economy, what changes occurred in it as a result of the pandemic crisis, and why did innovations prove to be necessary? What steps have been taken by governments to support corporate innovation in a time of a pandemic? What innovations did companies implement to survive in the market?

Selected results of the research were analysed to answer the posed question. One of the surveys was structured on the interviews conducted with the people connected with the entrepreneurship ecosystem in Germany. The purpose of the interviews was to find people's reactions to the coronavirus crisis and discuss their opinions on the resources allocated by the

government to ease the consequences of the economic downslide. The surveys showed that during the pandemic the resources were targeted by the government on the protection of large companies, single entrepreneurs and the entrepreneurs affected by COVID-19. The aid that was rendered includes tax support, other forms of financial assistance by Liquidity Guarantee Funds (that fund provides guarantees for medium and large companies affected by COVID-19) as well as the loans and special programmes provided by KfW (*Kreditanstalt für Wiederaufbau*) i.e. German state bank for development (KfW, 2020).

Nonetheless, many allocated resources, such as KfW loans, were not available for innovation start-ups (particularly in their inception stage) since they did not meet the basic criteria prerequisite for qualifying for the support (Kuckertz et al., 2020). Germany is not the only case; the same situation is to be observed in other countries. A majority of political initiatives taken to protect the economies during the pandemic crisis were addressed to the functioning corporations, industrial sectors and economies in general. By this token, those resources have been intended to protect employment and sustain the necessary economic activity.

During the pandemic crisis, the focus was placed on protecting the present, while the future of the economy seemed to be of lesser importance. It should be noted that there are, among others, innovation start-ups whose role is to shape the economy of the future. During this time, they were left without government support and yet remained the most vulnerable to the impacts of the coronavirus crisis.

The change in the situation that affected all branches of the economy necessitated the action of the governments aimed at alleviating the negative consequences of the pandemic crisis. The recovery policy was targeted at supporting the industries that were most vulnerable. Regrettably, that action has not included support for innovation that would facilitate the introduction of new solutions, following the much-wanted handling of the COVID-19 pandemic.

It can be observed that the European Union committed to supporting innovation by funding scientific research and innovation in key areas of the economy; however, these efforts were limited to selected sectors of the economy. In April 2020, it expressed support for the first action plan under the European Research Area, called ERA vs Corona, which aimed to counteract the effects of the coronavirus crisis (Sharma et al., 2022). It can be noted that funding was provided for projects primarily related to the development of diagnostics, vaccines, treatment, epidemiology, mental health, as well as support for ICT technologies (Pleśniarska, 2022).

3.2. Economic Changes

The situation attributable to the coronavirus had an impact on all industries owing to the dramatic changes in demand and supply (Mention, Ferreira, Torkkeli, 2020). The industries that were more vulnerable to losses, and those that might benefit from the coronavirus crisis, are presented in Figure 2.

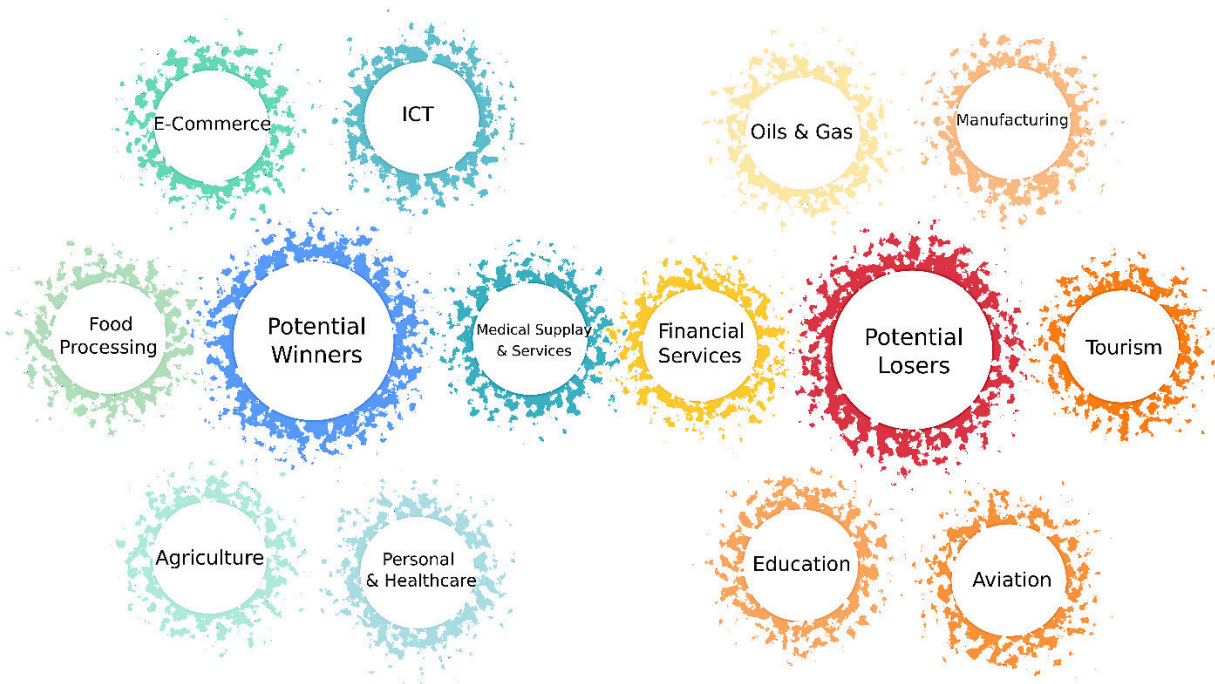


Figure 2 Vulnerable industries and those with the prospects for rapid development in the time of coronavirus crisis.

Source: Own study based on (Dcode, 2020).

In the short-term perspective, it is apparent that the pandemic crisis has brought not only threats but also opportunities. The industries that benefited at that stage of the pandemic include medicine, the food industry, the chemical industry, ICT, e-commerce, and farming.

ICT proved to be most useful. It served not only for human interaction, but also for social contacts and communication with next of kin (Kirk, Rifkin, 2020). These technologies bridged the gap created by physical distancing, enabling people to stay in touch, share experiences, and provide emotional support despite being apart. Moreover, ICT played a key role in sustaining educational and professional activities, enabling remote learning and telework, which allowed society to function under new conditions.

Co-creation, innovation, and ingenuity developed alongside the acquisition of new skills by DIY methods, where even people unfamiliar with the technology learned some new applications (Kirk, Rifkin, 2020). A major role was played by ICT, including e-commerce. At the same time, an increase in the importance of social media platforms as tools for knowledge exchange and support in the process of learning new skills was observed.

Social media were used for the exchange of information in the home improvement area (house refurbishments, landscaping) that boosted retail e-commerce sales. As noted by Meheli Basu and Vanitha Swaminathan (2021), threats such as pandemics, recessions, and other social crises alter consumers' regular lifestyle choices. This is mentioned by Katarzyna Witczyńska (2022), who notes that the global coronavirus pandemic affected consumer behavior worldwide. Consumers began spending more time at home, leading them to purchase products from online stores.

As a result of the COVID-19 pandemic, the shift from in-person learning and work to remote formats was revolutionary in nature. It should be noted that universities were the foremost beneficiaries of ICT, reaping its technological potential during the pandemic. Chinese universities were the first to apply distant learning online via the internet. At the same time, to prevent the backlog in education, Chinese universities, headed by the Ministry of Education of China, launched educational platforms so that faculty could lecture online. As noted by Iwona Chomiak-Orsa and Klaudia Smoląg (2022), the COVID-19 pandemic contributed to the widespread adoption of remote learning. At the very beginning of the pandemic, the transition from in-person processes to remote ones was revolutionary. Teachers and students had to switch "overnight" from traditional teaching and learning methods to remote learning.

Many leading universities participated in an exceptional social initiative by sharing with the community, free of charge, several tens of thousands of high-quality training materials and teaching platforms. The universities that excelled in this area include, among others, the University of Peking (the oldest and most renowned university in China), the online school at Tsinghua University, and the foreign language teaching platform in Peking (Wang, Cheng et al., 2020).

As noted by A. Kuckertz and L. Brändle (2020), the experience gained following the Katrina hurricane and the tornadoes in Tuscaloosa, Alabama, and Joplin, Missouri, shows how entrepreneurs continue to bring the economy back on its feet by providing the victims of these catastrophes with necessary resources while utilizing social capital. Such highly motivated individuals achieve both commercial and social goals. As noted by Rachael Behr and Virgil H. Storr (2022), necessity entrepreneurs are also highly resilient, as they face difficult circumstances and yet manage to persevere.

4. Types of Innovation Activity – Discussion

As shown by history, pandemics such as the Black Plague in the Middle Ages (the 15th century) and the Spanish Flu at the beginning of the 20th century triggered social innovation (Kirk, Rifkin, 2020). It should be noted that there is also organizational innovation, which involves embracing work processes, technical advancements, and technological innovations (Chlebowski, 2020). Knowledge, the ability to learn by adapting to a new environment, and innovation are commonly considered prerequisites for the functioning and development of both individuals, organizations, local communities, regions, and entire countries globally.

Innovation is a prerequisite since innovative companies have the ability to predict and adapt constantly to a wide range of crises (Kuckertz, Brändle et al., 2020). This refers to broadly understood innovations introduced in organizations engaged in economic activities. Such

innovations include new technologies, processes, and business models aimed at enhancing efficiency and adaptability.

The use of videoconferencing technologies surged during the pandemic crisis, and ZOOM™ evolved from a little-known brand into a product recognized in many countries. Digital technologies help reduce social distance, yet nothing demonstrates that virtual contacts can replace face-to-face encounters or physical contact between people. Research shows that customers are becoming fatigued with ZOOM™, which may be attributable to challenges involved in using this virtual communication technology. Communication via video tools (compared to face-to-face contact) requires focusing on the faces presented on the screen, and it lacks feedback from noticing and interpreting non-verbal elements (Kirk, Rifkin, 2020). Additional research was conducted to examine the strengths and weaknesses of the Zoom application, its role within the community, and its new uses. Another analysis was carried out showing how a company can retain its customers and sustain its growth rate once the crisis subsides (Kominers, Gonzalez, 2020).

Even though face masks have been relatively common in China, they were rarely used in Western cultures before the COVID-19 pandemic. Yet, with the advent of the pandemic, all kinds of face coverings, designed to protect both the wearer and others, became standard. At the same time, many consumers have started treating textile masks as fashion accessories, adorning them or making them from special fabrics in matching patterns or colours (Kirk, Rifkin, 2020). A good example of this innovation is a “trikini”, which is a bikini with a third textile part added whose function is to cover the face (thus replacing the traditional face mask). In other words, a trikini is a three-piece bathing suit.

There is a negative perception of the pandemic situation; yet, paradoxically, it may bring positive aspects to businesses and create new opportunities. The situation promotes learning to cope with new circumstances and fosters innovation (Tan, 2020). The pandemic crisis has caused disruptions in daily life and livelihoods worldwide, but human ingenuity and resilience are manifested in the form of innovation (Sharma et al., 2022).

The new circumstances make people aware of the need to promote sustainable business (Mention, Ferreira, Torkkeli, 2020). L. Boone, the chief OECD economist, noted (2020) that governments should support sustainable development policies. He said, “The economic and social prospects for the approaching decade depend on the policies we implement today. Rebuilding the economy needs an additional drive in the form of global cooperation. Governments must seize this opportunity to create a more just and sustainable development. Building prosperity is the consequence of dialogue and cooperation at the level of states and globally, through mutual trust”.

Despite the fact that the foregoing presents the situation in developed countries, it must not forget about the famine caused by the COVID-19 pandemic, which could lead to global starvation, particularly in light of the growing numbers of people in need of food across Europe (Cattivelli, Rusciano, 2020). D. Beasley, the Head of the World Food Programme (2020),

presented the results of an analysis during a session of the UN Security Council. The results show that extreme starvation could affect 265 million people worldwide. In 2020, this number grew by 130 million compared to the figure from the previous year. He stressed the fact that the world is “on the verge of a starvation pandemic”. As noted, the pandemic crisis has led to widespread food insecurity, particularly in low-income regions, which has further deepened inequalities. This has made it increasingly difficult for many to access food that would meet their needs.

5. Conclusions

Having considered the fact that the world has not experienced a pandemic of such magnitude for over a century, little research has explained the emerging situation and the effects taking place in both social and economic, as well as political and economic spheres. There is no research available on this subject, and the publications that urgently came out in the studied years are still open to discussion. A new crisis situation, not just in the health sphere, but also in social, political, and economic aspects, has not yet been fully documented by scientific sources. Those publications that have already been printed provide just some insights into the state that has emerged.

The results of the research present observations based on practice, providing some explanation of the current situation of companies and forecasting the outcomes for the future. The analysis provided by this article may partially fill the gaps in the literature within this area. It also allows for answering the posed questions while supporting the hypothesis that economic innovations play a significant role in the pandemic crisis, both from a social and economic perspective.

The results highlight the necessity of building enterprise resilience to crises through investments in innovative technologies and business models. These findings can assist policymakers in designing effective support mechanisms for businesses in crisis situations. Further research may focus on a detailed assessment of sectoral and regional differences in innovation creation during crises.

Most likely, new pandemics will become a threat in the future. Therefore, it is important to remember that innovation allows us to cope with crisis situations. Moreover, innovation enables the shaping of future enterprises. In such extreme circumstances, research on corporate innovation, which allows companies to survive and develop, is crucial. Knowledge of how to cope with such situations is essential for political and business decision-makers. The article has raised issues that substantiate further research.

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PROTECTING AND PROMOTING POLISH TECHNOLOGICAL HERITAGE WITH THE TOURIST TRAIL OF DIGITAL CULTURAL HERITAGE: CONCEPT, CRITERIA, AND GROWTH POTENTIAL

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Purpose: Digital technology has significantly affected Poland's socioeconomic and cultural development. Regrettably, information about the early days of Polish software, computers, factories, and research centres is yet to be aggregated. The study aims to develop the concept of the Tourist Trail of Digital Cultural Heritage in Poland (the Trail) and refine its theoretical foundations. It focuses on expanding the list of places relevant to the history of the Polish computer and electronics industry and specifying inclusion criteria.

Design/methodology/approach: The primary method, desk research, included reviewing the literature, reports, and online sources. The authors identified critical locations that could be included in the Trail. The study also investigates existing thematic routes in Poland to identify and employ the best practices.

Findings: The desk research yielded several dozen places linked to the history of Polish technology. These are museums, former production sites, and heritage landmarks, like monuments, squares, and plaques. The authors also proposed potential trail signage and ways to promote the Trail. Integrating historical, educational, and technological domains can improve the awareness of Poland's contribution to preserving digital cultural heritage and promote thematic tourism.

Research limitations/implications: This exploratory research requires verification in the field. The challenges include unstable museum premises and the lack of specific regulations on establishing and maintaining tourist trails.

Practical implications: The Tourist Trail of Digital Cultural Heritage in Poland has the potential to improve public awareness of Poland's contribution to the history of the global computer and electronics industry. It can also animate technology heritage tourism. Increased tourist traffic can stimulate local economies.

Originality/value: It is the first attempt to devise a concept of the Tourist Trail of Digital Cultural Heritage in Poland. The study offers new insights into the protection of technological

heritage and suggests how it can be effectively incorporated into tourist and educational portfolios.

Keywords: digital heritage, tourist trails, computer science history, technology museums, electronics industry.

Category of the paper: Research paper.

1. Introduction

With technology inherently fused with our daily lives, cultural heritage is a natural object of interest. It includes unique human knowledge and forms of expression that convey cultural, educational, scientific, and administrative values. Less obvious digital heritage items are technical, legal, medical, and other content that was born digital or digitised from analogue renditions (UNESCO, 2003). It is critical to protect it so posterity can access these resources (Król, Zdonek, 2022).

Today, digital heritage faces a severe risk of oblivion. The history of electronics, computers, and video games has become an important domain worthy of preservation and promotion (Kowert, Quandt, 2015). The main threats are rapid ageing of equipment, lack of stable funding mechanisms, blurred responsibility for maintaining digital heritage assets, and inadequate regulations (Thwaites, 2013). These challenges call for effective strategies and administrative and legal tools to support heritage protection. They should align with local conditions, available resources, the urgency of the problem, and long-term forecasts on the future of technology and archiving methods (UNESCO, 2003). In light of the above, computer and gaming museums not only record the course of technological development but also play an important educational, cultural, and socioeconomic role (Naskali et al., 2013). When included in thematic routes, they can aid in disseminating knowledge of the history of technology, furthering digital education, integrating communities, and stimulating the local economy by attracting tourists interested in digital culture. However, many challenges lie on the path of those who intend to establish, maintain, and expand the operations of such places. The concept of the Tourist Trail of Digital Cultural Heritage in Poland is an attempt to support them.

Poland has many thematic routes through which people can discover a plethora of cultural heritage dimensions: historical, culinary, and architectural, to name a few. Why not offer a Tourist Trail of Digital Cultural Heritage in the digital era? Research shows that digital heritage includes hardware (Król, 2021a) and software (Król, 2021b), shaping today's culture just as much as paintings, sculptures, sacral masterpieces, and architectural monuments (Portalés et al., 2018). The digital Trail could comprise technology museums, innovation centres, and places linked to the history of the Polish computer industry to provide education, inspire young generations, and support thematic tourism (Król, 2024).

Digital technology has significantly affected the socioeconomic and cultural development of Poland. Regrettably, information about the early days of Polish software, computers, factories, and research centres is yet to be aggregated (Król, Zdonek, 2022). There is no single, unified method for celebrating history in the tourist context. The present study addresses this gap by identifying specific places and objects that could become part of the thematic route. The present study is intended to elaborate on the existing concept of the Tourist Trail of Digital Cultural Heritage in Poland (Król, 2024) and evaluate its potential role in promoting the history of the Polish computer and electronics industry. The Trail would include technology museums and locations central to the development of the Polish computer and electronics industry, such as former production facilities, research centres, and other landmarks. Additionally, the study aims to define the criteria for including locations in the Trail and analyse its potential impact on cultural tourism and technology education in Poland.

This is the second article in a series on the concept of a thematic route in Poland focused on digital cultural heritage (Król, 2024). The authors put forward a hypothesis that, just like tourists are offered wooden architecture routes, trails of wooden churches, or culinary trails, they should be able to follow a digital cultural heritage tourist trail. It assumes that a coherent and well-marked tourist trail of digital cultural heritage could contribute to: (1) improving public awareness of the Polish contribution to the history of the computer and electronics industry; (2) stimulating interest in technology heritage tourism in Poland; (3) integrating existing museum and historical initiatives; and (4) stimulating local economies through larger numbers of visitors to places linked to the history of technology. The hypothesis further posits that digital heritage can be effectively promoted as a tourism product, just like architectural or culinary heritage, as long as the concept for promoting it and information dissemination tools – signage and digital channels – are prepared appropriately.

Research to date focuses on digital cultural heritage museums (Król, 2024). The present article is the next step and fills in a research gap by covering museums of old equipment and software as well as places celebrating the history of Polish technology efforts, such as monuments, squares, factory buildings, and industrial facilities. Therefore, the tangible outcome of the study is an expanded list of sites commemorating the history of technology in Poland. The study is part of a mini research project, ‘Mapping Digital Cultural Heritage Museums in Poland (DigiMap)’. DigiMap is part of ‘Regional Excellence Initiative’ (RID/SP/0039/2024/01).

2. Background

2.1. Thematic routes as part of tourist infrastructure in Poland

Thematic routes are an important component of the Polish tourism infrastructure. They support tourism in its many varieties: sightseeing, cultural, and ecotourism. Their impact goes beyond recreation and covers economic, social, and cultural aspects as well (Niedziółka, Krasnodębski, 2023).

Polish tourism has a long history of tourist trails. They also come in diverse types: walking, cycling, horseback riding, kayaking, and special trails (Niedziółka, 2011). The modern approach to trail blazing takes into account their role in creating tourism products, shaping the tourism environment, and attracting tourists (Stasiak, 2006). Still, the legal framework for blazing and operating trails in Poland is inconsistent (Stasiak et al., 2014). Two acts of law are relevant to tourist safety: (1) the Act of 18 August 2011 on safety and rescue operations in mountain areas and organised skiing sites (Polish Journal of Laws of 2023, item 1154) and (2) the Act of 18 August 2011 on safety of people in water areas (Polish Journal of Laws of 2023, item 714). Nevertheless, comprehensive regulations for planning and blazing tourist trails are yet to be enacted, so further conceptual and legislative effort is called for.

Trails focused on eminent figures and important historical events are an outstanding category of thematic routes in Poland (Table 1). Some examples include the Nicolaus Copernicus Memorial Road Tourist Trail, Fryderyk Chopin Trail, John Paul II Papal Trail, or the Grunwald Trail, marking the largest medieval battle in Europe near Grunwald. Another remarkable collection is architectural heritage trails, such as the Trail of the Eagles' Nests, among castles and castle ruins in Silesia and Lesser Poland.

Table 1.
Selected tourist trails in Lesser Poland

No.	Name	Place, location, range	Primary theme
1.	Lesser Poland Trail of Wooden Architecture	Małopolskie Voivodeship	A total of 255 secular and sacral objects
2.	Lesser Poland Oscypek Trail	Suski, Nowosądecki, Nowotarski, and Tatrzański Districts in Małopolskie Voivodeship	Traditional Podhale products (primarily Oscypek, a traditional cheese from the region) promoted in 26 shepherds' huts
3.	Trail of the Eagles' Nests	Śląskie and Małopolskie Voivodeships	Castles and castle ruins in the Kraków-Częstochowa Upland
4.	Lesser Poland Gothic Art Trail	Małopolskie Voivodeship	Gothic architecture heritage
5.	Lesser Poland John Paul II Papal Trail	Małopolskie Voivodeship	Places where Karol Wojtyła (Pope John Paul II) hiked
6.	Lesser Poland Wine Trail	Małopolskie Voivodeship	Meetings with owners of 65 vineyards and their products
7.	Lesser Poland Garden Trail	23 municipalities in Małopolskie Voivodeship	Regional garden science, history, culture, and architecture

Cont. table 1.

8.	Lesser Poland Kościuszko Uprising Trail	Małopolskie Voivodeship: Kraków, Krakowski, Proszowicki, and Miechowski Districts	Places linked to the Kościuszko Uprising
9.	Kraków Fortress Trail	Kraków	Forts, defence walls, fortifications, and similar objects
10.	Lesser Poland Way of St James	Małopolskie Voivodeship	St James, patron saint of pilgrims

Source: own study.

Cultural trails often focus on tangible heritage, including architecture. However, some cover intangible heritage as well, such as culinary traditions and local foods. The most important thematic routes in Lesser Poland are the Oscypek Trail, with shepherds' huts where traditional regional cheeses are made, and the Wine Trail, which promotes wine tourism (Kruczek, 2018). Other prominent thematic routes are military trails and pilgrimage ways. The Kraków Fortress Trail invites tourists to defensive structures from various historical periods. The most outstanding pilgrimage trail is the Lesser Poland Way of St James, part of the European network of ways leading to Santiago de Compostela (Mróz, Mróz, 2013).

The popularity of tourist trails reflects the growing demand for such products in regions' promotional strategies to enhance their tourism value. Research indicated that the routes have to employ new technologies and embrace evolving tourist expectations (Stasiak, 2014). The central challenge for the immediate future is to introduce coherent regulations for establishing, managing, and promoting tourist trails so that their potential for the tourism sector can be fully used.

2.2. Museums of digital cultural heritage. Establishing, potential and limitations of growth

The Polish legal framework sets principles for establishing, organising, and operating public and private museums. To establish a museum, one has to satisfy specific formal criteria that guarantee proper operation and attainment of educational, cultural, and scientific goals. It is relevant here that 'Under the current legal framework, private and public museums are created in two steps...' (Golat, 2008, p. 12). Additionally, there are two procedural paths: (1) the 'official' one provided in such regulations as the Act of 21 November 1996 on museums (Polish Journal of Laws of 2022, item 385) and (2) the 'private' one, which is more flexible. The official method involves listing the museum with the Ministry of Culture and National Heritage of Poland. In this case, the museum needs a policy with the name, registered office, scope, and funding. Such an organisation also has to keep a register of all items in its collection. Experts noted that '...operators of such places face numerous financial problems. These give rise to issues with personnel and factual value when they cannot employ competent staff. It leads to troubles with ensuring conditions for proper storage and exhibition. Another challenge is to inventory, document, analyse, and catalogue the artefacts (Studnicki, 2018, p. 171). It makes it a little easier to establish a museum if it is given the status of 'pending

organisation'. This way, the institution can be created in stages with a temporary policy and organisation of the exhibition area, depending on the resources. Experts noted that 'The "pending organisation" status gives more freedom to select and arrange exhibits. A predefined, and inalterable permanent exhibition is not required then' (Pstrocka-Rak, Rak, 2021, p. 163). Despite more freedom, the museum institution still remains a museum according to the Act. In this context, private museums seem to enjoy greater organisational flexibility. This way, individuals can create expositions in line with their vision and the local community's needs. Private museums are often the fruit of the passion of their founders, which makes them particularly unique. Experts noted that 'Communing with old objects, experiencing their purpose during workshops, for example, and living the narrative around them can provide a journey different from everyday life, which makes them a source of ludic quality' (Studnicki, 2018, p. 171). Private initiatives can be more personal and individualised, which is an added potential for addressing market niches. On the other hand, public museums operated by central or local public authorities under the Act on museums have an official statute. They are obliged to pursue the mission of protecting national heritage, such as the National Museum in Warsaw or the Museum of the History of Poland. In addition, museums under the aegis of state or international organisations usually enjoy more funds and access to professional staff at the cost of a more rigid structure and less flexibility in responding to the audience. The bottom-up approach helps stimulate local communities and aficionados to protect and promote digital heritage. However, it comes with funding and professionalisation challenges.

Museums of computers and games have great potential. They provide technology education, preserve digital cultural heritage, and support thematic tourism and innovation. As education venues, they allow visitors to learn the history of technology and its impact on the world today. Unlike traditional exhibitions, these institutions are often interactive so that visitors can commune with the exhibits. Operational 1980s or 1990s consoles allow them to see and experience the technology of the era long gone. It is particularly attractive for younger generations who find retro gaming and retrocomputing increasingly fascinating, and allows older people to remember their youth. Digital cultural heritage museums can also play a central role in tourist trails. When included in thematic routes, they can promote regions and enhance their cultural product portfolio. A well-designed trail combining various technological heritage aspects can become an international tourist attraction.

Still, cultural heritage museums face numerous constraints, challenges, and problems, especially private museums. The primary challenge is operational funding. Most private technology museums worldwide do not receive steady support from the state. They need to look for alternative income sources. Workshops, space rentals, sponsors and patrons (crowdfunding), or special events are the most common funding methods. Alas, they often fail to cover all operational costs. Experts noted that 'Most IT museums in the world lack patronage and central or local government funding' (Pstrocka-Rak, Rak, 2021, p. 168). Another challenge is to keep digital exhibits operational. Maintenance of decades-old electronics requires specific

storage conditions and expert knowledge. Then, the next complication, expected to worsen with time, is the dwindling number of experts familiar with archaic technologies, combined with limited access to original spare parts. Experts noted that ‘...hardware and games (software) are more at risk of digital decay, worsening poor accessibility of digital media even more’ (Swalwell, 2009, pp. 265-266). This is not only due to the limited durability of plastics but also the condition of microchips and data carriers (Garda, 2014). In addition, it takes significant time to repair and restore hardware and software, and the conservation effort is not made easier when documentation is unavailable. The problems will intensify with time, bringing new digital heritage protection challenges for museums (Setniewski, 2006).

2.3. Exhibitions in digital cultural heritage museums

How exhibits are displayed at museums of digital cultural heritage is relevant here. Should consoles, arcade video games, and computers be merely ‘silent machines’ in display cases with emulated software? Experts noted that ‘Retro gamers do not prefer emulation as such because the reconstruction of the actual experience requires original equipment from the period’ (Garda, 2014, p. 123). Emulation fails to offer the complete journey, starting with booting, controls, smell, and original sounds, down to image clarity and pace of operation. Therefore, the original devices are critical for retaining the ‘original experience’. The hardware includes monitors, joysticks, and keyboards that contribute to the authentic experience from the past. This exhibit display approach necessitates substantial effort and funds to preserve and keep the devices operational. Private museums can allow visitors to see and interact with exhibits thanks to greater freedom and fewer formal restrictions. Experts noted that ‘Exhibiting institutions face a daunting task today. On the one hand, they have to respond to visitors’ needs. On the other hand, they have to ensure appropriate safe conditions for exhibits in line with regulatory requirements to protect and preserve them for posterity (Makiła-Polak, 2019).

2.4. Digital cultural heritage museums and the co-exhibition of arcade video games, pinball machines, computers, and consoles

Museums of digital cultural heritage play a central role in preserving the history of video games. They often offer arcade video games, pinball machines, computers, and consoles. Furthermore, their collections can include household appliances like radio receivers, TV sets, or mobile devices, as well. Their co-occurrence in the museum space is an opportunity to present the evolution of technology, interactive entertainment, and its impact on culture and socioeconomic development. The functional analysis enforced with such a display design reveals the complexity of relationships among household appliances and arcade video games: differences as well as similarities.

Arcade video games used to be an impactful part of the entertainment landscape for decades. Their build and usage set them apart from computers and consoles at home. As new technology opportunities occur and retro gaming grows more popular, a question arises as to whether

arcade video games could be integrated into household gaming equipment. The problem is especially relevant considering the changes in practices related to collections, historical reconstructions, and exhibitions on video gaming.

Personal computers and game consoles have been designed for private entertainment at home. In contrast, arcade video games were intended to be used in public spaces as commercial coin-op machines. Through placement in arcades, pubs, train stations, hotels, or tourist accommodations, they were readily available. Such machines were seldom kept for private use (Dziatkiewicz, 2017). During socialism in Poland and in the 1990s, arcade video games provided the only access to video games for many Poles, especially those who could not afford a computer or console. Today, arcade video games are a rare occurrence. Original devices are mostly found in museums, entertainment venues, and private collections (Dziatkiewicz, 2024).

The main obstacles limiting private ownership of arcade video games are their price and spatial requirements. Original devices are expensive and hard to fit in a typical residential unit. In addition, the original arcade video game experience is relatively hard to replicate at home, which is much easier for consoles and computers. Although emulators like MAME and arcade video game box replicas are available, the experience of communing with original systems cannot be simulated (Dziatkiewicz, 2024).

The technology behind the original arcade video games is substantially different from the inner workings of household gaming hardware. Their dedicated hardware architecture makes most models compatible with specific titles (games) only. In some, the data carriers, such as motherboards or cartridges, could be changed, but it was more complicated than in the case of personal computers or consoles. The appearance and functions of arcade video games were often modified in Poland. For example, the original controls of ‘Defender’ with a single joystick and five buttons were expanded to accommodate two players (Dziatkiewicz, 2019a).

Arcade video games offered much better technology than devices at home in the 1980s and 1990s. The graphics quality, animation smoothness, and controls responsiveness were much better, which made arcade video games more attractive. Ported versions of arcade video games for personal computers and consoles were usually less perfected in visuals and mechanics due to hardware limitations (Dziatkiewicz, 2019b). Moreover, arcade video games were easier to use. All the player had to do was insert a coin. They were structurally built to be more robust than household devices, allowing them to withstand intensive use in public spaces. The virtually uninterrupted use in readily available locations required special components. Unlike computers and consoles, which could require some technical knowledge to maintain, arcade video games were intuitive and thus accessible to a broad audience (Dziatkiewicz, 2019a).

Arcade video games are exhibited in various museum institutions and thematic areas today. There are several types of such places, like video game museums, computer museums, and other entertainment venues. Poland’s most prominent arcade museums are the Kraków Arcade Museum and the Warsaw Arcade Museum, with both vintage machines and more

contemporary models. Another important place of digital heritage in Poland is the Museum of Electronics in Kraków with the Chorzów branch (Figure 1).

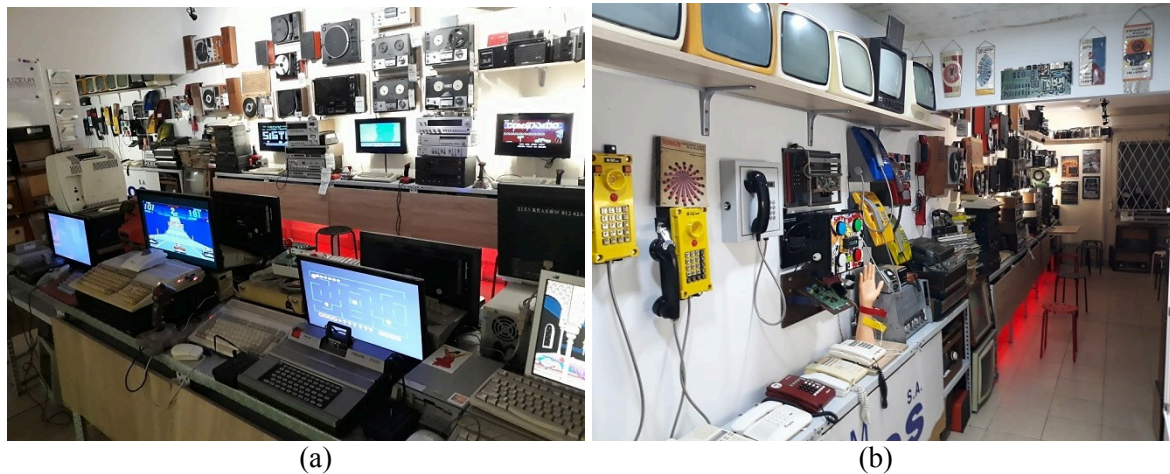


Figure 1. Part of the exhibition at the Museum of Electronics in Kraków. Left to right: computer and audio equipment (a). TVs and telephones (b).

Source: Król (December 2023).

All the exhibits at the Museum of Electronics in Kraków are operational. It is mostly thanks to the knowledge and skills of the curators and access to spare parts. All this is because the museum used to be an electronics store and service centre. Hence the substantial spare parts resources.

Some places are devoted solely to computers and consoles, like the Museum of Consoles, Video Games in Karpacz, Museum Games & Computers of the Past Era in Wrocław, or the Museum of Computers and Games in Warsaw, which offers VR experiences as well as retro hardware. In some locations, arcade video games are displayed together with other electronics, as is the case in Land of Retro Gaming Pixel-Mania in Władysławowo or the Museum of the History of Computers and IT in Katowice. There are also thematic institutions like Terra Technica – Jukebox & Pinball Time Travel Museum (Chvalovice-Hatě, Znojmo, Czechia), which displays arcade video games, jukeboxes, pinball machines, and vintage vehicles (Table 2).

Table 2.

Selected (described) centres / meeting venues / exhibitions / pinball machine and arcade museums in Poland and abroad

No.	Name	Place	Primary focus	Comments
1.	Kraków Arcade Museum	Kraków (Poland)	Arcade video games, simulators, and pinball machines	The largest arcade museum in Poland
2.	Warsaw Arcade Museum	Warsaw (Poland)	Arcade video games, simulators, and pinball machines	A branch of Kraków Arcade Museum
3.	Museum of Consoles, Video Games in Karpacz	Karpacz (Poland)	A private museum of consoles and video games	The first video games museum in Poland

Cont. table 2.

4.	Land of Retro Gaming Pixel-Mania in Władysławowo	Władysławowo (Poland)	Arcade video games and household appliances	A very extensive and diversified collection
5.	FunHouse Katowice	Katowice (Poland)	Pinball machines and arcade video games	An interactive museum of pinball machines and arcade video games
6.	Museum of the History of Computers and IT	Katowice (Poland)	Polish and foreign computers, including ODRA	A private museum (pending organisation) of the history of computers and computer science
7.	Terra Technica – Jukebox & Pinball Time Travel Museum	Chvalovice-Hatě, Znojmo (Czechia)	A collection of arcade video games and jukeboxes	The largest global museum of jukeboxes and pinball machines
8.	ArcadeHry	Červený Újezd (Prague-West, Czechia)	Nearly only arcade video games	A retro gaming house and museum

Source: own study.

User experience is critical for investigating differences between using an arcade video game and an emulator. Although modern technology can emulate original games, it is no match for interaction with a physical machine. Relevant aspects include visuals, how the image is displayed, control modes, and the arcade atmosphere. Arcades played a social role; people met, competed, cooperated, and enjoyed spontaneous interactions there. Memories of people who spent time in arcades often involve a combination of sharing emotions, cheering, and watching players compete (Dziatkiewicz, 2024). Culturally and socially, arcade video games stay relevant as part of video gaming heritage. Their presence in museums and collections confirms their unique impact on the history of electronic entertainment.

3. Materials and methods

The research was conducted under the ‘Mapping Digital Cultural Heritage Museums in Poland’ (DigiMap) project, REI project No. K/658/2024/WRE. It has been funded through regranting under ‘Improved potential of management and quality sciences through better use of Polish rural capital’ co-founded by the Republic of Poland under a Minister of Science scheme ‘Regional Excellence Initiative’ (contract No RID/SP/0039/2024/01). A popular science description of the research results, a raster map, and an interactive map of the museums of digital cultural heritage in Poland, together with preliminary conclusions and results of a pilot study, were published on a thematic website <http://digitalheritage.pl> and in a research article (Król, 2024). The present effort is a continuation of work on the concept of a tourist trail of digital cultural heritage. It focuses on reviewing historical analyses and media reports and identifying critical elements that can be integrated into the digital cultural heritage trail in Poland.

The desk research reported here involves analysis of available sources on digital cultural heritage, including popular science literature, media reports, and information on cultural trails (Bednarowska, 2015). It is founded on scientific and popular science references as well as reports of institutions involved in cultural heritage protection and promotion. The authors analysed input from experts, retro fans, and museum curators in conjunction with academic publications, strategic documents, and online resources, including content on websites of organisations engaged in cultural heritage digitisation. Exploration of secondary sources revealed new places that could be valuable additions to the Tourist Trail of Digital Cultural Heritage in Poland.

4. Results

An analysis of the existing tourist trails confirmed that the Tourist Trail of Cultural Heritage can seek inspiration from thematic routes. Architectural trails, such as the Trail of the Eagles' Nests and the Wooden Architecture Route, offer well-blazed paths and detailed guides. These can be presented as a mobile application or interactive maps. Historical trails, such as the Grunwald Trail, focus on commemorating historic events and figures, which can be transposed into the story about milestones in the history of the Polish computer and electronics industry, told through plaques in places linked to former production sites (Table 3).

Table 3.

Comparison of existing tourist trails and the planned Tourist Trail

Trail category	Characteristics	Primary advantages	Potential aspects to adopt
Architectural trails (Wooden Architecture Route, etc.)	Architectural heritage: sacral and secular. Focused on aesthetic and historical values	Preservation and promotion of heritage buildings, stimulation of regional tourism	Marked routes, guides, and mobile applications with descriptions
Historical trails (the January Uprising Trail, Grunwald Trail, etc.)	Commemoration of historic events and figures. Monuments, battlefields, graves, burial sites, and commemoration sites often included	Building a historical identity and historical education	Information plaques at locations critical for the history of the computer industry
Thematic routes (the John Paul II Papal Trail, etc.)	Focused on historic figures and their heritage (routes along places linked to famous scientists, artists, or politicians)	Promotion of historic figures and cultural education	Interactive narratives on people and events relevant to the history of computers and microelectronics in Poland
Industrial trails (Industrial Heritage Trail, Old Mines Trail, etc.)	Former industrial plants, mines, and factories. History of regional technology and industry.	Preservation of industrial heritage and promotion of post-industrial regions.	Organisation of routes connecting former production plants, museums, and research centres.

Cont. table 3.

Planned: Tourist Trail of Digital Cultural Heritage	Route of museums of computers and games, places linked to the history of the computer industry, former production plants, and technology heritage sites.	Popularisation of the history of the Polish computer and electronics industry and growth of technology heritage tourism.	Marking, online guides, interactive applications, routes between museums, factories and technology heritage sites.
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Source: own study.

Thematic routes, like the John Paul II Papal Trail or Nicolaus Copernicus Memorial Road Tourist Trail, demonstrate how historic figures can be effectively promoted. In the context of the Tourist Trail of Digital Cultural Heritage, this could mean narration on the pioneers of Polish computer design and the places where they worked, which could be displayed in public spaces or available in an interactive guide. Industrial trails, such as the Industrial Heritage Trail, provide models for organising routes connecting former factories and research centres. The tourist Trail of digital heritage must integrate museums and historic sites to build a cohesive tourism product.

4.1. List of points of interest on the Tourist Trail of Digital Cultural Heritage

The public space explored so far revealed locations that collect and exhibit digital cultural heritage artefacts. Over thirty institutions in Poland have ‘museum’ in their name. The list of museums operating under a statute or rules approved by the minister for culture and national heritage (not to be confused with the State Register of Museums) contains several facilities partially or entirely devoted to computers, consoles, and games. These are (List MCNH, 2025): (1) Museum of Engineering and Technology in Kraków (item 77), (2) National Museum of Technology in Warsaw (item 355), (3) Museum of the History of Computers and IT (pending organisation) (item 463), (4) Museum of Computers and Gaming Consoles in Osielsk (item 794), (5) Museum of Computers and Games in Warsaw (pending organisation) (item 800); and an interesting proposal: (6) Museum of Radio-frequency Engineering in Bydgoszcz (pending organisation) (item 582). Their number changes quite dynamically. Two such museums were closed down in 2024: (1) Museum of Toys and Computer Games RetroManiak in Zakopane and (2) Club Museum of Retrocomputers, Games, and Demoscene in Opole – Dragon Museum Project 1.0. Two new ones were opened at the same time: (1) Good Old Retro, an interactive museum of old computers and consoles in Gniezno and (2) Museum of Games and Technology in Białystok by the Podlachia Retromaniacs Foundation. Places celebrating the history of technology in Poland, mostly museums of digital cultural heritage, are presented in Figure 2. This fact poses a certain difficulty with keeping the Tourist Trail of Digital Cultural Heritage up to date.

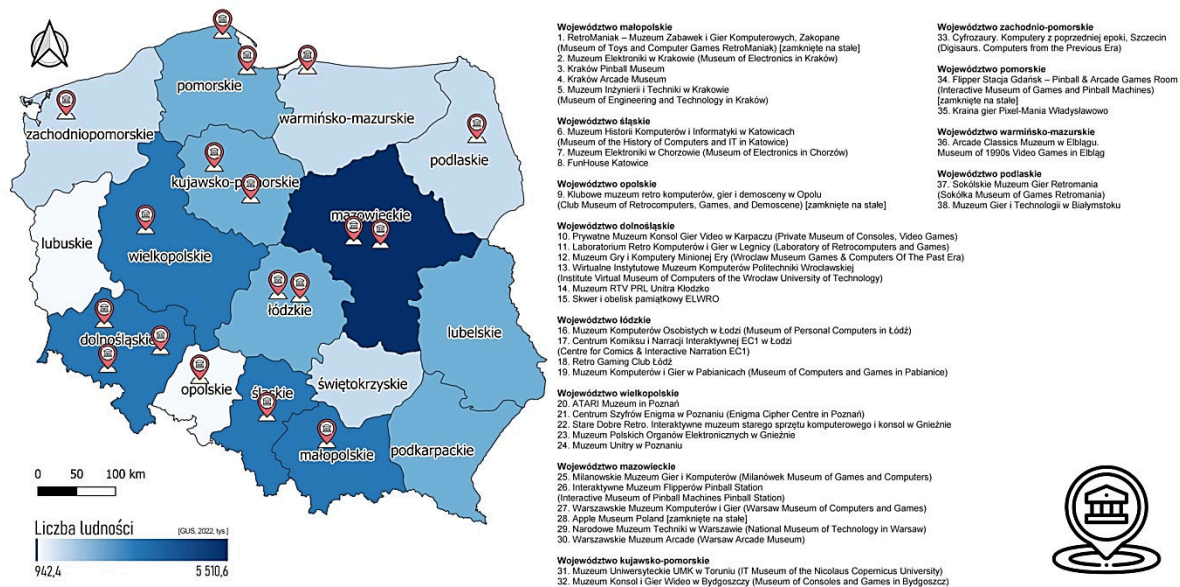


Figure 2. Map of places celebrating the history of technology in Poland, mostly museums of digital cultural heritage (Population, Statistics Poland, 2022, thousand).

Source: original work by Król, K. *A high-resolution map file can be downloaded from one of the authors' website: <https://digitalheritage.pl/2024/04/18/szlak-dziedzictwa-cyfrowego/>, 3.04.2025.*

Objects that form the core of thematic routes, such as architectural trails, are often permanently attached to their locations. It is not true for museums of digital cultural heritage. They often struggle to rent premises for a long term and are forced to relocate, like the Apple Museum Poland (moved in 2024), or have no permanent seat, like the Museum of Personal Computers in Łódź (as on 28.02.2025). Other museums/exhibitions are mobile or virtual, like the Museum of the History of CPUs and Computer Science (CPU Museum, 2025). Interviews with museologists and retro fans demonstrated that premises and rent, followed by utilities, are among the most severe problems when establishing and maintaining a museum of digital hardware (Król, 2024).

Research to date (Król, 2024) yielded a list of locations – especially museums – that could potentially make up the Tourist Trail of Digital Cultural Heritage. In-depth studies enlarged the list with other types of places. Although not museums, they celebrate the history of Polish computer design, so they fit the profile of the Trail. The Polish computer design was not limited to research or university environments. Production plants and R&D centres played just as important a role. One can still find their traces in cities in Poland. Many of them have ceased to exist, but there are monuments, squares, or new buildings in their places, still marking Poland's contribution to the history of the electronics and computer industry (Table 4).

Table 4.*Selected locations marking the history of Polish engineering*

No.	Name	Address	Description	Current status
1.	Krakowskie Zakłady Teleelektroniczne (Kraków Communications-electronics Facility) TELKOM-TELOS	14–18 Lubelska Street, Kraków	A factory of radio equipment and telephones, including specialist telephones	A residential estate has been built in place of the factory floor
2.	Ośrodek Badawczo-Rozwojowy Mikroelektroniki Hybrydowej i Rezystorów (R&D Centre for Hybrid Microelectronics and Resistors)	39 Zabłocie Street, Kraków	A research and development facility of TELPOD	A building from the late 1970s still exists. It is currently Zakład Mikroelektroniki (Microelectronics Facility) in Kraków. In 2002, it was incorporated into the state Institute of Electron Technology
3.	Centrum Naukowo-Produkcyjne Mikroelektroniki Hybrydowej i Rezystorów (Science and Production Centre for Hybrid Microelectronics and Resistors) Telpod in Kraków UNITRA-TELPOD	4 Lipowa Street, Kraków	Zakłady Wytwórcze Podzespołów Telekomunikacyjnych (Communications Sub-assembly Production Facility)	The building still exists. The business has moved to Skawina near Kraków. The building now hosts the MOCAR Museum of Contemporary Art.
4.	Krakowska Fabryka Aparatów Pomiarowych (Kraków Factory of Measuring Apparati) MERA-KFAP	G. Zapolskiej Street, Kraków	A manufacturer of measuring equipment and computers	The office and factory buildings have been demolished and replaced with blocks of flats
5.	Krakowska Fabryka Kabli i Maszyn Kablowych, Zakład Maszyn Kablowych w Krakowie (Kraków Factory of Cables and Cable Machines, Cable Machine Facility in Kraków)	114 Wielicka Street, Kraków	A cable manufacturer	The factory building still exists and currently houses Tele-Fonika Kable SA
6.	A granite obelisk commemorating 23 workers of Kraków Cable Factory who died tragically during the German occupation	114 Wielicka Street, Kraków	A granite obelisk with a plaque	Still at the original location
7.	ELBUD	12 Wielicka Street, Kraków	The most popular electronics market in Kraków	The building has been demolished and replaced with an office building
8.	RADMOR S.A.	3 Hutnicza Street, Gdynia	A manufacturer of communications and household audio equipment	The building and company still exist. It now manufactures high-tech communications equipment

				for the military.
9.	DIORA S.A.	38 Świdnicka Street, Dzierżoniów	The first Polish factory of radios	The factory building has been demolished. Currently, a hypermarket is located at the site.
10.	Monument to Zakłady Radiowe im. Marcina Kasprzaka (Marcin Kasprzak Radio Facility) in Warsaw	18 Kasprzaka Street, Warsaw	The monument by Edmund Matuszek was revealed in 1975	Still at the original location
11.	Zakłady Wytwarzania Elektrotechnicznych (Electrical Engineering Product Facility) Eltra in Bydgoszcz; Elda-Eltra Elektrotechnika S.A.; the Eltra brand (1956)	2a Narciowa Street, 86-005 Lipniki near Bydgoszcz	A manufacturer of electrical sub-assemblies and radio equipment	Today, the company offers about 50 audio products and focuses on DAB+ models. It celebrated a centenary in 2023
12.	Monument to Wrocławskie Zakłady Elektroniczne (Wrocław Electronics Facility) 'Elwro' and Elwro Square	Situated on the intersection of Ostrowskiego, Grabiszyńska, and Klecińska Streets in Wrocław	The monument and the square commemorate Wrocławskie Zakłady Elektroniczne ELWRO from 1959–1993	The surroundings of the monument are well-kept. The monument still at the original location
13.	Stereo Style s.c. Adam & Marek Ziemianin	3 Poturalskiego Street, Kraków	The company has been manufacturing compact cassettes for over 30 years.	One of a few companies in the world today to offer cassette recording and production.

Source: own study.

Wrocławskie Zakłady Elektroniczne ELWRO, in existence from 1959 to 1993, is among the most prominent places related to the history of Polish electronics. It manufactured the Odra computers, which were a milestone of Polish computer science and industry. Today, the factory is commemorated by Elwro Square in Wrocław, which marks its impact on Polish technology.

Kraków had plenty of enterprises focused on electronics and microelectronics. Science and Production Centre for Hybrid Microelectronics and Resistors Telpod, at 4 Lipowa Street, manufactured telecommunications sub-assemblies. The building has been converted into the MOCAR Museum of Contemporary Art but remains an important part of the city's technology heritage. There was the R&D Centre for Hybrid Microelectronics and Resistors at 39 Zabłocie Street nearby. The building still exists and is home to the state-controlled Institute of Electron Technology.

Warsaw has a monument to the Marcin Kasprzak Radio Facility, an electronics and telecommunications equipment factory. It marks the institution's contribution to the history of technology in Poland. Another interesting example is RADMOR SA in Gdynia. It has been manufacturing communications equipment since the 1950s. Unlike many other enterprises, RADMOR still supplies high-tech communications equipment to the military and secret service, keeping its position in the Polish high-tech industry.

Stereo Style s.c. Adam & Marek Ziemianin boasts years of traditions in the production and reproduction of magnetic and optical data carriers. It has been promoting compact cassettes for years, driving the renaissance of the technology among fans of analogue music all over the world. Thanks to its commitment and experience, Stereo Style is respected for its high-quality cassettes and professional recording services. It combines a passion for classical formats with new technologies while ensuring precise craftsmanship and high fidelity. It is one of a few places in Poland where tradition meets high-tech craftsmanship.

The landmarks mentioned above, existing buildings, monuments, or squares, are important locations on the map of Polish digital heritage. They bear witness to the history of the Polish computer, electronics, and telecommunications industry. Their protection and promotion should play a critical role in how Poland's technology identity is shaped. The identity includes unique characteristics, development directions, and technology sectors determined by historical achievements, available resources, and state economic and scientific policies.

5. Discussion

The points of interest included in the Tourist Trail of Digital Cultural Heritage were selected with the following criteria: (1) a link to the history of the Polish computer and electronics industry. The point of interest has to be highly relevant to the development of digital technology in Poland. These are former production facilities, R&D centres, technical universities, and computer history museums; (2) status of a museum or exhibition. The Trail should contain institutions that collect and display artefacts linked to the history of computers, games, and electronics; (3) tangible remains of former facilities and institutions. This criterion covers buildings of former factories or technology institutions; (4) memorials in public space. This category includes monuments, commemorative plaques, or squares related to the history of technology. The Tourist Trail of Digital Cultural Heritage will be expanded into more places that meet the inclusion criteria. The focus will be on identifying lesser-known places that are highly relevant to the history of the Polish computer and electronics industry. Furthermore, promotional efforts are planned: educational events, interactive exhibitions, and collaborations with cultural institutions and technical universities. Trail use and access to the history of technology in Poland will be streamlined with digital tools, such as a mobile application or virtual guides.

5.1. Inclusion of institutions no longer operating in the original location

The inclusion of locations of former production facilities, research institutes, and other places linked to the history of the Polish computer industry can be of great historical and educational value (Gross, Huber, 2020). Although they may be gone now, such places can be

marked with plaques, monuments, digital reconstructions, or even virtual tours (Löwenborg et al., 2021). They can be significant for historical narrative by standing as testimony to the dynamic changes in the socioeconomic environment in Poland. It is a common practice to put up a commemorative plaque on an elevation or a different symbol in public space. One example is the plaque marking the location of Spółdzielnia Spożywców ‘Oszczędność’ (Frugality Food Producer Association) in Radom (Figure 3) or the Elwro obelisk and square in Wrocław (Figure 4).



Figure 3. Tenement elevation today (a). Radom (Poland). Plaque reads (b): A store of the Frugality Food Producer Association was opened in this house in 1869. The Board of the Branch of the Voivodeship Food Producer Association in Radom installed the plaque in 1969 to mark the centenary. Source: Król (October 2024).



Figure 4. Elwro obelisk and square in Wrocław. Source: Król (June 2024).

It is worth illustrating legal barriers to placing commemorative plaques in public space with case studies. The monument to Wrocław Electronics Facility ELWRO was erected thanks to the collaboration of the local government with community organisations. Although no transparent regulatory framework was available, the idea was included in the local heritage strategy thanks to the support from the City Council. In contrast, the housing cooperative in charge of the building constructed in the place of a demolished MERA-KFAP facility in Kraków refused to approve a commemorative plaque. It resorted to the lack of legal basis for modifying the building wall and the undetermined legal status of the parcel. These examples

show that successful signage installation hinges on regulations, goodwill, and grassroots initiatives. Simplifying administrative procedures could streamline the effort significantly.

Plaques, obelisks, monuments, squares, and street names are essential to ensuring a historical continuum and a full view of socioeconomic and cultural development. These markers commemorate important places and events, even if the original buildings have been demolished or converted to preserve heritage in public space. Plaques and memorials linked to digital cultural heritage celebrate lost cultural heritage (Maćkowiak et al., 2018). Some points of interest can be an important testimony to the history of the computer and microelectronics industry in Poland, even if they are gone. Marking them in urban spaces with monuments, plaques, or interactive methods such as QR codes could restore the memory of the places (Figure 5).

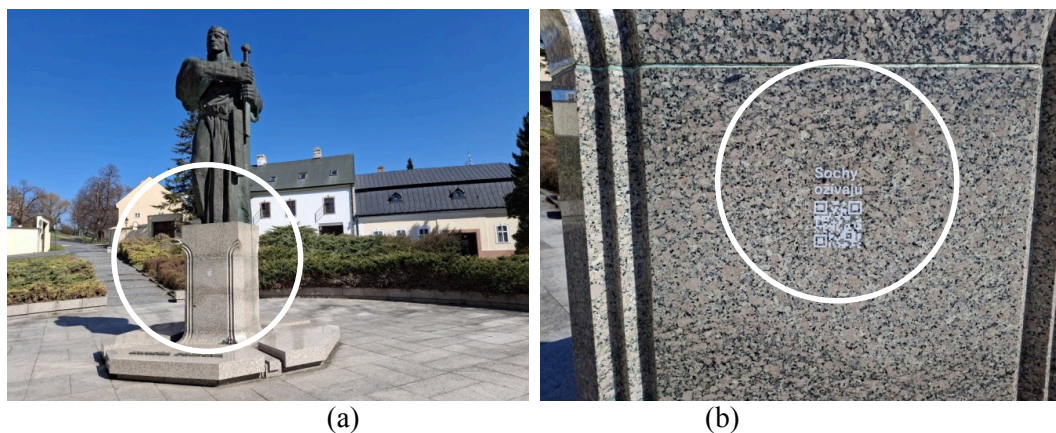


Figure 5. Statue of Prince Pribina in Nitra (Slovakia) (a) a QR code used to label a heritage point of interest (b).

Source: Karol Król (March 2025).

Figure 5 shows how QR codes can be used in the context of heritage. The Statue of Prince Pribina in Nitra (Slovakia) has a QR code as a new method of conveying information. After scanning the code with a mobile device, the user is redirected to a website with details of the place, its history, cultural significance, and local trivia. This way, knowledge is easily accessible in an attractive and interactive form without needing large signs or plaques on the monument. The content of the QR code can be updated without any physical intervention. These practical tools are particularly useful to tourists who wish to find out more about local history in a user-friendly way. This makes the statue a place of interactive historical interpretation in addition to a component of public space.

Placement of information signs and other markers of the past on the Trail entails particular challenges and can fail to meet tourists' expectations. They could be disappointed when they arrive at a location with no visible remains of the commemorated place. This issue could be prevented by providing a detailed description of the landmarks (Mansouri, Ujang, 2016). Moreover, legal, administrative, and bureaucratic obstacles must be tackled before plaques and other signage can be installed (Hjemdahl, 2022). It may be challenging to mark some locations

without approval from the local government or site owners. In light of the above, the best approach seems to be to divide the points of interest into two categories: (1) existing places that can be visited, such as museums, education centres, and former production facilities that are still operating or allow visitors and (2) historical places and objects that do not exist physically but have been commemorated differently, for example, with plaques, signs, or digital reconstructions. Notably, the priority seems to be to compile a complete documentation of the history of the Polish computer and electronics industry. Therefore, the Trail has to include marked locations of places that no longer exist. The combination of the two categories could yield the best outcome and make the Trail attractive for tourists as well as valuable in terms of education, heritage recording, and history.

5.2. Criteria for including points of interest in the Tourist Trail of Digital Cultural Heritage

Today, the Tourist Trail of Digital Cultural Heritage in Poland covers several dozen Polish technological development landmarks. The list of Trail landmarks can be expanded based on the inclusion criteria (Table 5). The role of the specific place in the development of Polish technology design is central here. The Trail can include places of science and education, such as research institutes, technical universities, or university laboratories that created the first Polish digital devices, computers, and IT solutions. This could make it more than just a historical record, perhaps an educational platform for posterity.

Table 5.
Selected inclusion criteria for the Tourist Trail of Digital Cultural Heritage

Criterion	Description
Links to the history of the Polish computer and electronics industry	The point of interest is highly relevant to the development of digital technologies in Poland, such as former production facilities, universities, and research centres
Status of a museum or exposition	Institutions that collect and display exhibits linked to the history of computers, games, and electronics
Material remains of former facilities and institutions	Places with former factory or technology institution buildings
Memorials in public space	Presence of monuments, commemorative plaques, squares or other markers related to the history of technology
Tourism potential and accessibility	Places that are easy to reach for tourists. They need to have tourism infrastructure and allow marking
Role in education and dissemination of knowledge	Places linked to technology education, such as university laboratories and research institutes
Social significance	Places linked to important historic events, conferences, demoscene meetings, or computer clubs
Degree of preservation and potential for interactive exhibition	Places with interactive exhibitions, operational retro hardware, and direct interaction with artefacts
Digital signage and online availability	Virtual presentation of the Trail, interactive online exhibitions, and historical reconstructions

Source: own study.

Another important criterion is the socioeconomic and cultural significance. The Trail should encompass places linked to historic events relevant to the Polish electronic culture, such as the first scientific conferences, microcomputer clubs, or spaces where the demoscene thrived. This highlights the social aspects of the history of the digital cultural heritage in Poland, in addition to the technological side.

The degree of preservation and the potential for interactive presentation are also important. Tourists naturally find places with operational exhibits where they can commune with technology more attractive. This criterion helps select those locations that allow visitors to run old computers, games, or other devices from the past.

Digital marking and online availability of reconstructions or models can be a factor in the future. The inclusion of virtual spaces, like interactive exhibitions or historical reconstructions in augmented reality, could substantially improve its reach and availability on a global scale. Integration with local initiatives and support from local communities are important as well. Collaboration with local governments, retro gaming festivals, or industrial museums can further the Trail's expansion, promote it, and help adjust it to the evolving needs of the audience. This way, it could contribute to the popularisation of knowledge by engaging enthusiasts and technical and computer amateurs in addition to merely recording the past.

The concept of the Tourist Trail of Digital Cultural Heritage is best put in a broader context by calling on similar international initiatives. One example is the Computer History Museum in Mountain View (California, USA), the centrepiece of the Silicon Valley Tech Trail, which offers a narrative on the history of computers using the latest exhibition techniques. Terra Technica in Czechia is a European leader. The largest museum of jukeboxes and pinball machines in the world combines museum, entertainment, and education. Retro Computer Museum in Leicester (United Kingdom) has interactive stations with original vintage hardware, inspiring practical solutions for exhibit management and visitor engagement. These institutions integrate education with user experience and a pronounced online presence (such as virtual tours and online databases of exhibits). These insights can help design a better Trail in Poland by transferring good practices for protecting and promoting digital cultural heritage.

6. Conclusion

The analyses reported in the article have led to several new decisions regarding the concept of the Tourist Trail of Digital Cultural Heritage. First, the list of places that make up the trail now includes new locations, like former factories and R&D centres. It was also noted that museums of technology often have problems with maintaining a constant address, which poses a challenge to the Trail's stability. The authors also defined inclusion criteria that take into account the historical significance, educational value, tourist accessibility, and knowledge

dissemination potential of the places. The analysis further revealed that Trail signage should involve public space (plaques, monuments) and digital solutions, such as mobile applications and interactive maps. Still, the research is far from exhausting the topic. It is a mere foothold for future work on the most extensive possible list of landmarks that should be part of the Tourist Trail of Digital Cultural Heritage in Poland.

These should be both museums and places marking the history of Polish computer design. Some types of points of interest include squares, monuments, and former businesses and factories that played a vital role in Poland's technological growth. Their inclusion affects the educational and cultural strength of the Trail. The places could be marked with signs with interactive QR codes giving access to old photographs, documents, and witness stories. Such an extended Trail could help build the public awareness of Poland's contribution to the history of technology, while putting digital heritage in the urban context. It could also 'invigorate' history so it is easier to learn and integrate with today's urban landscape.

Museums of computers and games are important institutions that record the history of technology and significantly affect education and culture. When included in thematic routes, they can substantially enhance the tourism opportunities offered by the region, attracting history and retro gaming enthusiasts. Despite the numerous challenges the institutions face, their role in education and culture is highly relevant. Their contribution to protecting and promoting digital heritage is pivotal, empowering future generations to delve deeply into the fascinating history of computers and games.

Research limitations and prospects

The primary limitation is the single research method, desk research. Secondary source analysis is valuable, but it cannot replace empirical studies. The research should be expanded to include interviews with experts, consultations with institutions involved in digital heritage, as well as public opinion research. Moreover, field visits to the prospective points of interest will be necessary to verify their status and availability. All this should be complemented with a survey among potential visitors and a legal and financial analysis to evaluate the feasibility and long-term survivability of the Trail.

The challenges and limitations of the Tourist Trail of Digital Cultural Heritage call for further in-depth analysis. Legal and administrative barriers that could affect the marking and formal establishment of the Trail require special attention. Analysis of financial models and potential support from public funds, public-private partnerships, or crowdfunding is just as critical. The final key component should be to analyse the Trail's impact on tourism and education, especially the public interest in the initiative.

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INFORMATION SECURITY INCIDENT MANAGEMENT AND CYBERSECURITY AWARENESS IN LOCAL GOVERNMENT IN POLAND

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Purpose: The aim of this article was to examine and diagnose the existing situation in the field of information security management in local government offices in Poland. The focus was on the following issues: information security incident management, training, security level assessment, and financial aspects.

Design/methodology/approach: The survey has exploratory character. It was conducted using the CAWI technique based on the online questionnaire which was sent to all offices of local government units: marshal offices, district offices and municipality offices.

Findings: The text presents some of the survey results on information security awareness and information security incidents conducted in 2023 in local administration offices in Poland, especially about the numbers of information security incidents, training, budgets allocated on information security management, and assessment of security levels. The research results provide knowledge about the existing situation in the field of information security management in local government administration in Poland.

Research limitations/implications: There are certain limitations to the use of survey research. The low level of participation means that the results may not be representative of the population. Additionally, respondents may intentionally provide false information or hide certain facts, which affects the reliability of the results.

Practical implications: The presented results provide a valuable knowledge base on cybersecurity management in local government offices and can be the basis for further research and analysis.

Originality/value: To the authors' knowledge, this type of research has not been conducted. The research results provide knowledge about the existing situation in the field of information security management in local government administration in Poland. Information security incident management is one of the elements necessary for the proper operation of Information Security Management Systems.

Keywords: information security, information security incidents, cybersecurity awareness, local administration.

Category of the paper: research paper.

1. Introduction

Information security management issues, from the management point of view, belong to the area of GRC (Governance, Risk Management and Compliance). A particularly important regulation in this context is the General Data Protection Regulation (GDPR), which imposes numerous obligations on local administration offices, in regard to having an Information Security Management System (ISMS) and reporting incidents related to personal data security breaches.

An information security incident has been defined in the standard ISO/IEC 27000:2018-3.31 as a single or a series of unwanted or unexpected information security events that have a significant probability of compromising business operations and threatening information security. A similar definition can be found in the standard ISO/IEC 27002:2022-3.1.15 information security incident – one or multiple related and identified information security events that can harm an organization's assets or compromise its operations.

The same standards define information security incident management as a set of processes for detecting, reporting, assessing, responding to, dealing with, and learning from information security incidents (PN-ISO/IEC 27000:2018-3.32) and as an exercise of a consistent and effective approach to the handling of information security incidents (ISO/IEC 27002:2022-3.1.16).

It should be noted that incident management is not only a set of actions and procedures enabling effective response to incidents, but also minimizing their effects and preventing their occurrence in the future. Information security incident management is one of the key elements of Information Security Management Systems (Lisiak-Felicka, 2024).

To properly manage an incident, it is, of course, necessary to both detect the security breach (the earlier, the better) and respond appropriately, both on the part of appropriate specialists (Digital Evidence First Responders) and employees of the organization that fall victim to the incident. Appropriate response to information security events is one of the issues covered by information security awareness.

The article focuses on cybersecurity issues in local government units. Importantly, cybersecurity is one of the key aspects of the functioning of local government offices. These institutions store and process huge amounts of data, such as citizens' personal information, financial information or strategic documents. The security of this data is therefore directly related to the security of citizens. Local government offices are obligated to comply with data protection regulations, such as the GDPR. A breach of data security can lead to identity theft, financial abuse and loss of public trust.

Every now and then and again the media reports cases of ransomware or other attacks directed towards the public administration in Poland. These incidents can paralyze the functioning of the office by blocking access to IT systems (see. e.g. Klimczuk (2024a, 2024b),

Makowiec (2024)). Such incidents can require expensive data recovery and cause delays in providing services to citizens.

Cyber criminals' activity also has an influence on the continuity of office operations. The functioning of local government administration is crucial to ensuring residents have access to basic services. In the event of a serious incident affecting an IT system, services may be interrupted, and citizens may lose access to offices' services.

Local governments often manage critical infrastructure, such as water supply, transportation systems, or energy systems. A cyberattack on such systems can have serious consequences for the local community (Banasik, Bagińska, 2019).

Failure to ensure an adequate level of cybersecurity can lead to a loss of trust in public institutions. Therefore, local government offices should invest in modern security systems, regular employee training to effectively protect data and ensure the continuity of their operations and services.

Cybersecurity Department in the Polish Ministry of Digital Affairs prepared a set of recommendations standardizing security solutions in networks and information systems (called the National Cybersecurity Standards (NSC)), based on the US National Institute Standard and Technology's documents. Given both their optional nature and the problems with information security management in local administration made apparent by the Supreme Audit Office's report (NIK, 2018), it seems interesting how local government in Poland deal presently with Information Security issues, so the aim of the research was to analyse the existing situation in the field of information security incident management in these offices.

To the authors' knowledge no in-depth diagnostic studies on the incident management in local government offices have been conducted.

2. Literature review

The issue of information security management in public administration has not been researched extensively. Typically, researchers focus on different types of organizations, enterprises, and economic sectors. In the article (Wenlong et al., 2023), the authors conducted a systematic review of the literature (including 380 English-language items from the Web of Science, Scopus, IEEE, ACM, ScienceDirect, SAGE, Oxford Academic and Google Scholar databases) devoted to empirical research on the effectiveness of the GDPR using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) approach. One of the conclusions of this review is that the literature on the GDPR in the public sector is sparse: the authors found only two articles: one regarding Poland (Lisiak-Felicka, Szmit, 2021a, pp. 1-21) and one – Czech Republic (Faifr, Januška, 2021, pp. 1124-1141). Although there are also a few other studies on ISMS and/or information security aspects of the GDPR in public

administration in other countries, such as Martins et al. (2020, pp. 205-216), Oliveira, Dias (2023), or Starčević et al. (2018, pp 163-176). Only rare articles are devoted to cases in local administration Homburg, Kokje (2020, pp. 211-218), Ali et al., (2020), Marcut (2018, p. 337) or Lisiak-Felicka et al. (2022, pp. 382-394) and there are also several articles published in national languages (e.g., in Polish: Jatkiewicz (2015) or Chodakowska et al. (pp. 129-148).

Obviously the GDPR-related issues do not exhaust the subject of information security, but even precisely determining the number of publications devoted to this topic may be difficult. One of the reasons is the lack of uniform terminology regarding information security. There are many terms used sometimes as synonyms, and sometimes with different meanings (e.g. information security, information safety, data security, data safety, cybersecurity, cybersafety). The term ‘local administration’ can also refer to various types of offices depending on the system of government in a particular country. Additionally, the terms ‘local government’, ‘local administration’, ‘municipality’, ‘civic government’ etc. are sometimes used. There is another systematic literature review based on the PRISMA protocol concerning the keywords ‘cybersecurity’, ‘cyber threat’, ‘cyber risk’, ‘local government’, ‘municipality’, ‘council’, and ‘smart city’ in the article (Hossain et al., 2025). The Authors identified 3861 records as result of the query: (articles titles, abstract, keyword contains: ((“cybersecurity” OR “cyberthreat” OR “cyber risk” OR “information security” OR “data security”) AND (“smart city” OR “local government” OR “municipality” OR “council”))) from Scopus, ScienceDirect, Directory of Open Access Journal, Wiley Online Library and QUT Library Collection and after two stages of the screening process (excluding books, chapters etc. and excluding articles not in English in the first stage and excluding papers irrelevant to the research aim in the second stage) only 123 papers were left.

In a different article (Vestad, Yang, 2023) the systematic review based on the query: (“municipal” OR “municipality”) AND “cybersecurity” was conducted and original search result that consisted of 627 papers and after title screening and abstract screening only 34 papers were left. The Authors distinguished 7 article topics: Smart Cities, Operational Technology, Elections, Human Issues and Cybersecurity Awareness, Crisis Management, Management and Governance and Municipal Technology (use of secure protocols and certificates by municipalities).

Comparing the number of articles focused on information security and local administration with the number of articles dedicated to information security management in general, even without conducting a systematic literature review, it is evident that the number of the former is one or even two orders of magnitude smaller (Table 1).

It seems that administration information security issues deserve more attention, especially considering the current situation of war beyond Poland’s eastern border. According to the Microsoft Threat Intelligence report published in 2023 (Microsoft, 2023) government, including local government institutions, are the most common target of attacks by

cybercriminals and Poland is the second most frequent target of cybercriminals after the USA (not counting Ukraine).

Table 1.

Number of publications devoted to information security management and information security and local government

	“Information security” AND “management”	“Cyber security” AND “management”	“Information security” AND “local government”	“Data security” AND “local government”	“Information security” AND “local administration”	“Data security” AND “local administration”	“Cyber security” AND “local government”	“Cyber security” AND “local administration”
Web of Science Core Collection (All fields)	9482	3476	31	13	2	0	10	1
Scopus (All fields)	131908	69847	1578	451	35	13	896	16
Science Direct	22515	10942	895	925	44	46	496	24
IEEE	14311	10979	1127	929	456	444	220	63
ACM	6711	4060	217	207	17	20	146	13
OpenAlex (Full text)	2182	385	9	1	0	0	1	12
Lens.org	34464	12013	365	342	25	30	167	8

Source: Authors' own study.

Additionally, the constantly increasing number of threats is confirmed by reports prepared by the national computer incident response teams: CERT.PL and CSIRT.GOV.PL (Figure 1 and Figure 2).

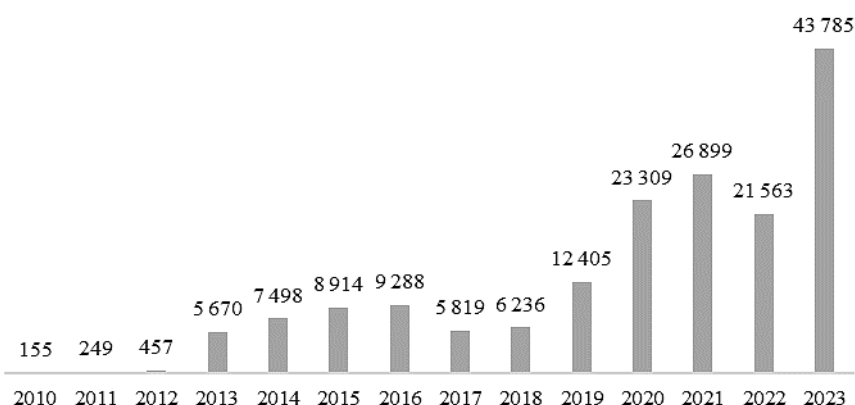


Figure 1. Numbers of incidents reported by CSIRT.GOV.PL.

Source: Authors' own study based on (CSIRT.GOV.PL, 2024).

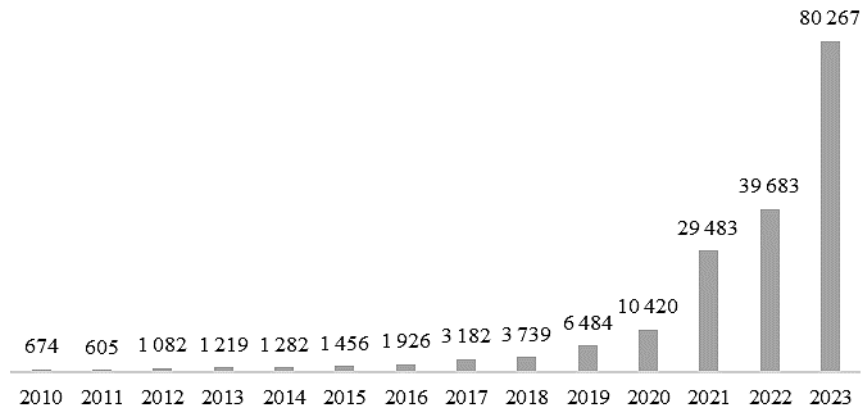


Figure 2. Numbers of incidents reported by CERT.PL.

Source: Authors' own study based on (CERT.PL, 2024).

These teams (CERT.PL and CSIRT.GOV.PL) are responsible for the registration and handling of network security incidents at the national level. The third team CSIRT.MIL also works at national level but it does not publish statistics about the incidents.

3. Research methods

The aim of the study was to analyse the existing situation in the field of information security management, especially incident management, in local government offices in Poland. The focus was on the following issues: information security incident management, training, assessment of a security level and financial aspects.

In social sciences, a survey is most often a tool used to learn about the opinions and positions of respondents. In our research, however, we used it to collect information about the existing state of affairs, primarily because - to our knowledge - no systematic analyses are being conducted on the cybersecurity of local administration. The following research questions were formulated:

- Q1: How many incidents have occurred in years 2020-2022 and where were they reported?
- Q2: Could offices count on support from other state administration bodies in the field of incident management?
- Q3: What were the dominant types of incidents reported and what is the most vulnerable element in the office to attacks by cybercriminals?
- Q4: Were offices providing good training in the field of cybersecurity?
- Q5: How offices assess the level of security and what is an approximate annual budget allocated to cybersecurity?

The survey was conducted using the CAWI (Computer-Assisted Web Interview) technique based on a questionnaire containing 44 questions, developed using Microsoft Forms. The survey was anonymous and was conducted at the turn of July and August 2023. The results of the part of the study devoted to the implementation and operation of information security management systems are presented in the article (Lisiak-Felicka, Szmit, 2023, pp. 400-407).

To conduct the study, e-mails were sent to all offices of local government units: marshal offices, district offices and municipality offices. As of January 1, 2023, Poland was divided into 16 voivodeships, 314 counties and 2477 municipalities (302 urban, including 66 cities with county rights, 677 urban-rural, and 1498 rural (GOV.PL, 2023).

Obtained 236 responses from 2,807 offices: 5 marshal offices, 34 district offices and 197 municipal offices. The distribution of responses was compared with the structure of administrative offices in Poland using Renkonen Similarity Index, S_r , calculated based on the formula (1):

$$S_r = \sum_{i=1}^i \min(p_{1,i}, p_{2,i}) \quad (1)$$

where p is the percentage share of a given fraction.

The calculated value was 0.95, which may be interpreted as very high similarity, therefore the structure of the studied sample was very similar to the structure of the population.

Figure 3 shows the geographical location of the offices participating in the study. Most responses were received from the following voivodeships: Greater Poland, Lesser Poland, Lodz, and Masovian. The visualization does not include the locations of the 5 marshal offices that participated in the study due to the possibility of their identification which would be equivalent to deanonymizing some participants. The survey was anonymous and therefore marshal offices were not asked about their location.

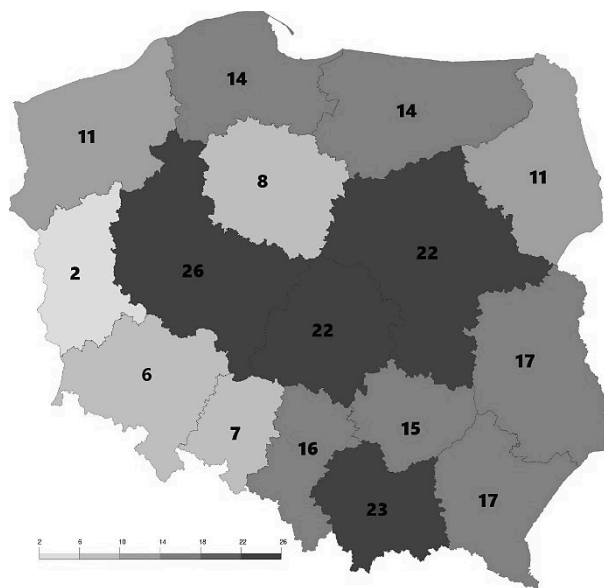


Figure 3. Geographic location of offices participating in the research.

Source: Authors' own study.

It should be noted that survey research is useful for obtaining quantitative data on a large scale, but its effectiveness depends primarily on the involvement of respondents.

4. Results

The results of the study are divided into the following sections: information security incident management, training, security level assessment, and financial aspects.

4.1. Information security incident management

Respondents were asked several questions related to information security incident management. Of the 236 respondents, 78 (33%) confirmed that they had experienced security incidents in the past. There were no such events in most municipal offices. Detailed results are presented in Table 2.

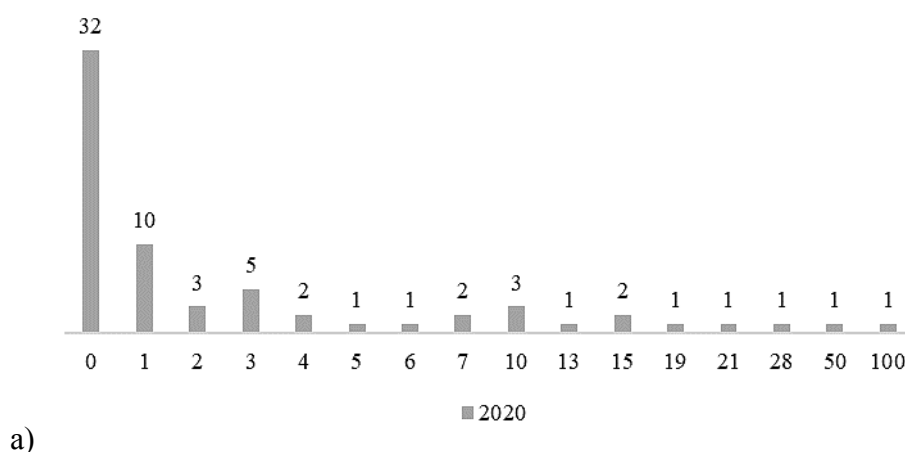
Table 2.

Answers to the question: "Have there been any security incidents in the office in the past?"

Have there been any security incidents in the office in the past?	Marshal Office	District Office	Municipal Office	Total
yes	4	19	55	78
no	1	15	142	158
Total:	5	34	197	236

Source: Authors' own study.

Next question was about the number of security incidents recorded between 2020 and 2022. The results are presented in Figure 4. The dominant numbers of incidents in the examined period were 0 and 1. Two offices refused to answer these questions.



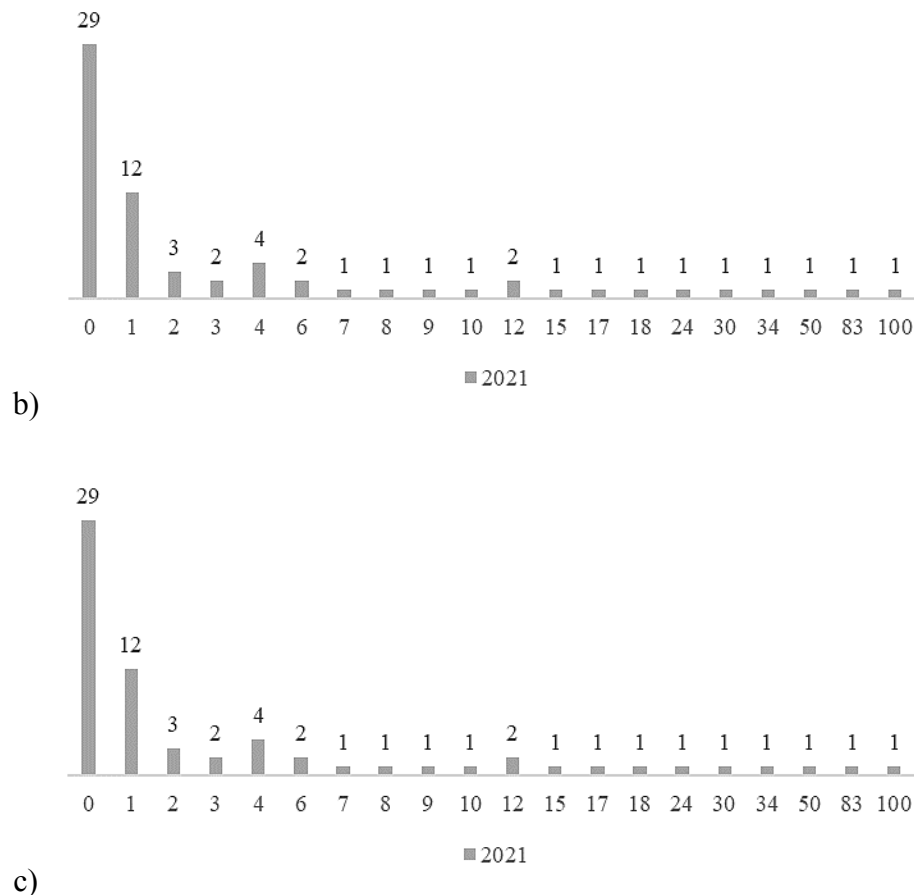


Figure 4. Answers to the question: “How many security incidents were recorded in 2020 (a), 2021 (b) and 2022 (c)?”

Source: Authors’ own study.

Of the 78 offices where security incidents have occurred, the vast majority (64) declared that they had reported this fact to CERT, CSIRT, the prosecutor’s office, the Personal Data Protection Office, or other appropriate entities.

Half of the offices (39) also declared that they could count on support from other state administration bodies in the field of incident management. This assistance consisted primarily of cooperation with computer incident response teams. In this context, respondents pointed to the help from CERT Polska - CSIRT NASK in terms of sharing knowledge (playbooks, forms for reporting incidents, instructions on how to proceed with reporting an incident, publications on new threats), but also in the ongoing handling of incidents (accepting reports, sending comments and feedback). Below are some of the respondents’ opinions about this cooperation:

- “CSIRT NASK - supports local governments during cyberincidents”,
- “incident analysis by CERT, possible technical assistance in the event of a security incident”,
- “assistance only from CSIRT NASK - assistance in incident analysis, recommendations, good practices, working meetings, evidence analysis, etc.”,

- “after submitting a report to CSIRT NASK, we receive support from operators who conduct post-intrusion analysis”,
- “substantive and technical assistance of the CSIRT NASK team during the analysis and response to the incident”,
- “in connection with the notification to CSIRT NASK, we received a quick response dispelling our doubts”,
- “CERT publishes messages about attacks on its websites. There is also a special application for information security coordinators, but it does not work well at the moment”.

The responses also indicated several advisory support in the field of incident handling, diagnostics, training, incident analysis, taking corrective actions, as well as cooperation with the Personal Data Protection Office in the field of incident reporting forms.

Authorities provided advice when the need for help was reported. Assistance was received in securing evidence, cooperation in the analysis of the effects of incidents or violations, provision of advice and recommendations, provision of incident response procedure and guidelines for further action on the incident, substantive support, exchange of experiences, joint training, common assistance in the development of documentation, training materials of the Chancellery of the Prime Minister and providing the offices with access to national cybersecurity system S46 in 2023 (S46-react is a project of the Research and Academic Computer Network - National Research Institute, which will help raise the level of cyber security and combat cyber threats more effectively).

The next question concerned the elements in the office that, in the respondents’ opinion, were most susceptible to attacks by cybercriminals. Respondents unanimously indicated that people (employees) are the weakest link in the security system (Figure 5). In addition to the elements provided in the catalogue, one office also indicated its own answer – “systems available from public addresses”.

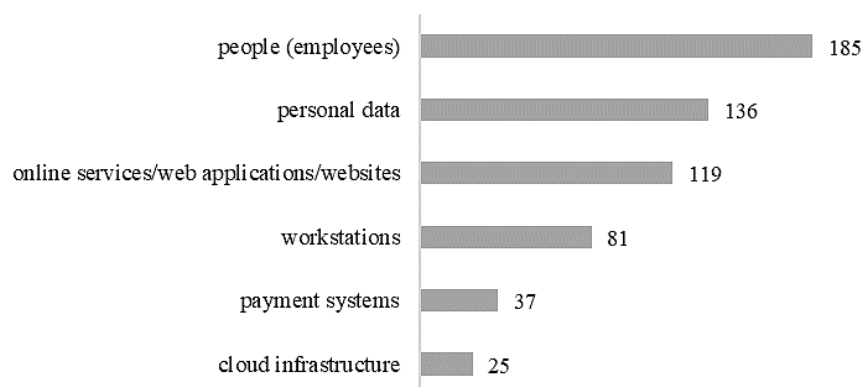


Figure 5. Answers to the question: Which of the following elements in the office do you consider most susceptible to attacks by cybercriminals?”

Source: Authors’ own study.

In the next question, respondents indicated the categories of incidents that, in their opinion, constitute the greatest threat to the office. The question uses the CSIRT GOV incident categories:

- Abusive content (e.g., harmful speech, child pornography, violence).
- Malicious code (e.g., virus, trojan, ransomware, dialer, botnet).
- Information gathering (e.g., scanning, sniffing, spam, social engineering).
- Intrusion attempts (e.g., attempts to exploit known vulnerabilities, login attempts).
- Intrusions (e.g., hacking into an account, application, system, infrastructure).
- Availability issues (e.g., DoS, DDoS, sabotage, failure, negligence, technical service work).
- Information content security (e.g., unauthorized access to information, unauthorized modification of information).
- Fraud (e.g., unauthorized use of resources, copyright infringement, impersonation, identity theft, phishing).
- Vulnerable (e.g., misconfiguration, vulnerability detection).
- Cyberterrorism (a terrorist event committed in cyberspace).

The responses are presented in Figure 6. The dominant category in responses is malware.

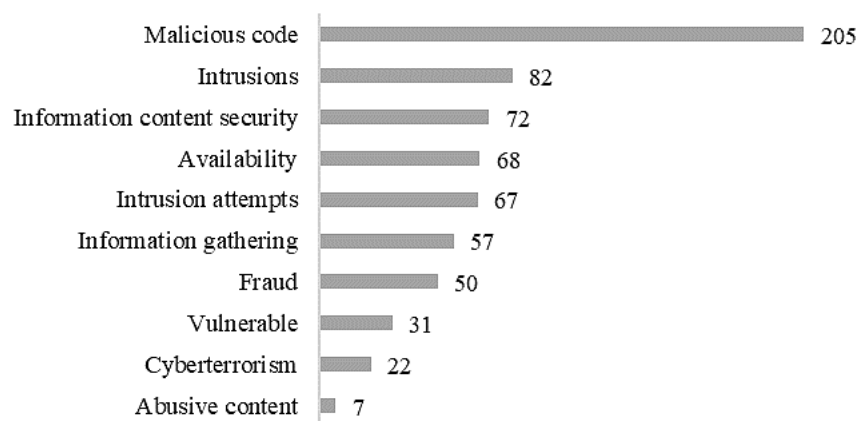


Figure 6. Answers to the question: “Which categories of incidents, in your opinion, pose the greatest threat to the office?”

Source: Authors’ own study.

One of the respondents gave his own answer: “unauthorized publication/sharing of data”, which, however, can be included in the “information content security” category.

4.2. Training

Respondents were also asked to answer questions related to training conducted for employees in the field of cybersecurity and related subjects. Out of 236 offices, 171 (72%) conducted such training. Table 3 presents data on the number of training courses conducted during the period under study (2020-2022). Based on the data provided by the offices, many offices conduct 1-2 training courses on this subject per year.

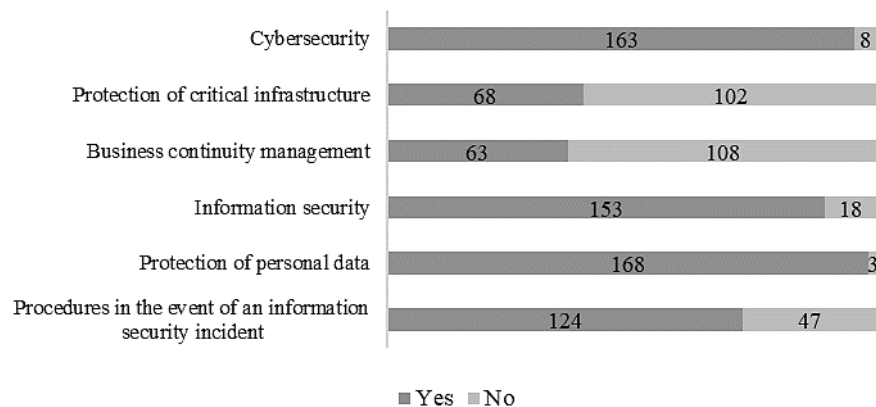
Table 3.

Answers to the question: “How many such training courses were organized in 2020, 2021, and 2022?”

Number of training courses	Number of responses		
	2020	2021	2022
1	95	96	106
2	21	25	27
3	2	5	15
4	2	1	2
5	4	2	2
6	0	1	3
7	0	1	2
8	1	2	0
10	0	0	2
14	0	0	1
15	1	0	0
16	1	0	0
20	0	1	0
30	0	0	1
no data	44	37	10

Source: Authors’ own study.

The dominant subjects of the training were: cybersecurity, information security and personal data protection. Detailed data are presented in Figure 7.

**Figure 7.** Answers to the question about the scope of training.

Source: Authors’ own study.

4.3. Security level assessment and financial aspects

The next question concerned subjective assessment of the level of security in the office on a scale from 1 to 5, where 1 was the lowest and 5 was the highest. Most respondents chose a rating 3 or 4 (Figure 8). Detailed data by type of office is presented in Table 4. The lowest ratings (1 or 2) were only selected by municipal offices.

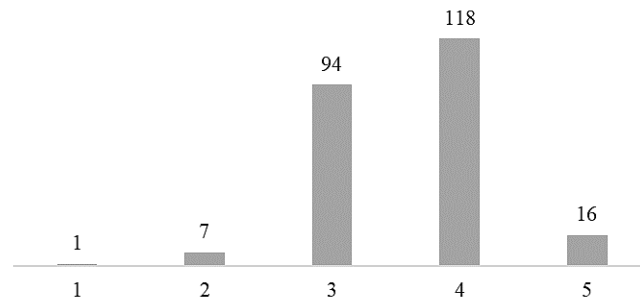


Figure 8. Answers to the question: “On a scale from 1 to 5, how do you rate the level of information security in the office?”

Source: Authors’ own study.

Table 4.

Answers to the question: “On a scale from 1 to 5, how do you rate the level of information security in the office?”

Assessment	Marshal Office	District Office	Municipal Office	Total
1	0	0	1	1
2	0	0	7	7
3	0	13	81	94
4	4	16	98	118
5	1	5	10	16
Total	5	34	197	236

Source: Authors’ own study.

Out of the 236 surveyed offices, only 8 assessed the level of cybersecurity management maturity in the organization - one district office and 7 municipal offices. When specifying the methodology according to which this assessment was made, 3 offices indicated CMMI (Capability Maturity Model Integration), and the remaining offices indicated their own answers: “other”, “according to the methodology used by the Data Protection Inspector”, “based on the requirements contained in PN ISO/IEC 27001 and §20 Regulation on the National Interoperability Framework (Regulation of the Council of Ministers), “external audit”. One respondent did not answer.

Respondents were also asked to specify the office’s indicative annual budget allocated to cybersecurity, including expenses for personal data security. The results are presented in Figure 9. The dominant answer was “less than 10,000 PLN”, which means that more than half of the surveyed offices allocate very small amounts for this purpose. Detailed answers to this question broken down by type of office are presented in the Table 5.

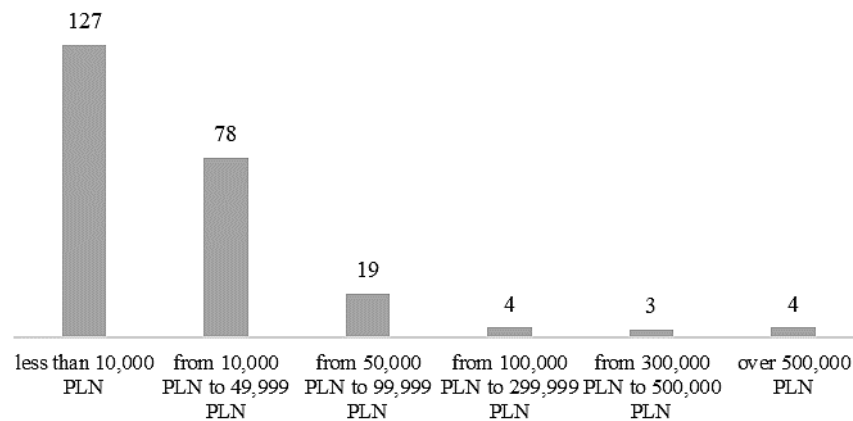


Figure 9. Answers to the question: “What is the office’s approximate annual budget allocated to cybersecurity, including expenses for personal data security?”

Source: Authors’ own study.

Table 5.

Answers to the question: “What is the office’s approximate annual budget allocated to cybersecurity, including expenses for personal data security?”

The office’s indicative annual budget for cybersecurity, including expenses for personal data security	Marshal Office	District Office	Municipal Office	Total
less than 10,000 PLN	1	8	118	127
from 10,000 PLN to 49,999 PLN	0	19	59	78
from 50,000 PLN to 99,999 PLN	1	6	12	19
from 100,000 PLN to 299,999 PLN	0	1	3	4
from 300,000 PLN to 500,000 PLN	1	0	2	3
over 500,000 PLN	2	0	2	4

Source: Authors’ own study.

The last question concerned the respondents’ opinions on the biggest problems in ensuring an appropriate level of cybersecurity in the office (Figure 10). The dominant answer was “lack of sufficient financial resources”, which directly corresponds to the previous question.



Figure 10. Answers to the question: “What, in your opinion, is the biggest problem in ensuring an appropriate level of cybersecurity in the office?”

Source: Authors’ own study.

Other problems mentioned by the respondents include: “some activities can only be conducted after office hours”, “the Municipal Mayor - the biggest problem”, “imposition of the most malware-riddled operating system by central/superior units”, “insufficient number of employees”, “too few IT staff”. One of the comments did not concern this question and read: “The Municipal Office has an information security policy developed and implemented by itself”. However, one of the respondents stated that “there is never the right level of security”.

5. Discussions

To the best of our knowledge, no comparable surveys of the issues of information security incidents and security awareness in local administration offices in Poland have been published. The above results (hereinafter referred to as survey C) were compared with our previous surveys, which were conducted in years 2012-2015 (survey A (Lisiak-Felicka, Szmit, 2016)) and 2019 (survey B (Lisiak-Felicka, Szmit, 2021b, pp. 101-115)).

Information security incidents occurred in 18% of offices participating in the survey A and in 25% of offices participating in the survey conducted in 2019 (B). In survey C this percentage has increased to 33%. Increasing number of affected offices may indicate both an increase in the actual number of attacks and an increase in their detection. Considering the large number of attacks reported by CERT and CSIRT teams (compared to the number of incidents in local government offices), it can be expected that the second factor is of great importance here. In previous research offices declared that they reported incidents to computer security incident response teams (CSIRT.GOV.PL and CERT.PL), to police, prosecutor’s office, and Personal Data Protection Office, so the target entities to which the incidents were reported are similar. In survey A there were incidental cases with help from other state administration bodies in the field of incident management. Currently, 16.5% of offices could count on such assistance.

As in the previous studies, officials determined that people (employees) are the weakest link in the security system. The next items are personal data and online services. Analysing the categories of incidents, in both the 2019 and 2023 surveys, the dominant type was malware, followed by intrusions and information content security. The number of offices where cybersecurity training was conducted decreased by 9 percentage points compared to the 2012-2015 (A).

Compared to the previous studies, officials are more optimistic in assessing the level of information security. While previously in 2012-2015 approximately 57% rated it 4 or 5, and in 2019 the percentage of offices that rated this level 4 or 5 was 59%. In the current survey 76% offices rated it as level 4 or level 5 (good or very good).

Financial aspects were also compared. Based on the results, it can now be concluded that the number of offices that allocate marginal funds of PLN 10,000 to financing information security has increased. In 2019 (B) it was 54% of offices, in the current study (C) about 61%.

As in the previous study, the biggest problem in ensuring the appropriate level of security is insufficient financial resources.

6. Conclusions

In conclusion, information security incident management is one of the elements necessary for the proper operation of Information Security Management Systems. To properly manage an incident, it is, of course, necessary to both detect a security breach (the earlier, the better) and respond appropriately, both on the part of appropriate specialists (Digital Evidence First Responders) and employees of the organization that fell victim to the incident. Appropriate response to information security events is one of the issues covered by information security awareness.

Properly responding to incidents requires appropriate preparation before they occur, hence it is necessary to apply a proactive approach that also takes into account potentially new threats in the risk analysis (such as the use of artificial intelligence in conducted attacks, activities related to hybrid warfare, etc.).

The results of research on the elements of ISMS in local government offices in Poland highlight several issues that may lead to security problems and, as it seems, should be of interest to the relevant state authorities.

First and foremost, the insufficient financial resources allocated to cybersecurity are striking. An annual security budget of less than 10,000 PLN is not just extremely low but outright unreasonable (it is lower than the monthly salary of a junior cybersecurity specialist in any commercial company).

Another concerning aspect is the persistently low number of reported information security incidents in offices. When compared to the total number of incidents in Poland and considering the size of local government administration, it can be highly likely assumed that this results not from a high level of security but rather from low detection rates or a lack of reporting of incidents whose consequences can be concealed or mitigated.

Given the above, one may fear that the relatively high self-assessment of the security level might be overestimated.

As part of further research work, it is planned to conduct similar research in other EU countries to compare data on information security management.

Acknowledgements

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INNOVATIONS IN POLISH ENTERPRISES IN CRISIS CONDITIONS

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Purpose: It is widely acknowledged that innovation is key to increasing company productivity. In times of pandemic crisis, the severe economic situation caused by COVID-19 has led to an increased focus by companies on innovations, particularly in processes and organizational structures. The topic of innovation in enterprises during crises is extremely important, as it makes entrepreneurs aware of the significance of utilizing innovation, especially in times such as the COVID-19 crisis. Due to the pandemic, innovative solutions and new ways of organizing work and management have been implemented in enterprises, all of which have been influenced by mass redundancies and forced isolation. By introducing previously unknown solutions, companies hope to survive in the market under crisis conditions. The aim of this study is to demonstrate the importance of introducing and implementing innovative ideas and solutions in a company during times of crisis. It is assumed that during crises, companies intensify their process and organizational innovation activities.

Design/methodology/approach: The purpose of this study was to analyze and evaluate the impact of the COVID-19 pandemic on the innovativeness of service sector enterprises in the Beskids Region. The study was conducted using a diagnostic survey method, with a survey questionnaire as the primary research tool.

Findings: The collected empirical material confirms the established hypothesis that innovation is a key determinant of a company's success. In the surveyed service industry companies, innovative solutions were introduced, and new organizational techniques were implemented to minimize the impact of the pandemic.

Research limitations/implications: The research is of a pilot nature. Its aim was to verify the planned research procedure, including the selection of surveyed enterprises and the research tools used. During the pilot study, not only the research procedure was tested but also the formulated questions and the responses given by the respondents. The pilot study confirmed the significance of the investigated issue. A random selection of 10 service enterprises was made for the study. It is proposed to increase the number of the surveyed enterprises in the Beskids Region.

Practical implications: It is recommended that research and development facilities be established in the surveyed enterprises and that qualified personnel be employed. This will enable the faster implementation of changes and innovative solutions in the future. Continuous observation and monitoring of crisis factors that may influence enterprise innovation are necessary. No foreign studies have been found in this area that would allow for a comparison of the applied solutions.

Originality/value: A novel aspect of this paper is the identification and analysis of innovations implemented by enterprises under crisis conditions. In the surveyed service sector companies, innovative solutions were introduced, and new organizational techniques were applied to minimize the impact of the pandemic. In particular, this involved the adoption of new work organization methods. The implementation of concepts such as remote work and hybrid working had a positive impact on the functioning of enterprises.

Category of the paper: empirical researches.

1. Introduction

Innovation is the result of complex relationships and interactions among multiple actors, and among the special role played by small and medium-sized enterprises. Innovations in companies developing intensively in favorable conditions.

A major problem is the insufficient cooperation economic and scientific environments, the low level of implementation of new technologies and the low number of new companies created on the basis of new technologies as well as the problem of financing innovation.

Changes constitute the main challenge of the 21st century. They may concern systems, countries, branches of economy, enterprises, departments, organizational units, as well as the human being. In the age of increased competition, enterprises are forced to continually search for methods and techniques aimed at improving their actions. The changes dealt with by every business entity are related with both closer and more distant environment. There emerge new companies which are bound to compete with the already existing entities (Łopatowska, Zieliński, 2012, p. 471).

According to Schumpeter, an entrepreneur's task is not to make new inventions, but rather to put them into practice. Entrepreneurs contribute to repeatable waves of prosperity - which exert a revolutionary impact on economy - as well as to recurrent periods of recession, induced by the influence of new products and methods disrupting a current balance (Polowczyk, 2009, p. 7).

The purpose of the study was to attempt to analyze and evaluate the impact of the COVID-19 pandemic on the innovativeness of service sector enterprises in Beskids Region. The following research question was posed: "What type of innovations were used in the surveyed enterprises in crisis conditions?"

The topic of innovation in enterprises during times of crisis is particularly important, as it makes entrepreneurs aware of the significance of implementing innovations, especially during crises such as the COVID-19 pandemic. Due to the pandemic, companies have adopted innovative solutions and new ways of organizing work and management, all of which have been driven by mass layoffs and the necessity of isolation. By introducing previously unknown solutions, businesses hope to survive in these challenging times.

For the surveyed enterprises, it is highly recommended to establish research and development facilities and to focus on hiring qualified professionals. This will enable faster implementation of changes and the adoption of innovative solutions in the future. Such a recommendation can also be applied to companies operating in other industries.

2. Innovative conditions and a company's on the market

A continuous emergence of new techniques and technologies, along with a gradual increase in competitiveness, can be observed in recent times. In such circumstances, an enterprise that fails to innovate or respond quickly to environmental changes risks collapse. Both business theorists and practitioners generally agree that innovation is now a key factor in competitiveness.

In developed market economies, a deeply rooted assumption—one that entrepreneurs have only recently begun to recognize—is that an enterprise's ability to absorb innovation is a crucial indicator of its modernity, efficiency, and productivity. Today, innovation is seen as a fundamental driver of enterprise development, enriching the market with high-quality products and services while also fostering organizational restructuring within companies and their environments.

Innovation should be viewed as a broad and complex set of resources aimed at enhancing managerial capabilities, strengthening competitive positions, and enabling enterprises, national markets, and societies to achieve economic gains. The ability to achieve these benefits is closely linked to competitiveness (Świtalski, 2005, p. 146).

W. Grudzewski and I. Hejduk Innovations are believed to enhance creation processes, increase productivity, improve effectiveness and product quality, and boost competitiveness. They also contribute to overall efficiency by optimizing work organization, removing barriers, activating resources, and improving occupational health and safety. Furthermore, innovations facilitate export opportunities, reduce the need for human labor through better organization, and enhance efficiency by utilizing more advanced and complex technical equipment, etc. (Grudzewski, Hejduk, 2001, pp. 451-452).

Innovation is the creation, development, and implementation of a new product, process, or service to improve efficiency, effectiveness or competitive advantage (Czerwińska-Lubszczyk, Gajdzik, Grebski, M.E., Grebski, W., Jagoda-Sobolak, Krawczyk, Kuzior, Wolniak, 2022, p. 12). From a psychological perspective, the definition of innovation is: *Innovation is individual ingenuity, talent associated with creativity, the ability to take risks, inventiveness, and the capacity to learn* (Brojak-Trzaskowska, 2021, p. 120).

Among the fundamental sources of success, J. Kay identifies reputation, innovation, and a company's strategic resources. Innovation can pertain to products, technology, as well as organizational and management systems. While original innovations form the foundation of competitive advantage, it is often challenging to retain their benefits exclusively. Due to the ease of idea replication, the original inventors frequently do not reap the full market rewards alone; instead, success and benefits are often distributed among multiple companies (Key, 1986, p. 145).

Hamel and Prahalad argue that identifying key areas of expertise within an enterprise enables the attainment of a long-lasting competitive advantage. Innovative knowledge drives the emergence of new industries and markets. The development of new competencies stems not only from technological advancements but also from the ability to meet evolving customer needs. These concepts are forward-looking, recognizing the accelerating pace of social change, which gives rise to new fields, emerging demands, and profound transformations in traditional sectors. In this context, innovation serves as a cornerstone for building essential business expertise (Hamel, Prahalad, 1999, p. 14).

Innovations make it possible for entrepreneurs and managers to perform important modifications, undertake new activities, offer new services and solicit innovative buyers. The ultimate test for a new innovation is its success on the market (Matejuk, 2005, p. 14).

Types of innovation can be classified according to various criteria, types, and effects (Jasiński, Głodek, Jurczyk-Bunkowska, 2019, pp. 24-25).

An innovative enterprise integrates three key elements in its operations: generating novel ideas, implementing them in practice, and bringing them to full realization. More broadly, an innovative enterprise is one that continuously seeks out and applies scientific research, novel concepts, and groundbreaking inventions. In today's competitive market, innovation serves as a critical driver of competitive advantage. Strengthening business competitiveness relies on identifying and shaping the essential factors that determine a company's overall condition.

According to Z. PierścioneK, the process of shaping and analyzing a company's competitiveness begins with customer perception. Buyers compare various aspects of competing offers, including product or service quality, functionality, price, novelty, and modernity. Other key factors include the diversity, complexity, and complementarity of the offer, the degree of innovation in both the product and the company, the customer's role in product creation, availability and purchase location, as well as the intensity and quality of promotion. Additionally, buyers consider modification costs, personal attachment and relationships, brand loyalty (toward the company and/or country of origin), after-sales service availability, brand reputation, company size and market share, delivery time, and various other factors (PierścioneK, 2003, p. 35).

In today's world, creating favorable conditions for fostering innovation is essential. The innovative activities of enterprises are becoming increasingly complex, and their dynamic growth is often constrained by limited internal resources. As a result, innovation frequently requires support from individuals or both internal and external institutions. A strong market position not only provides an enterprise with direct benefits but also facilitates easier access to external funding sources (Świtalski, 2005, p. 147).

Enterprises today are increasingly impacted by change, which has become more apparent in business operations. Commonly discussed issues include restructuring, reorganization, shifts in business direction, re-engineering, new technologies, emerging distribution methods, mergers, and acquisitions. What was once considered rare or exceptional has now become the norm. The era of companies relying solely on stable organizational structures for efficiency is gradually fading. To meet market demands, businesses must embrace flexibility in their daily operations and prioritize innovation.

Under current circumstances of highly turbulent environment, in order to shape the value of an organization and improve its competitive position, it is crucial to quickly identify and create change-triggering factors, and subsequently plan and carry out modification processes so that the change could bring desired effects. This ability allows the organization to acquire characteristics of self-learning and self-development, which in turn makes it possible to flexibly adapt to a new market situation and enhance competitiveness (Łopatowska, Zieliński, 2012, p. 472).

In order to reach a favorable competitive position on the market, it is essential to maintain a high level of innovativeness, which is described as the ability to permanently create and implement innovations that are appreciated by receivers thanks to their high level of modernity and quality.

3. Crisis

The word *crisis* comes from the Greek word *krisis* which has many meanings. It can mean a dispute, a preference, a separation, a struggle with something, a turning point or a breakthrough or watershed moment (Walas-Trębacz, Ziarko, 2011, p. 16). In today's perception, the statement is primarily associated by society with something bad. In the case of a company, it is a pathological situation that needs to be defined and then attempted to be eliminated by taking appropriate measures. However, the crisis has been with us from the beginning.

In direct reference to the economy and economics, until 2020, the word crisis was mainly associated with the year 2008, when the US economy collapsed as a result of the collapse of the global financial system, which contributed to the collapse of the global economy, which

was also felt in Poland (Barczak, Bartusik, 2010, p. 14). Today the word is associated with the SARS-CoV-2 virus pandemic, where the word crisis is not only considered in economic terms, but also in aspects such as health or politics. It is therefore important to define the statement correctly in order to be able to determine what kind of crisis a company is facing. It is worth pointing out that this phenomenon can be considered in relation to various aspects, such as the process, where special attention is paid to the very course of the crisis over time, the phases of the process, the places of origin or the problems in the development concept of enterprises (Walas-Trębacz, Ziarko, 2011, p. 18).

A crisis can be defined as a situation that severely disrupts a company's operations. It signifies a fundamental disturbance to the enterprise, often resulting in mass redundancies or even the indefinite closure of the business. Additionally, a crisis can also imply the partial or complete breakdown of the company's internal structure. More broadly, a corporate crisis refers to an event—or a series of events—that poses a significant threat to the organization as a whole. When the challenges become so severe that they jeopardize the core business, the enterprise's survival is at risk (Zelek, 2003, p. 85).

A crisis is a phenomenon that follows a structured sequence of events and stages before it fully emerges. Therefore, it can be understood and treated as a process. This process consists of events that are often sudden and unexpected for the company. However, a crisis may also result from long-standing irregularities—sometimes even known to the enterprise—where its onset is a consequence of inaction or poor management decisions. A crisis situation may begin to develop when a company starts experiencing unprofitability, rising costs exceeding revenues, organizational burnout reflected in a lack of motivation to achieve goals or embrace new challenges, a decline in innovation, or a sharp decrease in market interest (Barczak, Bartusik, 2010, p. 2).

To determine whether a company is at risk of a crisis, it is essential to assess its situation and identify both the presence and stage of the crisis. Defining a crisis requires a clear understanding and interpretation of what constitutes such a situation. A crisis is a combination of internal and external events and circumstances that significantly impact an organization, triggering lasting changes and transformations. Certain aspects are commonly associated with classic crisis situations, including rapid escalation, high social and political significance, the risk of conflict, heightened tensions, aggression toward opposing parties, and prolonged duration—sometimes even remaining hidden for an extended period (Markiewicz, Wawer, 2005, pp. 41-42). The concept of a crisis situation is complex and cannot be fully understood with a single definition. To grasp its full meaning, all aspects must be considered. It is particularly important to examine the term 'situation' itself—what it entails and how it applies in a crisis context. The term is used to describe the variability and temporality of different elements within a given framework. A situation can be defined as any dynamic arrangement of environmental factors that change over time.

A crisis situation encompasses the factors, circumstances, stages, and events that precede and shape a crisis. It often involves growing instability and uncertainty, as well as events that pose threats to life, health, property, or, in the case of enterprises, disruptions to their structure, profitability, and overall stability. In most cases, a crisis situation leads to a lasting decline in business performance and organizational destabilization. In extreme scenarios—such as a global crisis like COVID-19—if the state does not intervene with support, the company may face complete collapse.

A crisis can stem from various sources, often originating from seemingly minor or insignificant events that, through their consequences, lead to lasting destabilization or even the collapse of a company. But what are the most common causes of a crisis? What often acts as the trigger for a company's failure?

There is no single, clearly identifiable source of crisis. Its unpredictable nature makes it impossible to pinpoint one specific cause. While certain risk factors can be anticipated and mitigated, crises often arise from sudden, unexpected events—situations that were considered unlikely and for which neither society nor businesses were adequately prepared.

The epidemic threat posed by SARS-CoV-2 has become the absolute most important challenge of an economic-social as well as a political nature (Hajkowski, Szewczyk, 2023, p. 2). Today, there is no clear definition of a pandemic crisis. However, it can be said that this crisis is of a disruptive economic as well as social nature. What is more, this crisis should be treated as serious, as it has affected the European Union, including Poland, at a time of great economic and political instability. It is worth noting that the crisis is comparable if not worse in its effects to the crisis of 2008 (Zahradnik, Palmieri, Dirx, 2020, p. 2).

4. Problems of enterprises as a result of the coronavirus pandemic

The problem of the coronavirus in Poland began on 4 March 2020, the date of the first case of the SARS-CoV-2 virus recorded in our country. At the time, no one suspected that the virus could bring the world to the state we know today. In the early days of the spread of the virus, health was the main priority. However, as the epidemic turned into a pandemic, attention began to turn to the devastating effects the virus was having on the global economy. What was not thought was that a virus from the Far East would contribute to an economic disaster comparable to 2008. When the eyes of the entire country were on the public and the health service, businesses on virtually every level began to record losses. The financial markets experienced a meltdown due to the slowdown or complete freezing of the economy.

The world economy was not prepared for such an event. Many scientists and scholars conclude that mankind is now confronted with a 'black swan' event, where such an event is defined as unexpected, low probability and unpredictable on a global scale (Dobska, 2021,

p. 8). At the very beginning of the pandemic, there was already speculation that even if there was no outbreak in many countries, they would all feel the economic impact of the pandemic on the market. The financial markets had already warned of this a little earlier, when the decline in demand in China and the industrialised countries began to fall dramatically and the sectors involved in exporting products, selling raw materials or tourism began to record losses they had not experienced for years.

The way in which risks were understood before the pandemic has faded into the background. Before the pandemic, the main corporate threats were primarily political, economic, socio-cultural, technological, legal, environmental or ethical. During the pandemic, it appears that threats that were perceived as single criteria, today, through the coronavirus pandemic, threats arise from several segments at once. The results of the survey confirm that the impact of the pandemic on companies, the majority of entrepreneurs assess the impact of the pandemic as being felt - a total of 94%, with nearly 60% assessing the situation as very serious and a further just under 40% declaring that the impact is partly felt, but that the Board is still coping. Only just under 5% of respondents declare that the pandemic has a minor negative impact on the operation of their company, and no impact was declared by 3 companies out of the 809 surveyed (Męcina, Potocki, 2020, p. 9) with particular emphasis on political, social and economic risks.

The first and perhaps most shocking threat to businesses (and especially start-ups) is virtually total paralysis. Businesses were closing down overnight. In contrast to the previous crisis, here there was an immediate, total shutdown of many activities. In turn, the complete suspension of operations entailed further risks, namely a sharp drop in production, a rapid rise in unemployment or a reduction in foreign trade. A threat such as the total blocking of a company's operations has dire consequences (Zahradnik, Palmieri, Dirx, 2020, p. 4).

Another risk arising from the pandemic crisis was that directly resulting from the closure of enterprises, namely the reduction of employees. Companies, due to the suspension of their activities, were forced to reduce their workforce, which manifested itself as redundancies (Męcina, Potocki, 2020, p. 9). Despite the fact that the company is up and running and permitted to operate, by reducing the workforce the productivity, which had already been damaged by the lack of demand, also falls (Zahradnik, Palmieri, Dirx, 2020, p. 4).

5. Impact of the COVID-19 pandemic on the innovativeness of service sector enterprises in Beskids Region

Innovation is an essential component of any thriving and modern enterprise. For service companies, the ability to innovate becomes particularly crucial during challenging times, such as the COVID-19 pandemic.

In 2022, a study was conducted to examine whether innovation intensified in service companies in the Beskids Region during the pandemic crisis. The research was based on a standardized survey questionnaire, which was administered to 10 small and medium-sized enterprises (SMEs) in the service sector within the region.

Respondents provided insights into the types of innovations they introduced and the areas in which these innovations were applied. The survey also explored company performance, the benefits of implemented innovations, and business activities that fostered company growth. The study analyzed product, process, organizational, and social innovations in detail, while additional questions focused on demographic and profiling aspects.

Table 1 provides respondents' responses on the type of innovation introduced in enterprises between 2020 and 2022.

Table 1.

Innovations introduced in Polish enterprises of the service sector in 2020-2022

Type of innovation	Companies (%)
Product Innovations	5%
Process Innovations	10%
Organizational Innovations	100%
Social Innovations	70%

Source: own research.

All companies (10 companies) have implemented organizational innovations.

One company introduced product innovations and two companies introduced process innovations. Seven companies have introduced social innovations.

In the opinion of the respondents, organizational innovations related to changes in the organization of work and company management made in enterprises resulted in a significant reduction in the costs of the processes carried out.

The research carried out helped to confirm the research assumption that organizational and process innovation intensified under the conditions of the coronavirus pandemic crisis in the surveyed companies. Previously, employees had worked exclusively stationary. Unfortunately, while successive waves of coronavirus devastated the economy, the surveyed companies followed suit by introducing remote working. This turned out to be crucial because, as part of a management decision, when remote working was introduced, employees were able to work from home, thus avoiding the spread of the coronavirus within companies. Companies provided employees with the computers and tools needed to work remotely. Through such measures, companies ensured the safety of their employees while at the same time avoiding the loss of workstations. Over time, as the coronavirus waned, company management decided to introduce hybrid working, which was also one of the organizational innovations. This was a necessary procedure because not everything could be accomplished at home using only a computer. The main problems resulting from remote working were: lack of access to documents in the warehouse, lack of supervision of the correct loading and unloading of vehicles, limited communication with employees, burdening those in the office with the tasks of those in the

home office (printing out documents, labels and then passing them on to drivers and warehousemen).

Implementing innovation is a complex process requiring time and often considerable money. We are talking here about innovations introduced during the normal operation of a company. The situation becomes much more complicated when a crisis becomes a reality, and particularly when the crisis is caused by a virus that the world has never encountered before. This was also the case for the companies surveyed, when time pressure resulted in some difficulties during the desire to implement the necessary innovations. Due to the specific nature of the service industry, problems such as constraints due to regulations and legal standards and the lack of suitably qualified staff occurred. It was these two factors that became the main problems during the implementation of innovations. This resulted in a significant delay in the introduction of, for example, home office compared to other companies. A lack of technology information proved to be another problem. None of the companies surveyed had a research and development department.

The innovations that were introduced were mainly organizational innovations such as home office, hybrid working or downsizing. A problematic aspect may have been the crisis shield, where it directly relates to norms and legislation, which were known to change dynamically during the pandemic.

The situation with the coronavirus and the accompanying crisis will certainly be remembered in the history of the companies surveyed. However, these companies managed to survive the crisis by introducing and intensifying innovations, especially organizational innovations. Work organization (organizational) innovations such as home office or hybrid working may have worsened communication between departmental employees or made certain activities impossible and stopped for an indefinite period of time, but the company was not affected as significantly as other companies in the market. We should also not forget the technological (process) innovation aspects, such as the introduction of automatic magnetic card doors and the separation of employees by plastic sheets or the creation of separate work rooms. In addition, all sanitary protection measures were introduced.

6. Conclusions and recommendations for the enterprises of the Beskids Region

Innovation is a key determinant of business success. In the service companies surveyed, innovative solutions and new organizational techniques were introduced to minimize the impact of the COVID-19 pandemic.

Amid the crisis caused by the pandemic, service companies in the Beskids Region intensified their innovation efforts, particularly in the area of organizational innovation. This primarily involved implementing new work organization methods, such as remote and hybrid work models, which had a positive effect on business operations.

The measures adopted helped mitigate the risks brought on by the crisis. However, in the surveyed companies, these changes were implemented too slowly, and innovative solutions were introduced too late. Additionally, there were challenges related to insufficient knowledge of legal and technological requirements.

To address these issues, it is recommended that research and development (R&D) facilities be established within these enterprises and that qualified personnel be hired. This would enable a faster and more efficient implementation of innovations in the future.

Polish companies that had to limit or suspend their operations due to the pandemic could rely on government support. Poland received approval from the European Commission to allocate national financial resources to various instruments supporting businesses. The Financial Shield of the Polish Development Fund, as well as the Anti-Crisis Shield, provided real support for Polish entrepreneurs.

Polish centers of the Enterprise Europe Network, including the Polish Agency for Enterprise Development, continuously provide advisory services and support in establishing business connections.

7. Summary

In the history of the surveyed enterprises, the crisis accompanying the COVID-19 pandemic will undoubtedly be remembered. The companies survived this crisis by implementing and intensifying organizational innovations. Despite the lack of customers, employee layoffs, and the temporary suspension of business operations, the surveyed companies remained solvent and continued their activities.

Work organization innovations, such as remote work (home office) and hybrid work, may have worsened communication between departments or caused certain operations to be delayed or suspended indefinitely. However, these companies did not suffer as severely as others in the market.

It is also important to acknowledge technological innovations, which included the introduction of automatic doors with magnetic card access, the separation of employees with acrylic glass barriers, and the creation of individual workrooms. In all companies, mandatory sanitary protection measures were implemented by installing disinfectant dispensers.

Both business theorists and practitioners generally agree that innovation is one of the most crucial factors in a company's competitiveness. A company that fails to implement changes or responds too slowly to shifts in its environment risks collapse.

In connection with the COVID-19 pandemic, European Union member states, including Poland, had an effective tool for supporting selected groups of enterprises. However, whether it was utilized and proved effective depended largely on individual member states—their ability to forecast, plan, and implement appropriate measures in a timely and strategic manner, prioritize economic and social interests over political ones, and, to a significant extent, their budgetary capabilities (Kopeć, 2021, p. 98).

This article aims to characterize the process of change implementation in service sector enterprises during times of crisis. In the surveyed service companies, innovative solutions and new organizational techniques were introduced to mitigate the impact of the pandemic. In particular, businesses adopted new work organization methods, such as remote and hybrid work models, which had a positive effect on their overall operations.

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THE IMPORTANCE OF PERSONAL INCOME TAX IN THE BUDGETS OF MUNICIPALITIES IN POLAND IN 2019-2023

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Purpose: The general aim of the publication is to present the importance of personal income tax in the budgets of municipalities in the years 2019-2023.

Methodology: Analysis of data from the library of the Central Statistical Office.

Findings: The results of the assessment obtained as a result of the analysis of budget revenues of municipalities showed the significant importance of personal income tax, which in turn affects the implementation of a wide range of tasks by local government units. In the analysed period, the greatest changes in the legal system affecting the revenues of local government units took place, in particular, several significant modifications to the Personal Income Tax Act were made, which in turn poses a challenge for municipalities to take action in the field of effective management of budget revenues.

Research limitations/implications: The article contains a preliminary study. In the future it is planned to conduct additional quantitative and qualitative research.

Originality/value: The publication discusses the importance of personal income tax in the revenues of municipalities in Poland. The analysis took into account own revenues, subsidies and subsidies. The article also includes selected legal changes in personal income tax, which had an impact on the development of municipal revenues on this account.

Keywords: taxes, personal income tax, public finances, local government units.

Category of the paper: Research paper.

1. Introduction

The foundation of the independent economy of the commune is the budget. The condition for the ability of municipalities to perform the public tasks assigned to them is to ensure that these units receive an appropriate share in public revenues. The nature and scope of the decentralization processes taking place is directly related to the category of financial independence of municipalities, which is referred to as local financial autonomy. The distribution of public revenues at the systemic level requires that the own tasks of the municipal government are financed in the form of own revenues transferred to them. One of the sources of budget revenues of municipalities is personal income tax. Personal

income tax (PIT) in the Polish tax system is characterized by the fact that the revenues from this tax are divided between the State Treasury and local government units, i.e. municipalities, districts and provinces. This tax is classified as direct taxes, because the subject of taxation is a natural person earning income, and not business transactions, as in the case of corporate income tax on company income. PIT applies to income from: remuneration from employment, pensions, benefits, running a sole proprietorship, freelance profession and artistic, literary, scientific, creative, journalistic and educational activities. The aim of the publication is to present the importance of personal income tax in the budgets of municipalities in 2019-2023.

2. Personal income tax – theoretical connotations

Personal income tax was introduced by the Personal Income Tax Act of 26 July 1991, which replaced five acts in force until the end of 1991. These were the following acts (Dolata, 2013):

- a) The Act of 4.02.1949 on the tax on remuneration (Journal of Laws No. 7, item 41, as amended).
- b) The Act of 28.07.1983 on the equalization tax (Journal of Laws No. 42, item 188, as amended).
- c) The Income Tax Act of 16.12.1972 (Journal of Laws of 1989 No. 27, item 147, as amended).
- d) The Act of 28.02.1982 on the taxation of socialized economy units (Journal of Laws of 1987 No. 12, item 77 as amended).
- e) The Act of 15.11.1984 on agricultural tax – in the scope of agricultural tax on the income of natural persons from special branches of agricultural production, in the wording in force until 31.12.1991 (Journal of Laws No. 52, item 268, as amended).

The current act introduced a general personal income tax. This was one of the elements of the reform of the Polish tax system in the early 1990s. Since its implementation, it has been amended many times. Every year, new changes are made to its content. Both the causes and the nature of these changes are varied. To a large extent, they are dictated by the need to adapt the structure of the tax to the changing economic and social reality in Poland. These changes also result from the adaptation of the existing regulations to constitutional requirements, which in effect means that all structural elements of the tax are regulated in the act itself, and not in regulations. In addition, it should be noted that mainly since 2016, the changes introduced have been aimed at tightening the system of collecting this tax (Wolański, 2020).

An income tax payer is a natural person earning taxable income. This tax is a personal tax, which means that it covers all income earned by the taxpayer. The exception is income for which the Personal Income Tax Act does not apply. The second exception is the parallel existence of simplified forms of income taxation, contained in Articles 29-30 of this Act

(u.p.d.o.f.). The subjective scope of this tax is related to the issue of unlimited and limited tax liability. Natural persons who live in the territory of Poland are subject to unlimited tax liability, and the subject of taxation is their income in its entirety, regardless of where the sources of income from which this income is earned are located. Therefore, both income from domestic sources and from foreign sources are subject to the tax obligation. A limited tax obligation applies to natural persons who do not have a permanent residence in Polish, although they earn income here. The subject of the personal income tax is income. Therefore, all types of income are taxed, except for exempt income. Apart from strictly defined exceptions indicated in the Act, in the case of income obtained by the taxpayer from multiple sources, the subject of taxation is the sum of income from these sources. Income from a source of revenue is the surplus of the sum of revenues over the costs of obtaining them in a given tax year. (Kosikowski, Ruśkowski, 2008).

Revenues are money and monetary values received or left at the taxpayer's disposal in a calendar year, as well as the value of benefits received in kind and other gratuitous benefits (except for the cases specified in Articles 14-15, Article 17(1)(6), (9), (10) and (11), Articles 19, 25b, 30ca, 30da and 30f of the Personal Income Tax Act). This Act distinguishes the following sources of revenue (u.p.d.o.f.):

- a) service relationship, employment relationship, including cooperative employment relationship, membership in an agricultural production cooperative or other cooperative dealing with agricultural production, homework, retirement or disability pension;
- b) activities performed personally;
- c) non-agricultural economic activity;
- d) special departments of agricultural production;
- e) rent, sublease, lease, sublease and other agreements of a similar nature;
- f) cash capital and property rights;
- g) paid sale of real estate or part thereof and a share in real estate, cooperative ownership right to a residential or commercial premises and the right to a single-family house in a housing cooperative, right of perpetual usufruct of land and other things, if the paid sale does not take place in the performance of business activity and was made in the case of paid sale of real estate and property rights specified above – before the lapse of 5 years, counting from the end of the calendar year in which the purchase or construction took place, and other items – before the end of half a year, counting from the end of the month in which the purchase took place;
- h) the activities carried out by the controlled foreign company;
- i) unrealized gains referred;
- j) other sources: revenues not covered by disclosed sources or derived from undisclosed sources.

Sources of revenue are one of the fundamental categories that is related to the structure of income taxes. Revenues are an essential element of the income tax structure, so their origin must be normatively defined and their origin must be relevant. As a result, the determination of revenue always results in linking it to some source. Sources of income are the primary factor in the construction of the subject of taxation, which determines any further tax consequences (Huchla, 2018).

Personal income tax is characterized by the following features: is a personal tax that is charged to natural persons earning income from various sources of revenue after deduction of costs, takes into account the personal situation of the taxpayer, does not differentiate the burden from the point of view of sources of revenue and is an instrument of income distribution policy (Komar, 1996). Personal income tax is global in nature, which means that it covers the entire income of an individual, regardless of the source of its acquisition, so it gives a full picture of the financial situation of a given taxpayer and thus allows for the assessment of his ability to pay (Gomułowicz, Małecki, 2011).

3. Selected legal changes in personal income tax in 2019-2023

On 26 September 2019, the content of the Act amending the provisions concerning personal income tax was published in the Journal of Laws. On October 1, 2019, the PIT rate was reduced from 18 to 17 percent. The rate of 17 percent was applicable to incomes up to PLN 85,528. Above this threshold, a tax rate of 32% was charged on the surplus. In addition, tax-deductible costs have been increased. Costs before the changes, i.e. in 2018, were as follows (PortalGov.pl):

- a) PLN 111,25 per month (one-time employees);
- b) PLN 139,06 monthly (one-time employees, commuters);
- c) PLN 1 335,00 per year (one-time employees);
- d) PLN 1 668,72 annual (single-time employees, commuters);
- e) PLN 2 002,05 per year (multi-time employees);
- f) PLN 2 502,56 per annum (multi-time employees, commuters).

On the other hand, from 1 October 2019, tax-deductible costs amounted to (PortalGov.pl):

- a) a) PLN 250,00 per month (one-time employees);
- b) b) PLN 300,00 per month (one-time employees, commuters);
- c) c) PLN 3 000,00 per year (single-time employees);
- d) d) PLN 3 600,00 per year (one-time employees, commuters);
- e) e) PLN 4 500,00 per year (multi-time employees);
- f) f) PLN 5 400,00 per year (multi-time employees, commuters).

After the changes introduced as of 1 October 2019, the annual profit of a taxpayer who earned PLN 2 250 (minimum wage in 2019) amounted to PLN 472. On the other hand, with earnings of PLN 4 765 (average monthly salary in the national economy in 2019), it was PLN 732 per year (podatki.gov.pl).

Another important change introduced in 2019 in the field of PIT was the introduction of the so-called relief for young people. This is a special tax exemption that is intended to financially support people starting their professional career. The basic assumption of this relief is the exemption from income tax (PIT) of income earned by persons up to 26 years of age, up to a certain limit. The main reasons for introducing the relief for young people were (poradnik-finansowy.pl):

- a) increasing the attractiveness of employment for young people;
- b) facilitating professional starts;
- c) encouraging people to take up legal work;
- d) financial support at the beginning of the career.

The relief for young people is an important tool of social and economic policy, which aims at both the professional activation of young people and increasing their purchasing power. This relief is currently still in force. On November 15, 2021, the President of Poland signed the law called the Polish Deal (Act of 29 October 2021 Amending the Personal Income Tax Act, the Corporate Income Tax Act and Certain Other Acts). The new regulations came into force in January 2022, the regulations were published on November 23, 2021. From 1 January 2022, the tax-free amount in Poland has increased from PLN 8 000 to PLN 30 000. In addition, the tax threshold was raised from PLN 85 528 to PLN 120 000. Income covered by the 32% rate concerned those earned above PLN 120 thousand. The so-called relief for the middle class was also introduced. The basis for calculating the relief for the middle class was the value of the taxpayer's income, i.e. the gross amount. The amount of the relief was calculated as the product of revenues (gross amount) and the relevant ratio. These regulations were in force until 30 June 2022. The Act of 9 June 2022 amending the Personal Income Tax Act and certain other acts, the so-called "Polish Deal 2.0" was signed by the President of the Republic of Poland on 13 June 2022, and on 15 June 2022 the Act was published in the Journal of Laws (PIT.pl).

According to the new regulations, the PIT rate in the first tax bracket (i.e. to PLN 120,000) has been reduced from 17% to 12% for taxpayers taxed according to the general rules (tax scale), i.e. employed under an employment contract, a contract of mandate and entrepreneurs settling in this way. The tax-free amount of PLN 30 000 remained unchanged (Infor.pl).

4. Shares of municipalities in personal income tax

Since 1990, the activities of local government in Poland have undergone significant modifications. This was mainly related to changes in the system of its organization, as well as finances. The initiated process of decentralization of public authority provided municipalities with instruments shaping the stability of their income. Indeed, this concerned own revenues, including funds from the share in personal income tax. With the reactivation of local government in Poland, the amount of revenues of municipalities, both total and own, was determined, among other things, by modifications of their share in PIT revenues (Galiński, 2015). Already in 1984, the Budget Law referred to the provisions of the Act on the System of National Councils and Local Self-Government, in which it was specified that the revenues of local budgets are revenues from payroll tax in the amount of 85% of its revenues. In 1990, municipalities held a 30% share in the revenues from the payroll tax and from the payroll tax, as well as 50% of the revenues from the personal income tax taxed on general terms. On the other hand, since 1992, municipalities have been granted only a 15% share in personal income tax. In 1996 it increased to 16%, and in 1998 to 17% (Wójtowicz, 2014).

Payroll tax, payroll tax, equalization tax and personal income tax taxed on general principles were collected until the end of 1991. Since 1 January 1992, they have been replaced by a single, general personal income tax regulated in the Personal Income Tax Act of 26 July 1991. In such a situation, it was also necessary to amend the Act on Municipal Revenues, which came into force on the same day as the new Personal Income Tax Act. The shares in the revenues from the payroll tax, the payroll tax, the equalization tax and the personal income tax taxed on general principles were replaced by one share of the communes in the revenues from the personal income tax. The share percentage ratio was set at 15%. The Act on Municipal Revenues was replaced on 1 January 1994 by the Act on of 10 December 1993 on the financing of municipalities. Act on the financing of municipalities in the original wording of Article 4 set the percentage of the share of municipalities in the revenues of from personal income tax at the level of 15%. The share percentages have been maintained at the same level as in the Act on Municipal Revenues. The ratio of the share of municipalities in personal income tax revenues was doubled. This occurred on January 1, 1997, which increased to 16%, and on January 1, 1998, which increased to 17%. Another act that regulated the issue of revenues of municipalities and other local government units was the Act on the revenues of local government units in the years 1999-2003. This Act significantly increased the percentage of the share of municipalities in personal income tax revenues from 17% to 27,6%. Starting from the entry into force on 1 January 1999 of the reform changing the administrative division of Polish, which introduced a 3-level structure of territorial division, the share in PIT revenues has become a source of income not only for municipalities, but also for districts and self-governing provinces. Significant changes have also taken place since 2004, as the share of municipalities

in PIT revenues was set at -39,34%, where the amount of the commune's share in the revenues from personal income tax, constituting the income of the state budget, is determined by multiplying the total amount of revenues from this tax by 0,3934, subject to Article 89, and an index equal to the share of the personal income tax due in the year preceding the base year of the personal income tax residing in the territory of the commune, in the total amount of tax due in the same year. The ratio of the share of personal income tax due from taxpayers residing in the area of communes, districts and provinces respectively in the total amount of tax due is determined as a weighted arithmetic average of 3 calculation years comprising: the year preceding the base year, the year preceding the base year by 2 years and the year preceding the base year by 3 years, with weights of 0,5, respectively, 0,33 and 0,17. The index is determined on the basis of data contained in the tax returns submitted for a given calculation year on the amount of income earned and the annual tax calculation made by the remitters, as at 30 June of the year following the calculation year. If the data referred to in paragraph 4 are not available, the ratio of the share of personal income tax due from taxpayers residing in the area of the commune, district and province respectively in the total amount of tax due shall be determined on the basis of data from the last 3 calculation years for which these data are available, as at 30 June of the year following the calculation year (ustawa o dochodach JST).

The funds which constitute the communes' income from the share in the revenues from the personal income tax are to be transferred from the central current account of the state budget to the accounts of the communes' budgets by the 10th day of the month following the month in which the tax was credited to the account of the tax office. Funds constituting revenues of commune budgets from the share in personal income tax revenues for the month of December are transferred from the central current account of the state budget to the accounts of commune budgets in the following way: a) by 20 December of the financial year, an advance payment shall be in the amount of 80% of the amount transferred, in accordance with paragraph 2, for the month of November of the financial year; b) by 10 January of the following year, the amount constituting the difference between the amount of the share in the proceeds of the personal income tax which was credited to the account of the tax office in December and the amount of the advance payment transferred in accordance with item 1 shall be transferred.

5. Analysis of personal income tax in municipal revenues in 2019-2023

In Poland, the territorial division is as follows: communes, districts and voivodeships. The article focuses on municipalities that carry out a wide range of public tasks. In addition, they are equipped with the so-called own income. The publication examines local government units divided into municipalities with cities with powiat status and municipality without cities with powiat status. This division resulted from the fact that cities with county rights are

characterized by greater economic growth and development. In addition, they show greater financial independence compared to rural, urban and rural-urban communes.

Imposing on municipalities the obligation to meet a specific catalogue of community needs requires that these units be provided with income. Chart 1 presents the development of revenues of municipalities together with cities with powiat status in the years 2019-2023. The analyzed period covers both before and during the COVID-19 pandemic. In addition, during this period, the greatest changes in the legal system affecting the revenues of local government units took place, in particular, several significant modifications to the Personal Income Tax Act were made.

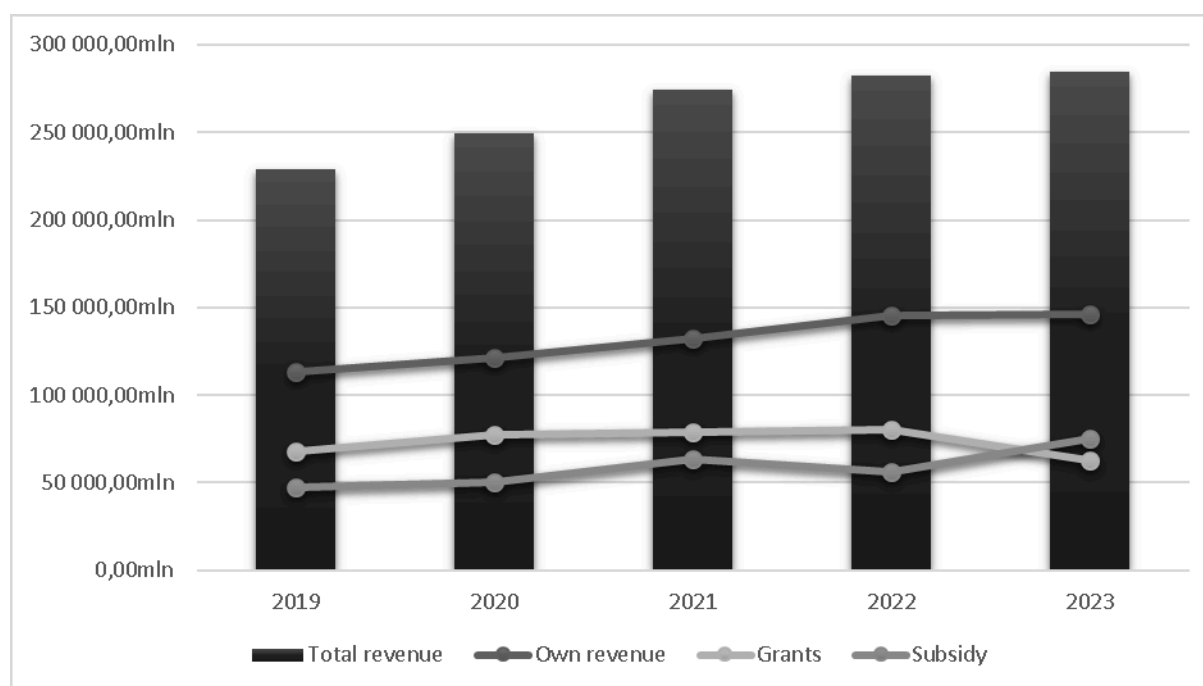


Figure 1. Revenues of communes and cities with powiat status by category in 2019-2023 (in PLN million).

Source: In-house analysis based on BDL data.

The total revenues of municipalities including cities with powiat status in 2019-2023 were characterized by an upward trend, which should be assessed as a positive phenomenon. In the case of the analysis of own income, although an increase was recorded, in 2023 compared to 2022 it was slower. In the case of subsidies, their increase is visible in the years 2019-2022. Only in 2023 compared to 2022 is a significant decrease visible. In terms of subsidies, only in 2022 compared to 2021 was a decrease was recorded.

Table 1.

Revenue growth of municipalities including cities with powiat status in 2020-2023 (in %, previous year = 100)

Specification	2020	2021	2022	2023
Own revenue	107,18	108,61	110,31	100,21
Grants	113,73	101,77	101,83	78,67

Cont. table 1.

Subsidy	106,03	126,34	88,08	134,53
Total revenue	108,88	110,07	102,72	100,92

Source: In-house analysis based on BDL data.

When analysing the dynamics of own income, it should be noted that its increase in 2023 compared to 2022 was insignificant (0.21 p.p.). The reason for this situation were changes in the personal income tax (PIT), which is the main source of income for local government units (LGUs), including municipalities and cities with powiat status. The changes in the personal income tax concerned the introduction of zero PIT for young people, increasing the tax-free amount, raising the tax threshold and reducing the basic PIT rate from 17 to 12 percent. Despite the compensation payments made by the Polish government, it turned out that they were insufficient with the constantly growing budget expenditures of municipalities and cities with district rights. In the case of subsidies, a significant decrease (21.33 p.p.) in 2023 compared to 2022 is noticeable throughout the analyzed period. The decrease in own revenues combined with an increase in current expenditure resulted in a significant decrease in the ability of local governments to implement investments. With regard to subsidies, in the entire analysed period in 2022 compared to 2021, a decrease was recorded (by 11.92 p.p.). The diversity of the structure of their revenues is of great importance for the entire financial system of municipalities and cities with powiat status.

Table 2.

Structure of own revenues of municipalities and cities with powiat status in 2019-2023 (in %)

Specification	2019	2020	2021	2022	2023
Agricultural tax	1,35	1,33	1,25	1,16	1,34
Forest tax	0,26	0,25	0,23	0,23	0,34
Property tax	20,52	19,90	19,76	19,24	21,39
Tax on means of transport	1,03	0,96	0,94	0,90	0,97
Inheritance and gift tax	0,29	0,25	0,32	0,37	0,40
Tax on civil law transactions	2,58	2,47	3,39	2,85	2,72
Business tax of natural persons, paid in the form of a tax card	0,06	0,05	0,14	0,13	0,13
Shares in taxes constituting state budget revenues - personal income tax	42,35	38,74	40,22	39,30	30,33
Shares in taxes constituting state budget revenues - corporate income tax	3,22	3,12	3,57	3,47	4,97
Stamp duty revenues	0,44	0,40	0,44	0,42	0,43
Revenues from the service charge	0,35	0,31	0,29	0,29	0,28
Revenues from the market fee	0,12	0,09	0,00	0,08	0,08
Revenues from other local fees collected by local government units on the basis of separate acts	5,82	7,30	7,94	8,24	9,04
Other income - receipts from services	5,20	4,00	4,23	4,86	5,66
Income from assets	6,22	6,09	7,11	6,54	6,58
Other income - funds for co-financing own tasks obtained from other sources	0,74	6,45	1,32	1,29	3,66

Source: In-house analysis based on BDL data.

In the structure of own revenues of municipalities and cities with powiat status in the entire analysed period, two important sources supplying the budgets of these local government units should be indicated. This is a share of personal income tax and property tax. The lowest share

of personal income tax in the own revenues of municipalities was recorded in 2023 (30,33%), while its highest share was in 2019 (42,35%). The share of property tax in the own revenues of municipalities and cities with powiat status in the analysed period is on average nearly 20%.

The above information in the field of finances concerned municipalities together with cities with powiat status. However, it is important to present the development of individual sources of revenue, broken down into cities with powiat status and municipality without cities with powiat status.

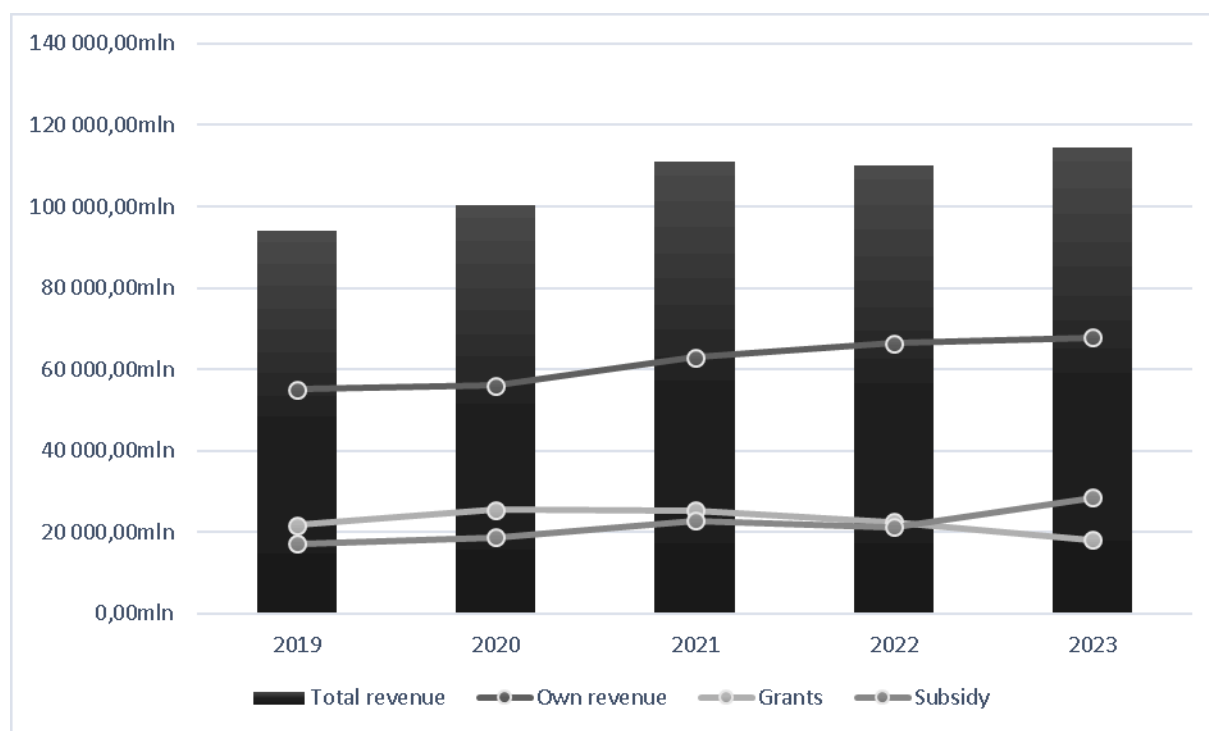


Figure 2. Revenues of cities with powiat status by category in 2019-2023 (in PLN million).

Source: In-house analysis based on BDL data.

The total revenues of cities with powiat status in 2019-2023 were characterized by an upward trend. Total revenue in 2019 amounted to PLN 93 894,37 million, and in 2023 it increased to PLN 114 341,97 million. In the case of the analysis of own revenue, an increase was recorded in the entire analysed period. In the case of subsidies in 2021-2023, they were characterized by a downward trend. In terms of subsidies, only in 2022 compared to 2021 was a decrease was recorded.

Table 3.

Structure of own revenues of cities with powiat status in 2019-2023 (in %)

Specification	2019	2020	2021	2022	2023
Agricultural tax	0,04	0,04	0,04	0,04	0,04
Forest tax	0,01	0,01	0,01	0,01	0,01
Property tax	16,39	16,45	15,87	15,97	17,39
Tax on means of transport	0,64	0,62	0,55	0,55	0,57
Inheritance and gift tax	0,33	0,31	0,37	0,44	0,49
Tax on civil law transactions	2,91	2,84	3,91	3,32	3,29
Business tax of natural persons, paid in the form of a tax card	0,05	0,05	0,15	0,15	0,13

Cont. table 3.

Shares in taxes constituting state budget revenues - personal income tax	45,15	43,09	43,33	40,87	33,36
Shares in taxes constituting state budget revenues - corporate income tax	4,75	4,65	4,95	5,33	7,34
Stamp duty revenues	0,59	0,56	0,59	0,63	0,65
Revenues from the service charge	0,02	0,02	0,01	0,01	0,01
Revenues from the market fee	0,04	0,03	0,00	0,02	0,02
Revenues from other local fees collected by local government units on the basis of separate acts	5,36	6,82	7,18	7,85	8,62
Other income - receipts from services	7,31	5,63	5,71	6,74	7,67
Income from assets	7,09	7,24	8,10	7,55	7,81
Other income - funds for co-financing own tasks obtained from other sources	0,30	3,66	0,50	1,05	2,20

Source: In-house analysis based on BDL data.

In the structure of own revenues of cities with powiat status in the entire analysed period, the two most important sources of budget revenues should be indicated, which are the share in the personal income tax and the real estate tax. The lowest share of personal income tax in the own revenues of municipalities was recorded in 2023 (33.36%), while its highest share was in 2019 (45.15%). The share of property tax in the own revenues of cities with powiat status in the analysed period is on average 16%. The lowest share in own revenues in the case of tax revenues was recorded in the field of agricultural tax, forestry tax and tax on business activity of natural persons paid in the form of a tax card.

It is important to present the development of revenues in municipalities without cities with powiat status.

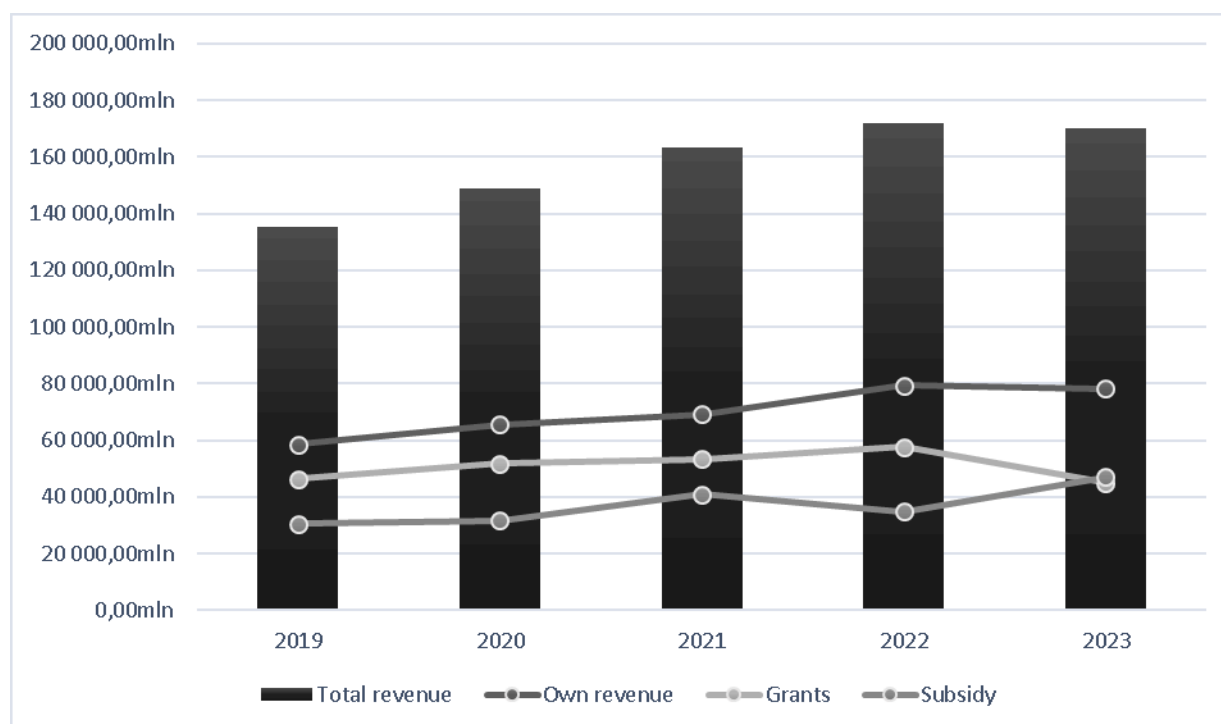


Figure 3. Revenues of municipalities without cities with powiat status by category in 2019-2023 (in PLN million).

Source: In-house analysis based on BDL data.

The total revenues of municipalities without cities with powiat status in 2019-2022 were characterized by an upward trend. Only in 2023 compared to 2022 is their decrease visible. In the case of the analysis of the development of own revenues in 2019-2022, an increase was recorded, with a decrease in 2023 compared to 2022. In the case of subsidies in 2021-2023, they were characterized by an upward trend. In terms of subsidies, only in 2022 compared to 2021 a decrease was recorded, which was characteristic for all local government units.

Table 4.

Structure of own revenues of municipalities excluding cities with powiat status in 2019-2023 (in %)

Specification	2019	2020	2021	2022	2023
Agricultural tax	2,59	2,43	2,35	2,10	2,47
Forest tax	0,50	0,45	0,44	0,41	0,63
Property tax	24,41	22,84	23,29	21,99	24,86
Tax on means of transport	1,40	1,25	1,29	1,20	1,32
Inheritance and gift tax	0,25	0,20	0,27	0,31	0,33
Tax on civil law transactions	2,26	2,15	2,92	2,45	2,23
Business tax of natural persons, paid in the form of a tax card	0,06	0,05	0,13	0,13	0,12
Shares in taxes constituting state budget revenues - personal income tax	39,71	35,02	37,39	37,98	27,69
Shares in taxes constituting state budget revenues - corporate income tax	1,77	1,81	2,32	1,91	2,91
Stamp duty revenues	0,31	0,26	0,30	0,24	0,24
Revenues from the service charge	0,66	0,56	0,55	0,51	0,51
Revenues from the market fee	0,20	0,15	0,00	0,13	0,14
Revenues from other local fees collected by local government units on the basis of separate acts	6,25	7,70	8,64	8,57	9,40
Other income - receipts from services	3,22	2,61	2,88	3,29	3,91
Income from assets	5,40	5,11	6,20	5,69	5,51
Other income - funds for co-financing own tasks obtained from other sources	1,15	8,84	2,06	1,49	4,92

Source: In-house analysis based on BDL data.

In the structure of own revenues of municipalities without cities with powiat status in the entire analysed period, it is necessary to indicate the two most important sources of budget revenues, which are the share in the personal income tax and the real estate tax. The lowest share of personal income tax in the own revenues of municipalities was recorded in 2023 (39,71%), while its highest share was in 2019 (45,15%). The highest share of property tax in the own revenues of municipalities without cities with powiat status was 24,86%, while the lowest was recorded in 2022 (21,99%). The lowest share in own revenues in the case of tax revenues was recorded in the field of inheritance and donation tax, tax on means of transport, forest tax and tax on business activity of natural persons paid in the form of a tax card.

6. Summary

The legislator's intention was to be the primary source of revenue for municipalities to be their own revenues. However, the differences in the level of own revenues have turned out to be so clear that in the situation of some municipalities their level is so low that it would even make it impossible to perform public tasks imposed on these local government units. These differences in the income situation of commune budgets are eliminated on the basis of financial transfers from the state budget to the budgets of municipalities. The financial system in Poland takes into account the category of income qualified as own and external, transferred from the state budget. Therefore, municipalities have at their disposal local taxes, shares in taxes constituting the income of the state budget, as well as targeted subsidies and general subsidies. Municipalities are key to their own revenues, which are also an indicator of their financial independence. However, the generated amount of own revenues of municipalities seems to be too low to fully guarantee the proper implementation of public tasks at the highest level. Moreover, it should be noted that the main purpose of the changes in the system of financing local government units after 2003 was to increase their own revenues, which was mainly achieved through an increase in the above-mentioned percentage shares in taxes constituting the income of the state budget, including primarily in personal income tax. Nevertheless, the percentage share in PIT depends on the economic situation. In the analysed period, the greatest changes in the legal system affecting the revenues of local government units took place, in particular, several significant modifications to the Personal Income Tax Act were made, which in turn poses a challenge for municipalities to take action in the field of effective management of budget revenues. Changes in personal income tax (PIT) may affect the revenues of municipalities in Poland in several ways, depending on the nature of these changes. If the government decides to reduce the PIT tax rate, it may lead to a reduction in revenues to municipal budgets. Municipalities receive part of their income from PIT, because part of this tax (the so-called PIT share) is transferred to local governments. A reduction in the PIT rate may therefore result in lower revenues for municipalities. Another aspect is the fact that if the tax-free amount is raised, people with lower incomes will pay less tax, which may also reduce PIT revenues to municipal budgets. This may be particularly important in the case of municipalities that have a large number of low-income residents. Tax credits such as child credit, housing credit, or others can affect the revenue of municipalities. On the one hand, they may reduce tax revenues of individuals, but on the other hand, they may stimulate local economies, e.g. through greater investments in housing, which may result in higher revenues from property taxes. Sometimes changes in the tax system may also include changes in the distribution of tax revenues between the central and local government levels. If a larger part of PIT is transferred to the central budget, it may result in a reduction in municipal revenues, which will force local authorities to look for other sources of financing or make changes in budget

policy. Changes in PIT may also have indirect effects, such as changes in the level of consumption, investment or migration of people, which may affect the revenues of municipalities in the long term. For example, if lower PIT rates stimulate economic development, it may lead to more income from other sources, such as business taxes. To sum up, it should be noted that changes in personal income tax may affect the revenues of municipalities in Poland both in the short and long term, depending on the nature of the changes, including reduction of rates, introduction of reliefs or changes in the system of distribution of tax revenues. Municipalities will have to monitor these changes and adapt their budgets to the new conditions.

From a political point of view, the state authorities should carry out analyses and forecasts in terms of possible consequences in the event of changes in PIT. It is also important to provide strategic guidance in the field of financial planning or to promote the adaptation of the tax policy to the current socio-economic situation. Another solution could be to indicate a new source of own revenues of municipalities, which would ultimately offset the effects of the reduction in budget revenues from PIT.

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MARKETING CONCEPT REVISITED. MARKET ORIENTATION AS A BASIS FOR THE MARKETING CONCEPT DEVELOPMENT

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Purpose: The aim of the article is to identify the most important characteristics of the marketing concept, as well as the most important dimensions of the market orientation perceived as a basis for the marketing concept development.

Design/methodology/approach: The article presents the nature and the most significant characteristics concerning both the marketing concept as well as market orientation. A literature review and an identification approach were used.

Findings: A properly defined market orientation and its most important characteristics are the basis for the effective and efficient implementation of the marketing concept within business management. Market orientation as well as marketing concept play a very crucial role in firms' strategies development, as well as in building and implementing modern and innovative business models.

Practical implications: Marketing concept is an important tool for building firm success and its competitive advantage. For the effective and efficient implementation of the marketing concept in the contemporary business management it is necessary to define the key components of the market orientation as well as the most significant processes and activities related to this orientation.

Originality/value: The most important features related to the marketing concept as well as market orientation were presented. The article is addressed both to researchers as well as managers and other business practitioners.

Keywords: marketing, marketing concept, market orientation.

Category of the paper: Conceptual paper.

1. Introduction

The role of marketing in widely perceived business as well as business management is constantly growing. Marketing is a very important tool for building the firm success as well as the competitive advantage of a firm. Particular importance is assigned to the concept of marketing, the effective and efficient development and implementation of which is the path to the above-mentioned success and competitive advantage.

In general terms, the marketing concept means a decision-making model that includes: (1) strategic analysis, (2) marketing goals, (3) marketing strategies and (4) marketing tools (Becker, 1983, p. 75).

The concept of marketing has had many studies in its classic approach, including mostly marketing-mix concept and components. At the same time, in recent years one may notice an increasing importance of the managerial and strategic aspects of the marketing concept, related to its perception as a factor strongly affecting business management performance as well as the formation and development of business models (Matwiejczuk, 2006; Kotler, Keller, 2022). Contemporary marketing concept is a very significant tool in building the firm success as well as in creating and sustaining the long-term competitive advantage of a firm.

The aim of the article is to identify the most important characteristics related to the marketing concept, as well as the most important dimensions of the market orientation, perceived as a basis for the marketing concept development and implementation. The article presents in particular: (1) the nature and the most significant characteristics of the marketing concept, (2) the most important firms' orientations towards the market, and (3) market orientation as a basis for the marketing concept formation and development.

2. The nature and the most significant characteristics of the marketing concept

In its original meaning, marketing was perceived as a type of human activity related to the market exchange, i.e. the exchange of products and services. Within the development of marketing concept, it was increasingly perceived and applied as a function integrating all decisions made in a firm as well as processes and activities aimed at acquiring and maintaining the target market that meets the needs, aspirations and development possibilities of the firm (Niestrój, 1996).

Contemporary marketing is a firm management concept based on market orientation. According to Ph. Kotler, there are four basic characteristics of the contemporary marketing (Kotler, 1994):

- 1) Customer needs related to the broadly understood managerial information system, an integral part of which is the marketing information system (subsystem).
- 2) Target market, understood as a precisely defined group of customers whose demand the firm plans and is able to satisfy within both the developed products' as well as services' offer and/or the conducted marketing program.
- 3) Coordinated marketing tools, processes and activities related to the integration of individual activities within the marketing-mix area, as well as the integration of marketing with the other firm areas.

- 4) Profitability, related to the firm profits achievement, taking into account long-term customer satisfaction as well as customer loyalty.

The challenges that are constantly gaining in importance, caused primarily by the various changes in the needs, preferences and expectations of customers, as well as by the intensifying the competitive processes, have led for many years to a gradual increase of the marketing concept significance within the development and implementation of the market strategies of the firms and supply chains. These challenges are one of the most important determinants of the Industry 4.0 concept, within which market strategies should primarily create the foundations for building a lasting, long-term competitive advantage of the firms on the market. A key component of the market environment, exerting a significant influence on the possibilities of using the concept of marketing and its tools, are competitive processes related to the activities conducted by the competitors (Wrzosek, 1997).

Marketing as a management concept focused on recognizing and satisfying the customers' needs, wants, preferences and expectations, includes four levels that constitute the marketing concept (Figure 1).



Figure 1. The marketing concept.

Source: Matwiejczuk, 2006, p. 3.

Basically, the marketing management process comprises a comprehensive marketing concept within the firm, which plays a coordinating role in relation to the all activities undertaken and implemented by the firm (Sławińska, Urbanowska-Sojkin, 1997).

The basis for the marketing concept formation and development is a multidimensional strategic analysis, which includes (Matwiejczuk, 2006):

- 1) Firm analysis, comprising in particular firm resources, capabilities and competences.
- 2) Competition and competitors analysis.

- 3) Market analysis.
- 4) Macroeconomic environment analysis.

Strategic analysis is based on the use of the specific tools that perform three basic functions:

- 1) Analytical functions, related to the events that took place in the past.
- 2) Diagnostic functions, related to the current state (present).
- 3) Prognostic functions, related to planning and predicting events in the future.

The next components (levels) of the marketing concept include:

- 1) Defining marketing goals and incorporating them into the structure of the firm goals.
- 2) Formation and development of the marketing strategies, integrated with the firm strategy as well as the strategic business units strategies.
- 3) Formation and development of the operational programs related to the composition of marketing-mix tools.

On the one hand, firms may perceive marketing as the basis for their market activities. Marketing is then the superior management orientation of the firm. On the other hand, firms may perceive marketing as one of the functions and/or one of the processes conducted by the firm. Taking into account these two perspectives, one may say about the so-called dual concept of (dual approach to) marketing (Figure 2).

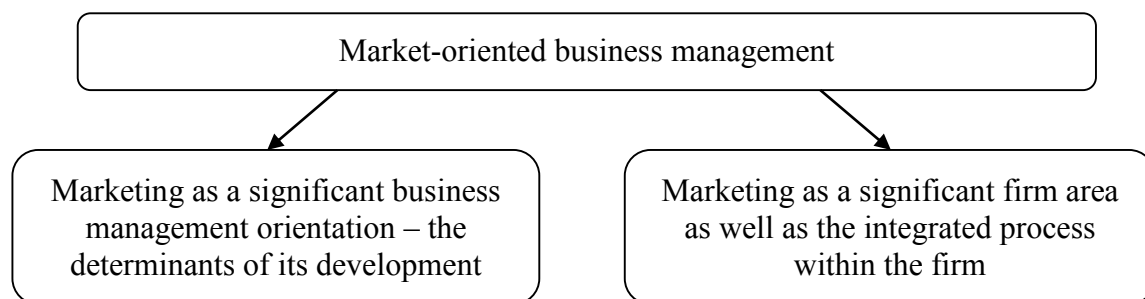


Figure 2. Marketing as a dual concept of the market oriented business management.

Source: Matwiejczuk, 2006, p. 3.

The basis for the marketing concept formation and development, perceived as the significant business management orientation, are megatrends which determine the development of marketing towards market-oriented business management. Among the most important megatrends influencing the above development one may indicate (Matwiejczuk, 2006):

- 1) Individualization of customer preferences, whose key position (role) is recognized in its operations by each firm adopting market orientation as the basis of its activities.
- 2) Changes in the structure, scope and forms of competition, related to the growing importance of marketing as a tool for building and maintaining the long-term competitive advantage of the firm.
- 3) Internationalization of the market, which remains under the significant influence of multidimensional changes occurring in the broadly perceived environment of the firms.

At the same time, marketing perceived as the significant firm area as well as the integrated process within the firm, requires proper positioning within the value creation chain, as well as an accurate definition of:

- 1) Goals, including in particular the definition of the corporate mission and overarching targets both in the scope of strategic and operational planning, as well as the overall integration of marketing goals into the general firm goals.
- 2) Strategies, specifying the most important problem areas of strategic planning in the firm, covering primarily the definition (identification) of the strategic business units, definition and selection of the target market, identification of the customers' needs, preferences and expectations, definition of the mission of individual businesses (strategic business units), definition of the functional strategies as well as the integration of the functional strategies with the overall (global) strategy of the firm.
- 3) Operational projects and programs, concerning the selection and application of the appropriate compositions of marketing tools (marketing-mix), including product, price, distribution and promotion.
- 4) Controlling methods and tools, allowing, among others, for a comprehensive assessment of the scope and degree of the plans implementation.

Such an understanding of the marketing concept is a basis for marketing processes and activities implementation in business management.

3. The most important firms' orientations towards the market

Contemporary marketing was not born only as a result of the development of various economic theories. It was also developed under the influence of changes taking place on the market as well as many trends, which marketing itself – as a concept of market-oriented business management – reflects to a large extent.

In the development of marketing several key stages can be identified. These stages are associated with successive, changing orientations, expressing the approach of the firm to the market. Among these orientations, the most frequently mentioned are (Przybyłowski, Hartley, Kerin, Rudelius, 1998; Czubała, Niestrój, Pabian, 2020):

- 1) Production orientation.
- 2) Product orientation.
- 3) Sales orientation, also referred to as promotion orientation or distribution orientation.
- 4) Marketing orientation, also referred to as customer orientation.

Production orientation, which is one of the oldest orientations expressing the firms' approach to the market, assumes that customers are inclined to choose products characterized by low price and wide availability. The most important activities of the firms focus primarily on achieving high production efficiency at the lowest total costs (Kotler, Keller, 2022).

In turn, within the product orientation it is assumed that customers choose products of the highest quality and innovation. For this reason, the main goal of the firms conducting this orientation is to strive for continuous development and improvement of their market offer.

The next orientation, i.e. sales orientation, is based on the assumption that customers will not purchase goods and services if producers do not conduct intensive promotional activities aimed at achieving a significant increase in sales (Kotler, Armstrong, Saunders, Wong, 2002). The basic tool used by the firms is the intensive, and often very aggressive promotion, supported by various solutions concerning channels, strategies and methods of distribution. For this reason, this orientation is also referred to as promotion orientation or distribution orientation.

Finally, marketing orientation focuses on the customers and their needs, preferences and expectations. Finding the ways to meet the requirements of the market and competition, allowing the firm to reach and sustain the competitive advantage, requires – above all – the continuous monitoring of the changing needs and expectations of customers. The basic condition for the accurate recognition and satisfaction of these needs is the implementation of marketing orientation, also referred to as customer orientation.

Ph. Kotler lists the following characteristics of the customer orientation (Kotler, Keller, 2022):

- 1) Definition and selection of the target market.
- 2) Identification of the ways and methods to recognize and satisfy customer needs.
- 3) Development of the integrated composition of marketing tools (marketing-mix).
- 4) Identification of the level of expected profitability of the markets served and products offered.

The basis for the implementation of marketing orientation (customer orientation) is the development of the so-called customer market. Marketing orientation indicates the need to adapt the entire activity of the firms to the needs of customers, while the customers themselves and their needs, preferences and expectations are perceived as the basis for the firm success as well as firm competitive advantage.

The above orientations do not present the evolution of marketing *sensu stricto*, but describe the general approach of the firms to the market and the processes occurring on the market and with the participation of the market. Firms, along with the changes occurring in their environment, make many changes in the scope of the degree of the market they serve, creating, forming and satisfying the needs, preferences and demands of customers, developing and enriching products, using methods, techniques and tools of marketing research, etc.

L. Garbarski, I. Rutkowski and W. Wrzosek also point that the significance of individual aspects of the broadly understood firm orientations is, among others, a derivative of the market structure, market capacity, market absorption, the degree of market atomization, etc., which – as a result – makes it difficult to unequivocally characterize the aforementioned orientations (Garbarski, Rutkowski, Wrzosek, 1998). Therefore, in the effective definition and application of the marketing concept, a very important role is assigned to marketing functions and tasks.

4. Market orientation as a basis for the marketing concept formation and development

As L. Garbarski, I. Rutkowski and W. Wrzosek write, marketing does not occur in all market conditions, but only when these conditions enable the development of market orientation within the firms activities. These authors emphasize that market orientation is the basis of marketing, as well as the complementary component of its characteristics. At the same time, L. Garbarski, I. Rutkowski and W. Wrzosek point that the basis of market orientation is a properly defined starting point of the actions taken (Garbarski, Rutkowski, Wrzosek, 1998). It can be perceived both in the subjective and objective approach.

In the subjective approach the starting point of the activities of a firm adopting the market orientation is identified with the customers, or more precisely with their broadly understood needs, preferences and expectations.

In turn, in the objective approach the starting point of the activities of a firm adopting the market orientation is associated with the market, or more precisely with one of its components which is demand.

The issue of market orientation appeared in scientific publications in the 1950s (Jaworski, Kohli, 1993). The results of many studies conducted over the last few decades have shown that market orientation has become one of the pillars of the marketing concept (Lafferty, Hult, 2001), also affecting other firm areas, including logistics, finance or operations (Matwiejczuk, 2013; Ashwin, Hirst, 2015). Marketing as a set of tools and activities significantly contributes to solving customer problems, also affecting the development of market orientation in business management.

In general, market orientation expresses the firms' approach to their conducting in the market. The identity and substantive capacity of market orientation consists of, among others, such research problems as: (1) the market and its mechanism, (2) the value for the customer and the determinants of its formation, as well as (3) the needs, preferences and expectations of the customers. The listed research problems constitute the "core" of the market orientation, the selected definitions of which are presented in table 1.

Table 1.*The definitions of the market orientation*

Author(s) (year)	Definition
B.P. Shapiro (1988)	A series of operational activities aimed at creating superior value for customers
A.K. Kohli, B.J. Jaworski (1990)	Activities involving understanding the market, in particular customer needs, transferring this knowledge within the organization as well as responding to customer needs
J.C. Narver, S.F. Slater (1990)	The business culture of an organization that builds the behaviors necessary to create value for the customer
R. Deshpande, J.U. Farley, F.E. Webster Jr. (1993)	A set of beliefs that puts the customer's interests above other needs, while taking into account the needs of other stakeholders, in order to achieve long-term profits
J.J. Lambin (2001)	A business philosophy that takes into account all market participants, occurring at every level within the organization

Source: Matwiejczuk, Jaworska, 2021, p. 17.

L. Garbarski, I. Rutkowski and W. Wrzosek “compare” market orientation with the two aforementioned firm orientations: (1) production orientation and (2) distribution orientation. According to these authors, firms adopting the market orientation as the basis of their operations should prioritize not only processes and activities related to recognizing and satisfying the customers' needs, expressed in customer suborientation (sometimes referred to as demand suborientation), but also processes and activities related to the monitoring of the competitors' behaviors and responding to their behaviors on the market, expressed in competition suborientation (Garbarski, Rutkowski, Wrzosek, 1998).

Firms implementing the market orientation, in addition to focusing on the needs, preferences and expectations of the customers, should also monitor the intentions and strategies of their competitors, as well as actively respond to their market behaviors. Therefore it can be said that market orientation is characterized by two basic dimensions:

- 1) Demand dimension, related to the customer (demand) orientation (suborientation).
- 2) Competitive dimension, related to the competition orientation (suborientation).

Customer (demand) orientation assumes that the activities taken by the firm are primarily aimed at demand creation and formation. Within the market orientation firms should primarily focus their processes and activities on the effective and efficient use of the marketing strategies and tools in various possible market situations.

Customer (demand) orientation is also of a key importance in the process of selecting and forming the firm market as well as the target market. Activities taken by the firms should contribute to achieving the customer satisfaction by presenting an offer of products and services (benefits) on the market which is consistent with the customers' needs and expectations. These activities are related to achieving the expected market outcomes by the firm, such as customer satisfaction, customer loyalty, or the firm market share.

In turn, competition orientation assumes that each firm conducts its market activities in a competitive environment, whose participants have an impact on the processes, activities and tasks carried out by the firm. The role of competition orientation in the formation of the ways of using marketing tools usually increases with the increase in competition in a given sector.

Competition orientation is of a key importance in assessing the scope and intensity of the competitive processes. It is related to achieving the expected economic outcomes by the firm, such as sales revenues, profit, profitability, etc., and consequently to achieving and sustaining the firm competitive advantage.

Among the most important dimensions of the market orientation of the firm J.C. Narver and S.F. Slater, apart from customer orientation and competition orientation, also indicate the so-called interfunctional coordination (Narver, Slater, 1990). Such a coordination plays a significant role in the integration of the processes and activities carried out within the various functional areas of the firm. These processes and activities concern both recognizing and satisfying the needs and expectations of the customers, as well as monitoring the competitors and responding to their market behaviors.

The formation, development and implementation of the market orientation is influenced (impacted) by a number of factors referred to as market orientation determinants. A.K. Kohli and B.J. Jaworski indicate the following as the most important determinants of market orientation (Kohli, Jaworski, 1990; Jaworski, Kohli, 1993):

- 1) Orientation of managers at the highest level of management in the firm towards the market as well as processes and tasks related to the firm activities conducted on the market.
- 2) Tendencies to accept risk by managers at the highest level of management in the firm.
- 3) Decentralization of decisions and actions (processes and activities) carried out by the firm.
- 4) Cooperation within the firm, as well as effective and efficient flow of information within the firm.
- 5) System of multidimensional benefits achieved by the firm, including in particular benefits achieved by firm employees, related to shaping customer satisfaction.

In turn, according to J.C. Narver and S.F. Slater, the most important determinants of market orientation include (Narver, Slater, 1990):

- 1) Implementation of customer orientation.
- 2) Implementation of competition orientation.
- 3) Effective coordination of resources, leading to the creation of the highest possible value both for the customer and for the firm.
- 4) Long-term perspective of the actions taken, related to the market behaviors of firms as well as the market and economic outcomes achieved by them.
- 5) Profit as a key outcome of the firm market activities and – at the same time – one of the most important economic outcomes achieved by the firm.

As A.K. Kohli and B.J. Jaworski point, market orientation comprises in particular the following components (processes and activities) undertaken and implemented by the firm (Kohli, Jaworski, 1990):

- 1) Gathering firm-wide market knowledge about current and future customers.
- 2) Sharing and disseminating this knowledge throughout the firm.
- 3) Responding to market signals by the firm.

Market-oriented firms, i.e. those of the firms which treat market orientation as the basis of their activities, focus primarily on the three levels: (1) the commitment to a set of processes, beliefs and values that permeate all aspects and activities, which are (2) driven (marked) by a deep and shared understanding of customers' needs and behaviors as well as competitors' capabilities and intentions, in order to (3) achieve superior results by satisfying customers better than competitors (Day, 1990; Hutt, Speh, 1997).

In addition to gathering knowledge about the market at the entire firm level as well as disseminating this knowledge within the firm, an important component of market orientation is the proper response of the firm to market signals. This is primarily related to the need to accurately identify processes and changes concerning the target market, product and production, distribution and promotion (Michna, Kmiecik, 2012). In a dynamic market environment and frequently changing customer loyalty, often inclined to change their purchasing decisions, it is very important for the firms to react quickly and effectively to variable market needs.

The marketing concept, apart from the systemic orientation to customer needs as well as effective and efficient satisfaction of these needs, should also take into account the integration of the individual marketing functions and tasks, methods and techniques of obtaining and using the appropriate marketing information, strategic orientation of the firm as well as firm operational effectiveness (Styś, 1998). Proper implementation of the marketing concept in the firm requires the "translation" of this concept into subsequent activities that make up the marketing management process.

5. Conclusion

As it was presented in this article, the role of marketing, and especially the marketing concept in business management is still growing. The marketing concept is not only a tool for building a firm success, but also for creating and strengthening the firm competitive advantage.

The growing significance of managerial and strategic aspects of the contemporary marketing is also associated with market orientation, which is the basis for implementing the marketing concept. A properly defined and applied market orientation, comprising customer orientation and competition orientation, allows for the use of a number of marketing potentials

related to the formation and development of the modern business models leading to the firm success as well as its competitive advantage.

Such business models may contribute not only to the creation of the aforementioned business competitive advantage, but also to building and strengthening the broadly understood firm competitiveness as well as to achieving the expected firm competitive position within the market.

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THE ROLE OF LEADERS IN ESTABLISHING AND MAINTAINING INTERORGANIZATIONAL RELATIONSHIPS

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Purpose: This paper aims to delineate the leader's role in both establishing and maintaining interorganizational relationships. It is leaders on whom the success of teams under their guidance hinges significantly, impacting the achievement of organizational goals, an entity's overall effectiveness, the efficiency of its operation, market positioning, and relationship-building with external entities.

Design/methodology/approach: As business and technological trends evolve, leaders need to demonstrate not only managerial skills but also interpersonal skills, empathy, and flexibility. The objectives were achieved through a pilot study using a PAPI, CAWI survey method with a self-constructed questionnaire. The target group was middle- and top-level managers, currently students of the Master of Business Administration. The study focuses on the dynamics of inter-organizational relationships, their form, motivation, and leadership roles.

Findings: The pilot study findings underscore the significance of a leader possessing both knowledge and appropriate character traits within an organization seeking inter-organizational collaboration. The leader's primary objective should be to inspire individuals to forge relationships, complemented by effective organizing or planning tailored to the sector's requirements.

Originality/value: The article introduces insights into the role of leadership in establishing and maintaining inter-organizational relationships, highlighting qualities such as respect, open communication, and teamwork. It provides a valuable basis for understanding leadership dynamics in the public and private sectors. To date, there has been no research in the literature on the location and dynamics of leadership in education. This pilot study is the first phase of a larger project and shows that the research direction is valid based on the analysis of the literature and the experiences of managers.

Keywords: leader, inter-organizational relations, private and public sector.

Category of the paper: Research paper.

1. Introduction

In a turbulent and competitive environment, companies continuously seek opportunities to improve their market position (Kozioł-Nadolna, 2020). Interorganizational relationships and ensuing interorganizational collaborations serve as avenues for organizations to enhance their competitive edge. Through collaboration among entities, organizations generate a synergy effect, bolstering access to cutting-edge and high-technology resources (Bańkowski, Rzepka, 2024).

In our increasingly complex global landscape, which sees organizations collaborating at various levels, the role of a leader in establishing and maintaining interorganizational relationships becomes paramount (Cortellazzo et al., 2019). As business and technological trends evolve, leaders must not only exhibit managerial skills but also demonstrate interpersonal abilities, empathy, and flexibility. It is leaders on whom the success of teams under their guidance hinges significantly, impacting the achievement of organizational goals, an entity's overall effectiveness, efficiency of its operation, its market positioning, and relationship-building with external entities. Consequently, it can be assumed that leaders wield substantial influence (Rzepka, 2023) over the quality of relationships—both internal and external.

To foster positive, enduring, and long-term relationships, leaders must consider several critical aspects, such as collaborating with various stakeholders (this applies to both internal and external stakeholders) that should be built on effective communication, conflict resolution and negotiation (in order to uphold harmony and cooperation among partners), as well as building trust at multiple levels—within the organization and beyond. Leaders must also show understanding of the needs and values of their business partners, and embrace an innovative approach to partnerships (which is manifested in openness to new ideas and strategies that might enhance the value of cooperation among all involved parties). Another important aspect involves continuous monitoring and improving interorganizational relations; leaders must therefore regularly assess the quality of relationships their organization have with other entities, respond to changing market conditions, and adapt their collaboration strategies on that basis.

This paper explores research entities from both the public and private sectors, each operating under distinct principles, goals, and strategies. Public enterprises receive subsidies from the state budget (Mitek, Micuła, 2012). Their primary advantage lies in their ability to focus on fulfilling their mission rather than solely pursuing financial gains. For public organizations, having a stable source of funding is crucial (Kozarzewski, Bałtowski, 2016). State subsidies enable them to pursue additional objectives, such as scientific research. On the other hand, private enterprises aim to generate income. By earning profits, they can fulfill tax obligations, compensate employees, and invest in further development.

2. Literature view

In light of the above, the main objective of this article is to define the role of leaders in establishing and maintaining relationships between organizations across various sectors (public and private) and their business partners. Additionally, three specific goals have been formulated: (1) to investigate leader traits that positively impact organizational management effectiveness and efficiency in both the public and private sectors; (2) to detail activities undertaken by leaders in organizations in public and private sectors in order to nurture relationships with business partners, and (3) to articulate the role of leaders in public and private sectors when it comes to establishing successful business relationships.

The structure of this paper has been intentionally designed to align with its goals. It comprises three distinct sections: the theory part (which delves into issues related to the role of a leader within modern organizations and explores its dynamics in the public and private sectors), the methodology part (which presents the research methodology employed in this article), and the empirical part (which analyzes and interprets the results of own research).

2.1. Leaders in contemporary organizations

A leader, as defined by Iwińska (2023) is an individual who exerts a positive influence on other employees without resorting to coercive tactics. Their attitude depends on a set of soft skills (e.g. communication, creativity, dynamism, adaptability) that directly shape their management style (Szczęsna, 2021) and how they are perceived by others. The primary objective of a leader is to optimize the potential and competencies of other employees (Kopertyńska, 2015).

Nowadays, when organizations largely operate based on the VUCA concept (volatility, uncertainty, complexity, and ambiguity), leaders must exhibit agility and flexibility and need specific competencies across various domains such as social competence (e.g. empathy), organizational acumen (e.g. organizing work), strategic thinking (e.g. planning), and technological literacy (e.g. analyzing data) (Grześ, 2022). A comprehensive overview of the desired competencies of a contemporary leader is presented in Table 1.

Table 1.

Leader competence overview

Type of competence	Characteristic
Interpersonal competencies	problem-solving ability, delegating authority, establishing relationships, demonstrating empathy and openness, influencing others
Specialized competencies	qualifications, knowledge, experience, management skills
Innovative competencies	creative thinking, aptitude for continuous learning, ability to absorb new solutions

Source: Own elaboration based on Kopacka (2015).

Today, leaders encounter many challenges (as outlined in Table 2), and their organizational roles are exceptionally intricate (Grześ, 2022). Both external and internal conditions can directly affect an organization's functioning. As a result, leaders must grapple with new challenges (Deloitte Insights, 2019):

- entry of new generations into the labor market,
- changing organizational environment,
- technology development,
- evolving customer expectations.

The role of a leader involves a series of activities aimed at addressing the challenges posed by the modern market (Mazur-Wierzbicka, 2020). Among these, interorganizational relationships play a crucial role as the determinants in facilitating effective responses to the above-mentioned challenges. In their relationships with employees, leaders should exhibit three key traits: affirmation, repetition, and charisma (Garita, Martinez, 2016). Furthermore, inclusiveness and flexibility allow leaders to understand employees and their needs (Travaglione et al., 2017). Inclusive leaders constantly seek input from their employees during decision-making processes (Cortellazzo et al., 2019). Therefore, it is important for the leader to effectively build and foster strong relationships with their business partners.

2.2. Public and private sectors

The public sector is a part of the economy that encompasses organizations that are under state and local government authority (Fryczyńska, Fierla, 2015). These institutions provide public services, spanning many aspects of the society such as education, transportation, or healthcare. Notably, public organizations rely on funding from public resources (Brol, 2021). In highly-developed economies, the public sector's influence continues to grow (Kóska-Wolny, 2023).

The private sector comprises enterprises operating in the market in pursuit of generating profits. These businesses, regardless of their legal form, include all entrepreneurs (Ostrowiecki, 2015), and are focused on high efficiency and competitiveness. They engage with the market-seeking customers, thus looking for ways to improve their economic operations. Due to its clear ownership structure, it is easy to distinguish this sector from the public one. It is regarded as "the most productive, innovative, and effective" (Olbińska, 2013) sphere of the economy.

Both public and private organizations grapple with the impact of environmental conditions (Kóska-Wolny, 2023). However, the private sector is particularly sensitive to crises that occur in the environment (Ostrowiecki, 2015). A critical element of organizational functioning of organizations across sectors is competitiveness, i.e. participation in market competition. For public organizations, competitiveness is the ability to achieve their intended goals in the market efficiently, effectively, profitably, and economically using selected tools. A public organization is considered competitive when at least two conditions are met: there exist at least

two entities with the same or similar goals, and these entities operate in the same competitive arena (Stankiewicz, 2005).

When considering the aforementioned definition, it is important to differentiate between the objectives of public and private organizations. Public entities focus their goals on implementing activities with a public and social orientation, whereas private sector organizations pursue commercial goals. Kędzierska (2005, p. 98) highlights that competitiveness in the private sector pertains to a business's capacity to thrive in a specific industry under free-market conditions. Enhanced competitiveness solidifies a company's position within the industry, reducing its susceptibility to external pressures and economic downturns. This has become particularly significant in open economies, which are more vulnerable to crises. There are several factors that influence the development of an enterprise's competitiveness, including the number, size, and diversity of enterprises, product assortment, the degree of market saturation, technological advancements, among others.

Understanding the disparities between sectors is important for tailoring management approaches within specific organizations. Three fundamental factors that directly influence management discrepancies in the public and private and public sectors include ownership, financing, and control. Public sector institutions are community-owned, financed through taxes, and subject to political oversight, whereas organizations in the private sector are owned by shareholders or owners of the company, financed by customers, and controlled by market forces (Boyne, 2002).

Boyne (2002) delineates four spheres where an institution's public or private sector status affects its management: organizational environment, goals, structures, and the values the leaders uphold. The most important distinction between activities of public and private institutions lies in their divergent objectives. While private sector organizations are profit-oriented, public entities are committed to providing public services (Brol, 2021). Financing mechanisms also differ significantly between public and private entities. Public organizations rely on public funds, whereas private counterparts draw from private sources. Moreover, operational modalities vary as private sector operations often push boundaries within legal frameworks, engaging in activities not explicitly prohibited by law, while public organizations must adhere to regulatory frameworks and guidelines (Rostkowski, 2012).

3. Research Methodology

The research results presented in this article stem from a segment of a broader research initiative conducted collaboratively by the Lublin University of Technology and the University of Warsaw. Titled "Interorganizational Relations in the Socio-Economic Economy", the project

spans from October 1, 2023, to September 30, 2024. The research aims to delve into various facets of interorganizational relations, including:

1. Definition and forms of interorganizational relationships.
2. Factors motivating and impeding interorganizational relationships.
3. Controlling mechanisms within interorganizational relationships.
4. The role of leaders in shaping interorganizational relationships.
5. Organizational structure and competencies.

The initial phase of the research project, Stage I, comprised a pilot study conducted from December 2023 to January 2024. The study aimed, among other things, to expand knowledge in the realm of interorganizational relationships, with particular focus on taking insights from leaders in the respective sectors into account. For this reason, the research sample was purposefully selected. The survey questionnaire was distributed to students enrolled in the Master of Business Administration postgraduate program at the Lublin University of Technology. The study was conducted on the assumption that these students wanted to develop their insights into organizational dynamics because of their managerial positions.

The research technique used for that purpose, PAPI (Paper and Pen Interview), allowed for a 100% response rate, yielding 47 completed questionnaires. In this paper, the authors discuss the responses from 46 participants. One respondent identified their organizational affiliation as belonging to the public-private sector, making it impossible to categorize the affiliation within the control variable, which delineates organizational sector as either private or public.

As part of the research process, a self-constructed survey questionnaire comprising 15 closed questions was utilized to collect data. The questionnaire included single-choice and multiple-choice questions, along with a five-point Likert scale, facilitating the measurement of respondents' views. Analysis of the responses indicated a predominance of male participants (60.9%) with managerial experience averaging 11-15 years (26.9%) in organizations that had been operating for a minimum of 11 years (84.8%). A comprehensive breakdown of data on the 46 respondents is provided in Table 3.

Table 2.

Breakdown of respondent characteristics – sex, position held, type, and duration of organization existence

Sex	
female	39.1% of respondents
male	60.9% of respondents
Managerial position held	
under 5 years	19.4% of respondents
6-10 years	15.1% of respondents
11-15 years old	26.7% of respondents
16 years or older	10.7% of respondents
Not applicable	28.1% of respondents
Type of organization	
private	52.2% of respondents
public	47.8% of respondents

Cont. table 2.

Duration of the company's existence	
0-1 year	0.0% of respondents
2-5 years	7.3% of respondents
6-10 years	7.3% of respondents
11 years or more	85.4% of respondents

Source: Own study based on research.

It is important to note certain limitations of the pilot studies discussed in this article. Notably, the research sample was confined to postgraduate students from a single university in Lublin (specifically, the Master of Business Administration program at the Lublin University of Technology). Consequently, the research lacks insights from leaders in other regions of Poland. Additionally, there's ambiguity regarding the positions held by respondents within their respective organizations, with over 28% of them not occupying managerial roles.

4. Findings

A contemporary leader, whether in the public or private sectors, must possess a variety of qualities that set them apart within both internal and external environments. These characteristics include but are not limited to, strong communication skills, the ability to inspire motivation, empathy, creativity, innovation, decisiveness, and effective time management. Chart 1 illustrates those leader traits that contribute positively to organizational management effectiveness.

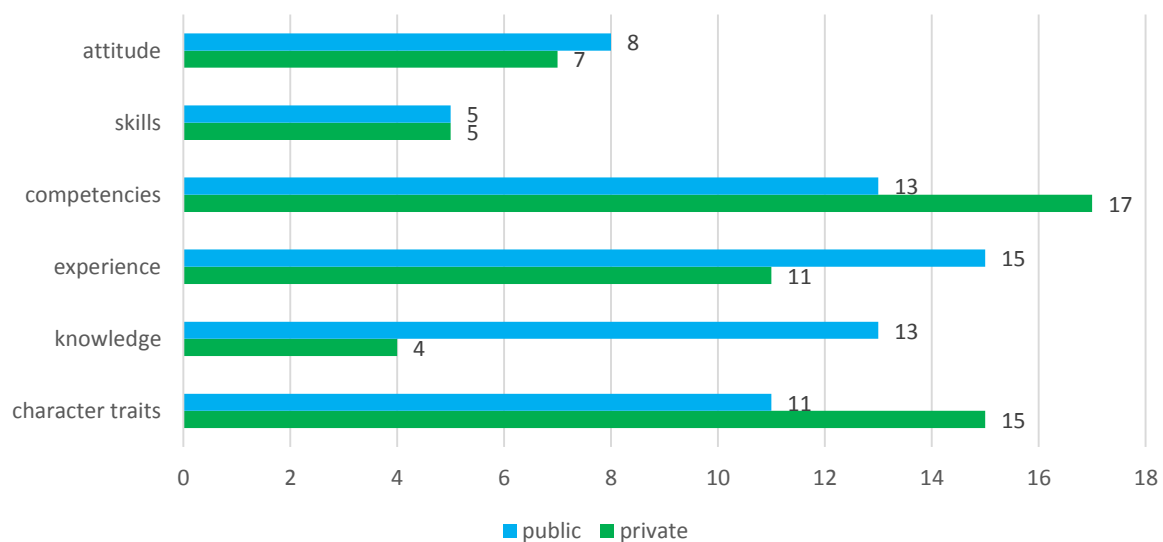


Figure 1. Leader traits contributing to effective enterprise management (n)¹.

Source: Own study based on research.

¹ The suggested question was a multiple-choice one (a maximum of 3 answers).

The data in figure 1 indicates that in public organizations, leaders who exert the greatest positive impact on management effectiveness are: competencies in the broadest sense of the word (17 responses) and character traits (15 responses). The key attributes of a public sector leader include experience (15 responses) and knowledge (13 responses). Conversely, the least emphasized traits are skills (5 responses in each sector), and in the public sector specifically, knowledge was perceived as less impactful for effective organization management. Among respondents from the private sector, knowledge garnered three times more responses (13 responses).

The data presented in figure 1 underscores the unanimous recognition among all respondents of the three most critical attributes of a leader in enterprise management: competencies (totaling 30 responses), alongside experience and character traits (each receiving 26 responses). These findings echo the predominant views of respondents from the private sector. Respondents from the public sector also emphasized the significance of a leader's knowledge (13 responses). Conversely, the importance attributed to skills received the lowest number of responses.

Leaders within organizations undertake a myriad of functions aimed at ensuring efficient business operations and nurturing relationships with business partners. These functions often entail a blend of tasks performed across various stages of cooperation or concurrently. Figure 2 provides insights into the functions performed by leaders in the process of establishing interorganizational relationships.

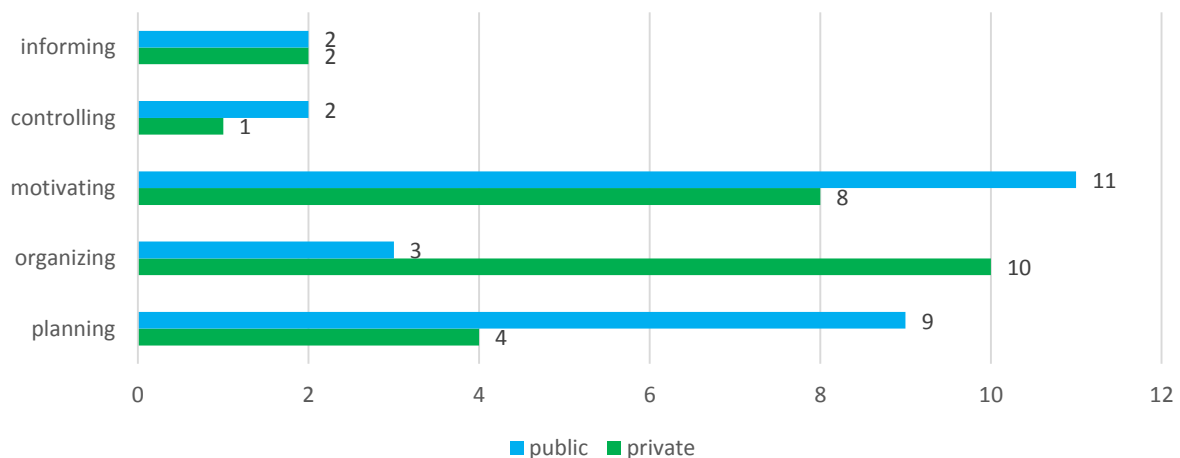


Figure 2. Leaders' tasks in establishing interorganizational relationships (n).

Source: Own study based on research.

The data presented in figure 2 indicates that, for public sector organizations, the primary function attributed to the leader in establishing interorganizational relationships is motivation (11 responses), followed closely by planning (9 responses). According to respondents, the functions of controlling and informing are deemed the least useful in establishing relationships with partners. Conversely, for private sector representatives, the most crucial

function of a leader in establishing interorganizational relationships is organizing (10 responses), followed by motivating (8 responses).

Maintaining relationships with business partners is paramount due to the continuous evolution of the market and ever-growing customer demands. Best practices in building and sustaining enduring business relationships encompass conducting open dialogue, fostering cooperation, providing understanding during challenging times, exhibiting flexibility in adapting to changing market conditions, demonstrating self-confidence and charisma, and emphasizing the partner's individualism, among others. Effective maintenance of organizations' relationships with partners hinges on the proactive role of the leader and the actions undertaken in this process (refer to figure 3).

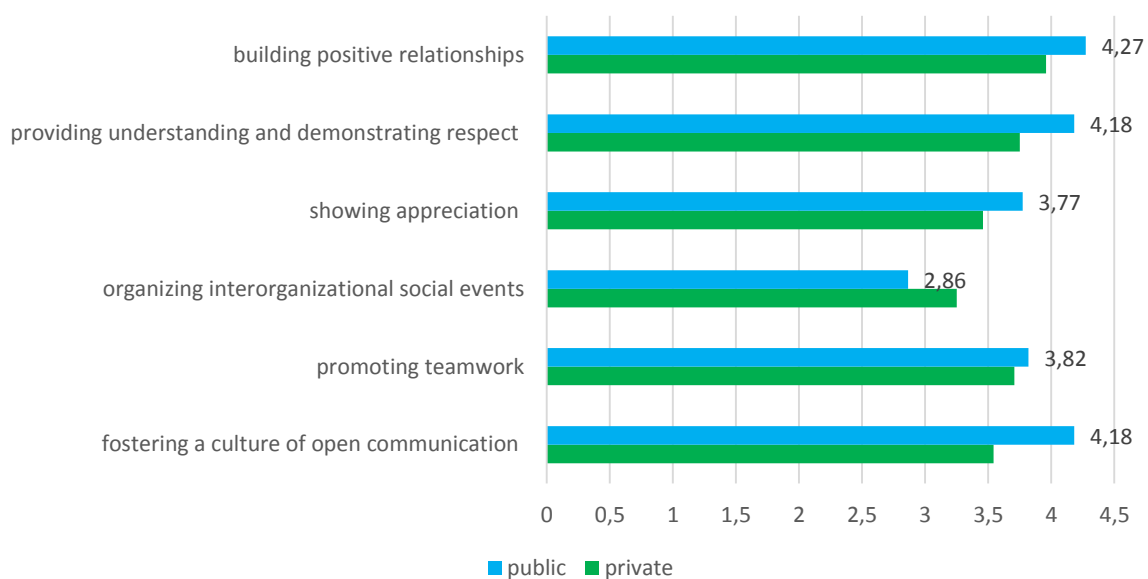


Figure 3. Respondents' activities for maintaining interorganizational relationships (average)².

Source: Own study based on research.

The data presented in Chart 3 highlights the primary activities conducted in public organizations to uphold relationships, emphasizing building positive relationships (average response rate of 4.27) and fostering a culture of open communication (4.18) as key endeavors in maintaining established partnerships. Similarly, in private enterprises, building positive relationships (4.27) and demonstrating understanding and respect are also predominant (average response rate of 3.75). Conversely, organizing interorganizational social gatherings is deemed least important by respondents in both sectors, with response rates of 2.86 in the public sector and 3.25 in the private sector.

² The question used a Likert scale of 1 to 5.

5. Discussion

Establishing interorganizational relations hinges on leaders possessing specific attributes tailored to their respective economic sectors, facilitating the achievement of organizational goals. For leaders in the public sector, essential traits include the ability to build cooperative networks, embracing change and being able to adapt to it, adherence to ethical values, and contextual intelligence, among other things. In the private sector, today's business demands individuals who are alert, agile, creative, and committed to continuous learning. A leader in this context requires analytical skills and a proactive approach to motivate and stimulate their team. In the post-Covid era, leaders characterized by lack of authenticity, agility, and teamwork are dispensable (ICAN Management Review, 2022).

The study findings reveal both similarities and notable differences in the leader's role in fostering and sustaining interorganizational relationships across the public and private sectors. In the private sector, respondents attributed the greatest importance to competences and character traits in positively influencing organizational management. Conversely, in the public sector, respondents emphasized the significance of experience and knowledge. However, when assessing the role of leaders in establishing relationships, the majority of respondents from both sectors identified motivating as one of the key leadership functions, and informing and controlling were considered secondary.

It is noteworthy that creating a culture of open communication as an action undertaken in organizations to sustain relationships with business partners, received a much higher average rating in the public sector compared to the private sector. This observation confirms the assumptions of the New Public Management doctrine, this doctrine advocates for a departure from the role of unilateral authority in determining the shape of the public sector, in favor of establishing a multi-entity system of dialogue and collaboration. In such a system, public authority structures engage with other entities in order to develop optimal solutions (Denhardt, Denhardt, 2000).

In today's era of heightened competitiveness, particularly within the private sector, it becomes imperative to adopt a unified economic and social mission. Engaging in competition for supremacy or striving for dominance often results in merely gaining a superficial advantage. The challenge for 21st-century manager-leaders lies in exercising wise, discerning, and primarily participative leadership, grounded in extensive internal and external collaboration. This participatory approach entails a balanced and somewhat controlled involvement of the organization's employees and partners in the decision-making process. Interorganizational collaboration should extend to collaboration with entities across various sectors of the economy, fostering mutual symbiosis (Mazurkiewicz, 2015).

The leader's role in establishing interorganizational relationships is important and complex (Hauke-Lopes, 2014). In the private sector, it is necessary for the leader to use various types of incentives to drive development (Ostrowiecki, 2015). According to our analysis, there are potential similarities across the sectors under examination for motivation. Respondents from both public and private organizations attributed significant importance on motivation as the most important role of leaders in building relationships.

In addition to motivating, respondents from the private sector emphasized the importance of organizing as the key activity in fostering collaboration, whereas those from the public sector highlighted planning. This divergence may stem from the distinct operational framework of both sectors. Public organizations are obliged to operate in accordance with applicable law (Rostkowski, 2012), necessitating careful planning in the relationship-establishing process.

Organizations in the private sector are often perceived as taking more actions to maintain relationships with their partners (Fryczyńska, Fierla, 2015). However, according to our research, respondents from the public sector rated activities related to maintaining relationships with partners more highly. Nevertheless, all respondents acknowledged similar types of activities. Maintaining interorganizational relationships may involve demonstrating respect, fostering positive bonds, as well as promoting teamwork and open communication.

This paper shows that the role of leaders within organizations is comprehensive and influenced by the specificity of the market in which they operate. This is evident in the varied responses in the study regarding the leader's role in establishing relationships across different sectors of the economy. The right combination of leader characteristics and actions is very important in establishing interorganizational collaborations effectively. The research findings highlight the different needs and requirements for leaders and their roles in the relationship-building process between the private and public sectors.

6. Conclusion

The aim of this paper is to delineate the leader's role in both establishing and maintaining interorganizational relationships. The pilot study findings underscore the significance of a leader possessing both knowledge and appropriate character traits within an organization seeking interorganizational collaboration. The leader's primary objective should be to inspire individuals to forge relationships, complemented by effective organizing or planning tailored to the sector's requirements.

Sustaining interorganizational relationships hinges on the leader's initiatives to cultivate positive relationships, demonstrate due respect, cultivate open communication, and encourage teamwork. Nonetheless, it is crucial to acknowledge that the study lacks representativeness,

thereby restricting the universal applicability of the findings. Nonetheless, the results serve as valuable groundwork for subsequent stages of research in this domain.

In today's context, it's paramount to embrace a shared economic and social mission, as competing for authority or seeking domination only yields superficial advantages - one may hold a title of director, but not necessarily embody leadership. The contemporary challenge for 21st-century manager-leaders is to navigate with wisdom, discretion, and above all, a participatory spirit grounded in extensive cooperation. This form of participation entails balanced and somewhat controlled involvement of the organization's employees and partners in the decision-making process. Interorganizational collaboration should span across diverse sectors of the economy, fostering mutual symbiosis.

It seems interesting to deepen the theory regarding the role of a leader by including the most important values and features of a leader in both studied sectors, especially in the opinion of young people. Research conducted by the World Economic Forum (World Economic Forum, 2022), which involved 31,000 people aged 18-35 from 186 countries, showed that the most valued leaders today are: honesty, loyalty, and modesty/humility. Respondents also noted that "according to young people, the public sector should be the leader in public services, including health care, education and security, and not the private sector".

We should consider deepening the theory surrounding the role of a leader, particularly by examining the most significant values and attributes of leaders in both the public and private sectors, particularly from the standpoint of younger generations. Research conducted by the World Economic Forum (World Economic Forum, 2022), involving 31,000 individuals aged 18-35 from 186 countries, revealed that honesty, loyalty, and modesty/humility are among the most prized qualities in leaders today. Furthermore, respondents emphasized that the younger generations believe that the public sector rather than the private sector should take the lead in providing essential public services such as healthcare, education, and security. This insight underscores shifting perceptions regarding the role of leaders in addressing societal needs.

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EMPOWERING MIGRANTS THROUGH CRAFT-BASED SKILLS: SOCIAL ECONOMY INITIATIVES FOR INTEGRATION AND INCLUSION

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Purpose: This paper explores how social economy projects can facilitate migrant inclusion through the cultivation of crafts-based skills, creating economic opportunities while fostering social cohesion. Crafts and traditional skills serve as powerful tools for empowerment, enabling migrants to gain employment, develop entrepreneurial initiatives, and participate actively in local communities. By examining successful case studies, engaging in traditional embroidery and handicraft cooperatives, this study highlights the role of social enterprises, cooperatives, and community-driven initiatives in supporting migrants through skills training, mentorship programs, and market access. Craft-based social economy initiatives provide economic opportunities while fostering cultural exchange and social cohesion. This study investigates how these initiatives empower migrants and contribute to their integration within local communities.

Design/methodology/approach: The paper employs a qualitative case study approach, examining three key projects—MADE51, Knit for Peace, Refugee Company, and INTERCRAFT—that utilize crafts-based skills to support migrant integration. These case studies are analyzed through the lens of social economy theory, focusing on their vocational training, entrepreneurship support, and community-building aspects. Data is gathered from project reports, interviews, and relevant literature to provide a comprehensive understanding of the impact of these initiatives.

Findings: The study demonstrates that crafts-based social economy projects significantly contribute to migrant integration by providing sustainable income opportunities, fostering cross-cultural connections, and enhancing social cohesion. The findings highlight the importance of vocational training, entrepreneurship, and intergenerational collaboration in these initiatives, showing how they empower migrants and offer a sense of purpose and inclusion.

Originality/value: This paper contributes to the understanding of the role of social economy projects in migrant integration, with a specific focus on crafts-based initiatives. It provides valuable insights for policymakers, practitioners, and social enterprises working with migrants, offering evidence of the positive impact of these initiatives on both economic and social inclusion. The article shows the importance of craftsmanship not only from the point of view of the products created and services offered, but also as a tool for integration and social inclusion.

Keywords: social economy, migrant inclusion, integration programs, cultural and ethnic diversity, craft, crafts-based skills, community engagement, cultural economy.

Category of the paper: Research paper.

1. Introduction

Migration has become an increasingly significant global phenomenon, with millions of people relocating due to economic, political, and environmental factors. Integrating migrants into host societies presents both challenges and opportunities, particularly in terms of employment, social inclusion, and cultural adaptation. Traditional economic models often fail to provide sufficient support, leaving many migrants in precarious employment or social isolation. In response, social economy projects—initiatives driven by social and environmental objectives rather than profit maximization—offer alternative pathways for migrant integration.

Migration, defined as the movement of people from one primary place of residence to another, can occur within a country (internal migration) or across international borders (international migration). It reshapes the lives of migrants and has profound effects on both the economies and societies of both origin and destination regions (De Haas, 2020). Migration is intrinsically linked to broader societal, technological, demographic, and environmental changes, including historical patterns of colonialism and their long-lasting impact on global mobility (Barnett, Adger, 2018). Contemporary migration trends are influenced by demographic transitions, particularly in regions with low fertility rates, where migration plays a pivotal role in reshaping population structures, including age distribution and dependency ratios (Coleman, 2006).

Migration can be temporary, such as seasonal or circular migration, or permanent. It may also involve involuntary, often short-term displacement due to unforeseen events like natural disasters or conflict. Migration is increasingly recognized as a key factor in shaping regional economies and social structures, often leading to the creation of new communities and altering social and economic dynamics in both origin and destination areas.

The integration of migrants into host societies presents both challenges and opportunities. Traditional economic models often struggle to adequately support migrants, leaving many in precarious social and employment situations. Social economy projects—initiatives that prioritize social, cultural, and environmental goals over profit-making—offer a promising approach to migrant inclusion, particularly those centered around crafts-based skills. These initiatives not only provide employment opportunities but also foster social cohesion by promoting cultural exchange between migrant and host communities.

While the issues of migration and the assimilation of migrants have been extensively studied within individual countries, considerably less attention has been given to the role of craft-related activities and programs in engaging migrants, refugees, and asylum seekers. Crafts-based initiatives within the social economy play a particularly valuable role in fostering inclusion. Handicrafts, textiles, ceramics, woodworking, and other artisanal skills provide economic opportunities while also serving as cultural bridges between migrant and host communities. These initiatives empower migrants by providing vocational training, facilitating entrepreneurship, and enabling access to fair-trade markets. At the same time, they help preserve traditional craftsmanship and promote cross-cultural exchange.

This paper examines the role of social economy projects that leverage crafts-based skills to integrate migrants, offering a more inclusive and sustainable pathway for their economic and social inclusion. This also constitutes the uniqueness of the presented content, which has so far been an unpopular topic of scientific research. The originality of this paper lies in its focus on the underexplored intersection between migration, social economy, and crafts-based initiatives. While the broader topics of migrant integration and social inclusion have been widely addressed, the specific role of artisanal skills—such as handicrafts, textiles, ceramics, and woodworking—in facilitating these processes has received limited scholarly attention. By highlighting how craft-related projects empower migrants economically and socially, preserve cultural heritage, and foster cross-cultural dialogue, this study offers a novel perspective on sustainable integration practices. The analysis of case studies further contributes original insights into how social economy models can serve as effective, culturally grounded tools for inclusion.

Through examining various case studies, the paper will assess how these initiatives contribute to migrant livelihoods, skills development, and community engagement, while emphasizing the importance of cross-cultural interaction and empowerment. These initiatives showcase the potential of crafts to enhance integration, foster resilience, and support both migrant communities and host societies.

2. Material and Methods

This study draws on two sources of material for content analysis: peer-reviewed scientific articles available online and websites of third sector projects. The selection of relevant literature was planned using the commercial scientific material databases Web of Sciences (WoS) and Scopus. It was planned to use three groups of keywords connected by AND/OR operators: I) *migrant/refugee/asylum seeker*, II) *assimilation program/integration program/inclusion program*, III) *craft skill/craft-based skill*. Both in the WoS and Scopus databases the search within All Fields/Abstract title, Abstract, and Keywords ended with zero results. The selection

was continued using Google Search Engine, by the snowball sampling method, initiated by reviewing entries listed and subsequently exploring their references. As the article progressed, supplementary sources were identified and integrated, enabling a detailed account of four programs targeting migrants, refugees, and asylum seekers, where inclusion was promoted through engagement in craft-based skill development. This, in combination with a literature review on craft skills and strategies for migrant inclusion, facilitated the identification of pathways through which the target groups can access income opportunities, intercultural support—both across national backgrounds and generations—and enhanced integration with the host society, contributing to greater social cohesion. The above is visually presented in Figure 1.

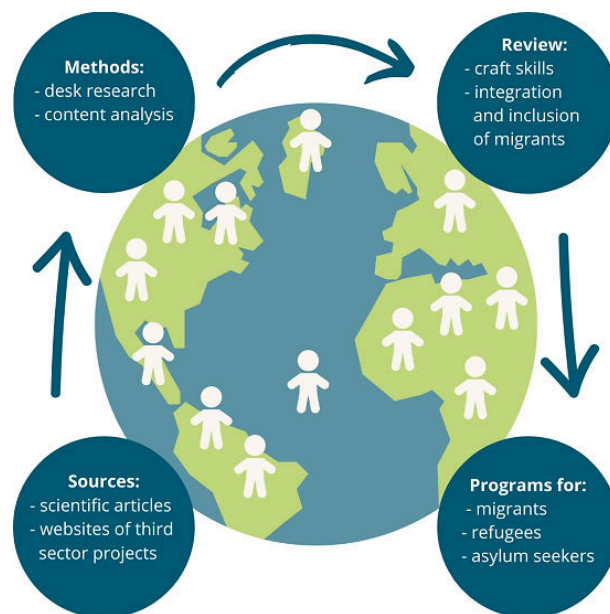


Figure 1. Highlights of the research process.

Source: Own elaboration.

This article, following the approach adopted in the report written by Fasani (2024), employs a broad definition of the term ‘migrant’, encompassing any individual who relocates to another country with the intention of residing there for a specified period of time, thereby excluding tourists and short-term business visitors. The scope encompasses individuals with diverse legal standings, including both permanent and temporary residents with valid permits, asylum applicants, recognized refugees, and those without legal documentation.

In the analysis, these four case studies were chosen due to their comprehensive representation of how craftsmanship can serve as an effective tool for migrant integration. The Table 1 provides an overview of the key criteria for selection, which demonstrates the varied and impactful roles these programs play in both migrant empowerment and community cohesion.

Table 1.*The key criteria of selection*

Criteria	Explanation
Diversity of approaches	The programs represent different models for integrating migrants through crafts—vocational training, entrepreneurship, and cultural exchange. This variety provides a comprehensive perspective on crafts-based integration strategies.
Geographic representation	The programs are based in different European countries, offering insights into how crafts can support migrant integration across diverse socio-political contexts.
Cultural heritage and social integration	These initiatives emphasize the preservation of cultural heritage through crafts while promoting social integration, allowing migrants to engage with and contribute to the host society.
Impact on community cohesion	The selected programs create opportunities for meaningful interaction and collaboration between migrants and host communities, fostering mutual understanding and reducing social tensions.
Proven success and recognition	Each program has demonstrated measurable success in integrating migrants economically and socially, making them exemplary models for scaling and adapting in other contexts.
Variety of craft disciplines	The programs encompass different crafts (embroidery, weaving, knitting, and woodworking), which are culturally significant and adaptable to modern markets, offering diverse pathways for migrant empowerment.

Source: Own elaboration.

3. Results – theoretical background

3.1. Craft skills

Craft is the art of producing objects using tools and manual labor, requiring a high level of skill. It involves the use of specialized techniques and carefully selected materials, and its essence is precision, and attention to detail (Zabulis et al., 2023). Craft involves the development and/or mastery of many skills. This includes both skills that can be described as complex or requiring a lot of time and effort, as well as simpler skills associated with lower qualifications. Maintaining, practicing and sharing craft skills also takes place in low-skilled jobs (Rostain, Clarke, 2025).

Materials devoted to craft skills can be divided into three groups showing: I) skills that influence the development of creative talents, II) skills necessary to perform craft work, and III) skills that are acquired through the practice of craft.

- I) The Crafts Council, in its Craft Skills Progression Framework, lists a group of skills related to early human development, allowing children to discover creative talents and become creators in the future. Skills focused on crafts include: creative idea communication – develop and share ideas; selection and use of materials and media; selection and use of tools and equipment, dexterity skills, risk taking, failure and resilience, using colour, texture and surface design and empathy (Crafts Council, n.d.). Critical thinking skills for analysis and conceptualization are also useful for crafts (Vermillion, Anderson, Rowe, 2014). As noted by M.-L. Rönkkö and J. Lepistö (2016), people with a developed ability for bisociative thinking, thanks to which they combine elements of different ideas and construct a completely new and original idea,

demonstrate a flexible way of thinking and can easily move from one step to another when making decisions during the craft process.

- II) According to V. Yliveronen and P. Seitamaa-Hakkarainen (2016), craft skills consist of motor, technical and cognitive skills (including perception and problem-solving). They are not a series of operations, but a combination of know-how, knowledge and thinking (Yliveronen, Seitamaa-Hakkarainen, 2016). In this article, the term craft-based skills refers to this group of skills. Table 2 presents a set of skills necessary within the creative industry. In the table below, it can be seen that researchers use different names to describe craft skills. Considering this group of skills, they can be divided into technical, entrepreneurial, and interpersonal craft skills. Thus, the group of technical skills includes planning skills, creating skills, and those resulting from the use of a given production method or the use of a given material, proportion, or movement. In the group of entrepreneurial skills, an important place is occupied by, among others, business communication skills, financial language skills, career self-management, financial management, marketing, negotiations, time management, and the ability to sell work. Some of them can also be classified as soft (interpersonal) skills, such as: communications, negotiations, presentations, and networking.

Table 2.

A set of skills necessary within the creative industry

Skills	Source
- Planning skills - Creating or making skills - The ability to make things by hand/manual skills (understood as the ability to use hands efficiently to perform a specific task or operation)	Müürsepp, Kikkull (2014)
- Interpersonal skills - Research skills - Business communication skills - Financial language skills - Flexibility - Career self-management - Financial management - Marketing - Negotiations - Presentations	Wilson, Stokes (2005)
- Technological skills	Bartosova (2011)
- Awareness of the appropriate legal framework	Haukka (2011)
- Small business skills - Developing professional networks	Bennett, Robertson (2015)
- Practical skills - Entrepreneurial skills - Personal skills (networking)	Luckman (2015), Luckman, Andrew (2020)
- Motivation - Interpersonal skills - Self-confidence - Communication and presentation - Time management - Resilience	England (2022)
- Ability to sell work	England (2022)

Source: Own elaboration based on England (2022); Müürsepp, Kikkull (2014).

III) As J. Vermillion, J. Anderson and D. Rowe (2014) note, the creator, beyond the artifact, develops a set of skills in the process of creation that are used in decision-making and the creation of other products. Crafting can also increase the creator's control over materials, construction and awareness of broader design issues such as the development process, production methods and environmental impact, as well as influence the consideration of alternative perspectives, managing complexity, visualizing ideas and early identification of potential problems (Pinski, Kane, Evans, 2018). Creating a new product, learning a new technique or creating variations of a design that require a complex learning process with experimentation and testing, also influences the development of physical and cognitive skills (Pollanen, 2015).

3.2. Factors related to the integration and inclusion of migrants

Migration is a challenge for both migrants and the host community. Concern about the limited resources of the host area causes obstacles related to the acceptance of new members of a community characterized by a different culture by the existing ones. Migrants also associate a change of place of life with a group of concerns related to functioning in a new environment, both for themselves and their closest relatives. These may concern residence rights, difficulties in finding a job, language barriers, culture shock, social isolation, unequal opportunities and possibilities for development, etc. Working out a solution that reduces or eliminates the concerns of both parties can promote the integration considered in four dimensions - structural, cultural, social and political. Structural integration is understood as the attainment of parity with the majority population in terms of economic resources and occupational status, primarily assessed through an individual's position in the labor market and household income levels. Cultural integration refers to the alignment of attitudes, values, and the adoption of a common language. Social integration denotes equal and reciprocal interaction between members of minority and majority groups. Political integration pertains to the extent of inclusion and participation in the public and civic life of the host society (Heath, Schneider, 2021).

Skills and qualifications of migrants are one of the indicators of their integration into the labor market. They enable migrants to find employment. According to data published in the report *Indicators of Immigrant Integration 2023* (OECD/European Commission, 2023), more than one third of immigrants in the EU are poorly educated, but the number of people with higher education is increasing within this group. Formal adult education plays a critical role in reducing educational disparities between immigrants and native-born populations in host countries. Participation in language courses is also positively associated with a higher likelihood of attaining advanced language proficiency, particularly among migrants who arrived with, at most, intermediate language skills (OECD/European Commission, 2023). Language proficiency in the host country is a key determinant of migrants' successful integration into the labor market, with strong associations observed between language skills, employment prospects, and income levels. Participation in language training not only enhances

employability and wage potential but also has a positive spillover effect on the educational performance of migrants' children. Educational credentials obtained within the host country are generally more effective in facilitating labor market entry and progression than those acquired abroad. This is primarily due to their alignment with local language and institutional standards, and the reduced friction in terms of recognition and employer acceptance. Supporting human capital development after migration—through formal education, training, and recognition of prior learning—can significantly improve the average educational attainment among migrants, thereby boosting both their labor market integration and long-term upward mobility. The recognition of foreign qualifications is particularly crucial, as it directly influences access to employment that matches migrants' skills and prevents the inefficient use of talent (Fasani, 2024). Within the European Union, migrants constitute approximately one-third of the workforce engaged in elementary occupations characterized by routine, low-skilled tasks and, frequently, physical labor. It is noteworthy that there is a gradual up skilling trend observable among migrant workers in these roles. However, many immigrants face systemic challenges in the recognition of their foreign qualifications and in securing employment that aligns with their skill levels. As a result, over qualification is prevalent, which not only diminishes the marginal returns to education but can also contribute to reduced motivation and job dissatisfaction among this group (OECD/European Commission, 2023).

L.A. Oucho and D.A. Williams (n.d.) include the following determinants that reduce negative perceptions of migrants and the challenges that accompany them: determination to maintain peace (manifested through various means of communication), mutual learning to understand cultural norms and values, and developing safe migration practices at the national, regional, and global levels. Zhang et al. (2023) emphasize that community participation is a way to promote the social integration of migrants. It helps migrants cope with, among others, inequalities and marginalization, acts as a mediator in solving community problems and easing tensions between migrants and residents in developed countries, and also helps to cope with intercultural/ethnic challenges. Several community-based activities have been identified as having a particularly positive impact on the integration process. Group meetings, for instance, facilitate the exchange of information, provide migrants with a platform for self-expression within an egalitarian setting, foster interpersonal connections, and offer emotional support—all of which contribute to a strengthened sense of belonging. Storytelling serves as another effective tool, enabling individuals to articulate personal experiences, process feelings of passivity or disempowerment, and contribute to the creation of shared memories, collective narratives, and community identity. Additionally, recreational activities—such as dance, sports, and travel—promote intercultural understanding and mutual appreciation. Researchers have further emphasized that the value of collective action within communities lies in its potential to transform initial social acquaintance into enduring partnerships rooted in mutual support (Zhang et al., 2023).

F. Fasani (2024) also notes that social partners and other private organizations play an important role in the assimilation process, enabling understanding of the complexity of migration and developing effective policies, as well as improving working rights and conditions, providing services, training and employment assistance. The researcher includes among the mentioned partners, trade unions and employers' organizations, institutions of the European Union and civil society organizations, including non-governmental organizations (Fasani, 2024).

Coley et al. (2019) identified three groups of determinants that affect migrant integration (Table 3). Among the actions that work well in integration, effective integration projects that are tailored to the needs of migrants and involve long-term investment are listed. According to the researchers, participation in integration projects has a positive impact on migrants' self-esteem. These programs are most effective when they are tailored to the target group, especially taking into account factors such as: the presence or absence of family networks or existing contacts, mental and physical health, the ability to speak a foreign language, previous qualifications and professional experience. Effective integration necessitates sustained, long-term investment. While certain elements can be addressed as immediate priorities, others inherently require a medium- to long-term perspective. Integration projects must be given adequate time to take root, foster trust, and build meaningful connections between migrants and local institutions. Additionally, migrants require sufficient time and support to develop English language proficiency, pursue education, and engage in training opportunities—crucial steps to prevent long-term social and economic marginalization. The category of projects also appears within the second group of determinants, encompassing projects that are adaptable, developed from best practice, co-designed, co-delivered and effectively evaluated. They should be, among others:

- adapted to the destinations of migrants (including rural areas and suburbs),
- engaging migrants in the implementation of the project,
- enabling access to online educational materials (also after the project is completed),
- enabling the possibility of measuring integration results (Coley et al., 2019).

Table 3.

Factors influencing integration of migrants

Factors that work	Factors that may work	Factors that don't work
<ul style="list-style-type: none"> - Cultural orientation. - Language skills. - High-quality social connections. - Partnerships between migrant community organizations and other institutions. - Effective integration projects 	<ul style="list-style-type: none"> - Recognizing the needs of different migrant groups. - Developing leaders in migrant communities. - Focusing on the community. - Strategies at the national and local level. - Projects that are adaptable, developed from best practice, co-designed, co-delivered and effectively evaluated. - The presence of family members. - Supporting migrants' physical and psychological health and minimising time spent in detention 	<ul style="list-style-type: none"> - A lack of support - Not recognizing integration as a holistic and long-term process

Source: Own elaboration based on: Coley et al. (2019).

4. Results – examples of social economy programs supporting migrants in Europe based on craft-based skills

Across Europe, various social economy projects have been developed to support the economic and social integration of migrants. These initiatives focus on vocational training, entrepreneurship, employment support, and cultural exchange, often using crafts and artisanal skills as a means of empowerment.

4.1. “Refugee Company” (Netherlands) – Entrepreneurship and Craftsmanship for Refugees

Refugee Company is a Dutch non-profit organization that supports the social and economic integration of refugees in the Netherlands. Recognized as a Public Benefit Organisation (ANBI) by the Dutch Tax Administration, it benefits from tax exemptions on donations and contributions, while also allowing donors to receive tax deductions under specific conditions.

The organization believes that employment is the key to successful integration, and it actively works to create work opportunities for refugees through its social enterprises and learn-work programs. By engaging in meaningful employment, refugees can build confidence, gain work experience, develop social connections, and achieve greater independence.

Refugee Company aims to contribute to an inclusive society by:

- Providing employment opportunities—both paid and voluntary—to help refugees take a step toward financial stability.
- Encouraging Dutch society to be more open and welcoming toward people with refugee backgrounds.
- Supporting personal development through language lessons, civic integration, and well-being programs.

The organization offers structured learn-work programs that last between six months and three years. These programs are operated through its social enterprises, such as:

- A Beautiful Mess – A creative space where refugees work in catering, fashion, and textile production.
- Mondmaskerfabriek– A face mask production facility providing employment to refugees during the COVID-19 pandemic.

Participants start their journey in "safe spaces", where they can gain work experience while also receiving language training, personal development coaching, and civic integration support. Refugee Company has already made a significant impact on refugee integration in the Netherlands, as reflected in its key achievements:

- 291 jobs created for refugees.
- 493 participants engaged in skill-building programs.
- A community of over 5000 people supporting refugee integration.
- 80,734 visitors engaging with the organization’s initiatives and projects.

By combining work, education, and community engagement, Refugee Company helps refugees become independent, active members of Dutch society while also fostering broader social acceptance and inclusion (Home - Refugee Company, n.d.).

4.2. MADE51: a global brand promoting artisan products made by refugees

MADE51 is an initiative launched by the UN Refugee Agency (UNHCR) to help forcibly displaced people re-establish their livelihoods by preserving their cultural heritage and integrating into both local and global economies. The program recognizes that while refugees may lose their jobs and homes upon fleeing their countries, they often bring with them valuable artisan skills and traditions that have been passed down through generations. These skills provide an opportunity for refugees to contribute to their host societies and rebuild their livelihoods through the creation and sale of handmade products.

MADE51 functions as a global brand of artisanal home décor and accessories crafted by refugees, with a focus on creating high-quality products while fostering social enterprises that support refugee artisans. The program identifies refugee artisans, helps them form strong artisan groups, and connects them to experienced local social enterprises. These enterprises collaborate with the refugee artisans to create unique product lines that are sold alongside the business's regular offerings. This connection between refugee artisans and local social enterprises facilitates the integration of these products into the global market, ensuring fair trade practices and the financial sustainability of both the artisans and the communities that host them.

MADE51 currently operates in 23 countries and collaborates with a network of 35 social enterprise partners, each of which undergoes a thorough assessment and onboarding process in collaboration with the World Fair Trade Organization. This collaboration ensures that social businesses adhere to fair trade practices, with regular monitoring to maintain the integrity of the program and ensure that refugees are supported in a safe and sustainable manner.

The initiative also provides business development assistance, artisan training, and product development to its partners. These efforts ensure that the artisans have the necessary tools to refine their craft, access markets, and build sustainable businesses. Furthermore, MADE51 markets the products of refugee artisans under its brand, helping to generate demand and connect the products to global retailers and consumers.

The impact of MADE51 is profound not only for the artisans but also for the communities they are a part of. For example, Sidi, a 55-year-old Tuareg blacksmith from Mali, produces various products such as tents, bags, and jewelry. Through MADE51, he learned to combine materials like leather, silver, and horn to create unique jewelry. This opportunity has allowed him to earn money, feed his children, pay for their education, and invest in raw materials to improve his craft. Sidi's story highlights the importance of collaboration and knowledge exchange, which motivates him to continue his work and build a future for his family.

Similarly, Ousseina, a Malian weaver, uses her skills passed down from her grandmother to weave intricate carpets. With the income from her craft, she is able to support her family, buying food, clothes, and even a goat. She values working with other women in the refugee community, exchanging techniques and sharing experiences, which gives her hope for a better future and a potential return to Mali.

With support from the European Union Emergency Trust Fund for Africa (EUTF), MADE51 has expanded its operations, strengthening its presence in Burkina Faso and launching in Niger. This expansion has allowed the program to reach more refugee artisans, offering them learning opportunities, technical support, and access to new markets. The initiative also introduced a new holiday collection in 2023, showcasing products from Afghan refugees in Pakistan and Malaysia, as well as Syrian refugees in Turkey, Armenia, and Lebanon.

MADE51 exemplifies how social enterprises and fair trade models can play a crucial role in refugee economic empowerment. By combining traditional artisan techniques with modern market access, the initiative helps refugees preserve their cultural heritage, regain their livelihoods, and contribute to their host communities. Through its global network, MADE51 not only provides financial support for refugees but also offers them a sense of purpose and dignity by allowing them to showcase their craftsmanship on the world stage (MADE51, n.d.).

4.3. Knit for Peace (UK): community knitting for those in need

Knit for Peace is a community-driven initiative based in the United Kingdom that seeks to provide warmth and support to vulnerable groups, including refugees, by engaging volunteers to knit essential items. The program's core aim is to create a sense of community and compassion while helping those in need. Through its collaborative efforts, Knit for Peace facilitates a range of activities that benefit both the recipients and the volunteers who participate (Table 4).

Table 4.
Key Features of Knit for Peace

Key feature	Description	Impact
Encouraging handmade contributions	Knit for Peace invites people of all ages and skill levels to contribute knitted items, such as blankets, hats, scarves, socks, and sweaters. Volunteers can knit at home or in organized groups.	Fosters a sense of connection with displaced individuals, offering a way for volunteers to help refugees.
Distribution to vulnerable communities	Once knitted items are collected, they are distributed to hospitals, refugee shelters, women's refuges, and other organizations. This supports those in need, especially refugees.	Provides warmth and comfort to vulnerable groups while symbolizing solidarity and support for people facing hardship.
Providing yarn and supplies to low-income individuals	Knit for Peace offers free yarn and supplies to low-income individuals, allowing them to contribute without the burden of purchasing materials.	Empowers low-income individuals, fosters inclusion, and helps participants improve their knitting skills.

Cont. table 4.

Fostering mental well-being and community engagement	Knitting has therapeutic benefits, helping to reduce stress and anxiety. It combats loneliness, especially among older individuals, through social knitting groups.	Promotes mental well-being and builds social connections, creating a positive environment for participants.
Promoting intergenerational connections	The initiative encourages participation across all age groups, where older participants mentor younger volunteers, and vice versa.	Bridges generational divides, promotes mutual understanding, and creates a balanced, harmonious community.

Source: Own study.

As illustrated in the Table 3, Knit for Peace integrates various approaches to support refugees and other vulnerable groups. The initiative not only provides physical support but also nurtures mental well-being, community engagement, and intergenerational connections. By encouraging participation from diverse backgrounds, Knit for Peace creates an inclusive, supportive environment where both volunteers and recipients benefit. This holistic approach plays a key role in fostering social cohesion and strengthening community bonds.

Knit for Peace is a powerful example of how community-driven initiatives can make a tangible impact on both vulnerable communities and the volunteers who support them. By engaging individuals in knitting for those in need, the program not only provides essential items to refugees and other displaced people but also promotes a sense of purpose, mental well-being, and social cohesion. The initiative's holistic approach—focusing on community engagement, intergenerational connections, and inclusion—demonstrates the profound impact that simple acts of kindness can have in improving lives and creating stronger, more connected communities (Knit for Peace, n.d.).

4.4. INTERCRAFT

INTERCRAFT is an initiative implemented under the Erasmus+ KA2 programme – Cooperation Partnerships, the main objective of which is to support the social integration of people with migration experience in the local communities where they currently live. The project promotes building intercultural and professional bridges through the active involvement of young migrants, social workers and local craftsmen. It implements activities that respond to the needs of migrants and third-country nationals who want to develop and use professional skills acquired in their countries of origin. The program was developed in response to three key areas of need identified by migrants, refugees, and asylum seekers, as well as the craft sector and social enterprises. It encompasses: I) fostering social inclusion within host communities, enhancing migrants' skill sets to increase their competitiveness, and facilitating their integration into the labor market; II) revitalizing the craft sector by promoting intergenerational knowledge transfer, supporting market sustainability, and introducing innovative approaches to skill transmission; III) equipping participants with interdisciplinary competencies, innovative methodologies, and tools to strengthen relationships between migrants and local communities in host regions.

The program categorizes its beneficiaries into three distinct groups: direct, indirect, and remote. Direct beneficiaries include young migrants, asylum seekers, and refugees, as well as local artisans in host communities, small and medium-sized craftsmanship enterprises (SMEs), social workers, and staff from social enterprises engaged in migration-related initiatives. Indirect beneficiaries comprise start-ups working with waste materials, youth civic associations promoting migrant social inclusion, professionals from the manufacturing sector clusters, start-ups specializing in ICT and Key Enabling Technologies (KETs), social enterprises focused on sustainability and the circular economy, young students from Design Higher Education Institutions (HEIs), and other social enterprises operating in the migration sector. Remote beneficiaries encompass policymakers from public administration institutions, decision-makers in social inclusion policies, youth associations that foster social integration through sports, and various third-sector organizations involved in social initiatives.

This structured approach ensures that the program's impact extends across multiple levels, fostering collaboration among key stakeholders in migration, sustainability, and social inclusion. The project aims to (Inter Craft, n.d).:

- Develop an innovative training methodology to enhance the creative potential of skills within the craft sector.
- Promote cross-cultural exchange and inclusion by integrating traditional craft knowledge with local professionals.
- Strengthen the competencies of social enterprise practitioners working at the local level in host countries.
- Create an intercultural craft atlas that maps diverse artisanal traditions.
- Analyze social enterprises that incorporate intercultural craft practices, emphasizing sustainable and circular economy principles.
- Implement an innovative joint curriculum that facilitates the development of soft, digital, and green skills.
- Establish a social platform serving as a digital hub for sharing educational resources, disseminating project outcomes, and fostering communication among participants.

Table 5 presents the activities carried out within the project.

Table 5.

Actions and effects planned in the Inter Craft project

Action /Effect	Specification
Field analysis in the partners countries: Italy, Greece, and Slovenia	Italy (Terra di Tutti): social enterprises all over Italy working in the fields of sustainable reuse, craftsmanship, immigration, solidarity economy, ethical fashion, social atelier, carpentry. Greece (Odyssea): social enterprises related to sustainable agriculture and transportation solutions, craftsmanship and handcrafted jewelry Slovenia (Terra Vera): social realities of the food sector, sustainable reuse and textile sector. European level (University of Florence).

Cont. table 5.

INTERCRAFT Syllabus	Essential training materials for implementing pilot actions aimed at testing the Joint Curriculum developed within the project. This document serves as a fundamental resource for educators and facilitators, providing comprehensive guidance on the required content, methodologies, and formats to ensure the effective delivery and assessment of the curriculum.
INTERCRAFT Pilot Action/s	It represents a critical phase in testing the previously designed Joint Curriculum by gathering both qualitative and quantitative data on the experiences of participating target groups, including migrants, asylum seekers, refugees, local artisans, and social workers. Its primary objective is to establish a blended learning environment where the envisioned innovative training methodology can be effectively tested. This initiative plays a key role in validating the Joint Curriculum through structured data collection, ensuring its relevance and adaptability. The overarching goal is to activate an integrated curriculum that facilitates the acquisition of soft, digital, and green skills among key target groups. Additionally, the Pilot Action aims to foster a collaborative learning environment that promotes intercultural dialogue, facilitating meaningful exchanges between individuals and skill sets. To ensure comprehensive monitoring, data will be systematically collected and documented through internal reports, ultimately contributing to the development of a structured training kit. The Pilot Actions encompass a diverse and interactive learning experience, bringing together migrants, social workers, designers, and artisans in a dynamic educational setting. Experts from various disciplines—including pottery, woodworking, textiles, and 3D printing—share their expertise to enhance collaboration and innovation. Beyond hands-on workshops, participants engage in cultural excursions, visiting museums, artisan studios, galleries, and heritage sites both within the region and beyond. Additionally, they explore local businesses, craft workshops, and reuse centers, enriching their understanding of sustainable and traditional practices.
INTERCRAFT Joint Curriculum	It facilitates the development of soft, digital, and green skills across three distinct target groups: young migrants, local artisans, and social workers. It is composed by 8 different module: 1. Crafting Connections for Inclusive Collaboration and Empathy, 2. Cultural Exchange and Intercultural Competence, 3. Interpersonal and Soft Skills, 4. Creativity and Design Thinking, 5. Craftsmanship and Traditional Knowledge, 6. Sustainable design and eco-social responsibility, 7. Digital Literacy, 8. Business and Entrepreneurship.
INTERCRAFT Atlas Map	Mapping of intercultural craft experiences.
INTERCRAFT Digital Tool	A project outcome designed as a digital social platform for sharing provided and generated materials, while also serving as a tool for disseminating information, communicating project activities, and showcasing achieved results.

Source: Own elaboration based on Newsletters nos. 1-13. (Inter Craft, n.d).

The Table 6 highlights how different social economy programs support refugees and migrants by leveraging their skills and providing economic opportunities. Refugee Company focuses on vocational training and entrepreneurship, helping refugees integrate into the Dutch labor market. MADE51, a global initiative by UNHCR, connects refugee artisans with international markets, ensuring fair trade and sustainable incomes. Knit for Peace, based in the UK, mobilizes volunteer knitters to create warm clothing for those in need while fostering social inclusion. Participation in the presented programmes can bring migrants a number of benefits, such as the development of competences, integration into the labour market, the opportunity to start a business, access to international markets, cultivating traditions, a stable source of income, material support for refugees, social integration and a positive therapeutic impact. Each initiative not only provides financial support but also promotes cultural preservation, skill development, and community engagement, helping displaced individuals regain independence and dignity.

Table 6.*Social economy programs and their benefits for migrants, refugees, and asylum seekers*

Program	Location	Main activities	Support areas	Benefits for migrants, refugees, and asylum seekers
Refugee Company (Netherlands)	Netherlands	Vocational training, apprenticeships, entrepreneurship support	Craftsmanship, gastronomy, fashion, graphic design	Skill development, job market integration, opportunity to start a business
MADE51 (UNHCR)	23 countries	Supporting artisans, international trade, collaboration with local enterprises	Handicrafts (jewelry, weaving, handmade décor)	Access to global markets, preservation of traditions, stable income
Knit for Peace (UK)	United Kingdom	Organizing volunteers to knit for those in need	Knitting, crocheting	Material support for refugees, social inclusion, therapeutic benefits for participants
INTERCRAFTS (transnational program)	3 countries + European level	Developing an innovative training methodology to enhance creativity in the craft sector while promoting cross-cultural exchange by integrating traditional artisanal knowledge with local professionals. Strengthening the competencies of social enterprise practitioners supporting migrants and maps diverse craft traditions through an intercultural craft atlas. Analyzing social enterprises that incorporate sustainable and intercultural practices, implements a joint curriculum emphasizing soft, digital, and green skills, and establishes a digital platform for resource sharing, networking, and project dissemination.	Supporting the social inclusion by fostering their integration into host communities. Providing interdisciplinary training and mentoring to enhance skills and improve employability in the labor market. Revitalizing the craft sector by promoting knowledge transfer and sustainability while encouraging eco-friendly and resource-efficient practices. Strengthening networks between migrants, local professionals, and policymakers further enhances community engagement and policy influence.	Enhancing skills by providing training in soft, digital, and green competencies, increasing employment opportunities through professional development. Supporting entrepreneurship by enabling migrants to apply and expand their artisanal skills in a sustainable business context. Fostering cultural exchange and inclusion, facilitates access to resources and networking via a digital platform, and promotes personal and professional growth by boosting confidence, adaptability, and social integration.

Source: Own study.

Each of these programs combines social action with economic support, helping refugees rebuild their lives and create new income opportunities. Furthermore, the Table 5 highlights the diverse strategies employed across various programs to integrate migrants into local communities through crafts-based social economy projects. These initiatives not only provide vocational training and employment opportunities but also foster social cohesion by encouraging cultural exchange and collaboration.

For instance, Refugee Company provides skill development programs in areas such as tailoring, woodworking, and graphic design while enhancing refugees' employability through business training and mentorship. MADE51 focuses on training refugee artisans in traditional crafts such as jewelry-making, weaving, and handcrafts, helping them market their products through social enterprise partnerships and global fair trade networks. Meanwhile, Knit for Peace engages volunteers and refugees in knitting and crocheting initiatives, fostering a sense of community and social integration through collective crafting.

Entrepreneurship is also a key focus in these programs. Refugee Company supports refugees in starting their own businesses or joining cooperatives, while MADE51 helps refugee artisans access global markets by collaborating with local social enterprises. Knit for Peace encourages both refugees and volunteers to contribute knitted goods to those in need, creating opportunities for economic participation through donations and sales.

Community engagement projects in Refugee Company, MADE51, and Knit for Peace provide spaces for cultural exchange, collaboration, and social cohesion. These initiatives bring refugees and local communities together through shared craft activities and intercultural workshops, promoting social integration.

Finally, policy measures and institutional support play a significant role in these initiatives. Refugee Company partners with local institutions to provide resources and guidance for refugees to integrate into the workforce. MADE51 works with governments and businesses to ensure refugees have access to fair trade markets and necessary funding. Knit for Peace supports refugee integration through policy advocacy, ensuring refugees receive the aid and opportunities they need.

By comparing these diverse approaches, the study underscores the effectiveness of crafts-based projects in facilitating migrant inclusion and highlights the importance of a multi-faceted approach that combines vocational training, entrepreneurship, community engagement, and institutional backing.

The Table 7 focuses on how Refugee Company, MADE51, Knit for Peace, and INTERCRAFT utilize different approaches to support migrants, refugees, and asylum seekers from training and skill-building to promoting social integration and securing institutional support. Four key areas of activity are being implemented as part of the initiatives: development of professional competences and potential of participants, support for entrepreneurship and professional activation, building social involvement and social integration, as well as support at the political and institutional level.

Table 7.*Social economy projects supporting migrant integration through crafts*

Method	Description	Example project & locations
Vocational training & skill development	Training programs in textiles, knitting, craftsmanship, and business development. Providing refugees with the skills to enhance their employability and create products for market.	Refugee Company – Vocational training in areas like tailoring, woodworking, and graphic design for refugees in the Netherlands. MADE51 – Artisanal skill development for refugees in areas like jewelry-making, weaving, and handcrafts. Knit for Peace – Volunteer knitting initiatives for refugees to improve skills in knitting and crochet. INTERCRAFT – Development of an innovative training methodology to enhance creative skills in the craft sector. Implementation of a joint curriculum focusing on soft, digital, and green skills. Equipping participants with interdisciplinary competencies, methodologies, and tools. Promoting intergenerational knowledge transfer within the craft sector.
Entrepreneurship & employment support	Supporting refugee entrepreneurs through cooperatives, microfinance, and market access. Helping refugees turn their crafts into income-generating businesses.	Refugee Company – Encouraging refugees to start their own businesses or join cooperatives, such as catering and fashion. MADE51 – Connecting refugee artisans with global markets through social enterprise partners, ensuring fair trade and sustainability. Knit for Peace – Creating opportunities for refugees to sell their knitted goods or donate to those in need, fostering community involvement. INTERCRAFT – Supporting market sustainability by revitalizing the craft sector. Enhancing migrants' skill sets to improve their competitiveness in the labor market. Facilitating the integration of migrants, refugees, and asylum seekers into employment opportunities. Analyzing social enterprises that integrate intercultural craft practices and sustainability principles.
Community engagement & social integration	Promoting social cohesion through collaborative work, shared experiences, and cultural exchange. Engaging local communities and refugees through shared craft projects.	Refugee Company – Providing a platform for refugee artisans to collaborate with local Dutch professionals and entrepreneurs. MADE51 – Encouraging collaboration among refugee artisans from different backgrounds, fostering a sense of community and intercultural exchange. Knit for Peace – Connecting volunteers with refugees to create garments for those in need, promoting social integration through knitting. INTERCRAFT – Promoting cross-cultural exchange and inclusion through collaboration between migrants, artisans, and social workers. Strengthening relationships between migrants and local communities in host regions. Establishing a digital social platform to foster networking, resource sharing, and knowledge exchange. Supporting youth civic associations and social enterprises working on migrant social inclusion.
Policy & institutional support	Advocacy for refugee rights, legal recognition, and support from governments and NGOs to promote refugee-led businesses and enterprises.	Refugee Company – Supporting refugee entrepreneurs with resources and guidance for integration into the local economy in the Netherlands. MADE51 – Collaborating with governments and local businesses to provide artisans with access to fair trade markets and funding. Knit for Peace – Supporting refugee integration through donations and policy advocacy to ensure that refugees receive aid and opportunity. INTERCRAFT – Engaging policymakers, public administration institutions, and decision-makers in social inclusion policies. Encouraging youth associations and third-sector organizations to foster social integration through sports and other initiatives. Structuring the program to influence migration, sustainability, and social inclusion policies at various levels.

Source: Own study.

5. Discussion

Although the topic of crafts supporting migrant integration is rarely discussed in scientific research, the literature suggests that practicing crafts can positively affect individual well-being. Factors such as materials, artifacts, a sense of achievement, opportunities for personal development, improvement of physical and cognitive skills, control over the body and emotions, as well as social and cultural aspects of crafts contribute to improving the quality of life. Crafts are seen as a recreational activity that enhances a sense of self-control and influences life satisfaction, even in situations where career prospects, life options or social networks are limited. Finely crafted crafts reflect the aesthetic intentions of the creator and the ability to evaluate and appreciate one's own achievements (Pollanen, 2015). The above may have a positive impact on the psycho-physical condition of migrants and thus also contribute to integration considered in all four dimensions - structural, cultural, social and political.

Crafts, like art, are also a dynamically developing sector of the economy, which creates numerous employment opportunities and thus facilitates the assimilation of migrants. Craftsmanship is currently undergoing a dynamic revival, increasingly recognized as an emerging industrial sector that offers significant benefits within educational, cultural, and economic policy frameworks (Jakob, Thomas, 2017). The process of revival of this field began in the second half of the 20th century, as a response to the growing popularity of industrial design and the mass production of consumer goods (Ebsco, 2022). Craft enterprises are mostly small and medium-sized enterprises (SMEs). The analysis of the EU Crafts and SMEs Barometer highlights the economic development of SMEs in all sectors and business categories (SMEunited, 2024), which can be an incentive for migrants to take up employment in professions based on crafts-skills and contribute to their structural integration. Craftsmanship is currently going beyond its traditional dimension, combining heritage with modernity and innovation. Thus, meeting the needs of modern consumers interested in authenticity, sustainability and personalized experiences in the luxury market (Fiftiers, n.d.). The increasing demand for craft products and services is described as the main driving force of the market. Its development is also supported by the emergence of digital marketing platforms and e-commerce, as well as the valuation of handicrafts as a carrier of tradition and cultural meaning that evokes emotional bonds (Blue Weave Consulting, 2024). The Business Research Company (2025) publishes the results of analyses emphasizing that in 2025 the arts and crafts market will record an 8.1% increase (from \$44.71 billion in 2024 to \$48.33 billion in 2025). On the other hand, forecasts indicate that in 2029 this market will reach an estimated size of \$65.18 billion (The Business Research Company, 2025).

The methods of integration and inclusion of migrants mentioned in sections 3.2 and 3.3 of this article are certainly not the only ones. Another possibility of supporting the community by using craft-based skills, that were not addressed in the research part, are organizations

established by representatives of the host community or migrants themselves and aimed at various groups in need of support – including people affected by natural disasters, women, representatives of national minorities, people from rural areas, people with disabilities and their relatives (Table 8). For example, in China, more than 1/10 of such enterprises are established by people of non-Chinese origin – broadly understood group of migrants. Engaging in socially necessary initiatives influences the positive perception of the host country by its population, builds bonds, promotes meetings and mutual acceptance.

Table 8.

Examples of craft-related organizations outside Europe within the social economy sector

Organization	Characteristic	Source
Tibetan-Qiang Embroidery Center	The center, founded in Chengdu, Sichuan Province, in the aftermath of the Great Wenchuan Earthquake, supports women from the Qiang ethnic minority by providing employment opportunities through training programs, workshops, and the production of items that incorporate traditional Qiang embroidery	Johnson, Shiling (2016)
Jian'ai Crafts Limited Liability Company	A social enterprise committed to supporting individuals with haemophilia, their families, and people with disabilities. Through the creation of paper carvings and sculptures, the design of knitting patterns, and the production of decorative items for celebrations and weddings, the enterprise offers meaningful employment opportunities while fostering self-confidence and empowerment.	Shanghai University of Finance & Economics Social Enterprise Research Center, Peking University Center for Civil Society Studies(2013)
Shanghai Social Innovation Park	A park offering professional training in fields such as graphic design, fine arts, and handicrafts, while also creating employment opportunities for individuals with disabilities.	Shanghai University of Finance & Economics Social Enterprise Research Center, Peking University Center for Civil Society Studies (2013)
Atlas design	A company that empowers women weavers from the Dong ethnic minority to share their traditional knowledge, unlock their economic potential, and highlight the cultural and economic value of women's craftsmanship	Sowley (2017)
Dancing Yak	This company delivers vocational training in sewing and manual production techniques, aiming to support and economically empower disadvantaged communities such as single mothers, persons with disabilities, and students.	Social Enterprise in Sichuan (2017)

Source: Own elaboration based on: Mazur-Włodarczyk (2021).

In addition to pursuing value creation and profit generation, these enterprises focus on skill development, promoting traditional crafts, and supporting individuals in disadvantaged life situations by offering employment opportunities and facilitating market access. Some of these businesses are founded by the craftsmen themselves (examples are shown in Table 9).

Table 9.*Examples of pro-social activities carried out within craft enterprises outside Europe*

Craftsman	Characteristic	Source
Li Dehua	This company provides employment to 130 people with disabilities, focusing on the traditional art of pyrography — the intricate decoration of wood, leather, and similar materials using a heated stylus to create burn patterns.	<i>Disabled craftsman helps locals live a better life with gourd pyrography</i> (n.d.)
Niu Chengguo	This cooperative brings together 300 members and provides employment to 200 people with disabilities, with the aim of improving their quality of life and preserving artisanal traditions.	<i>Beijing Gourd Artist Helps World Understand Beauty of China's Intangible Cultural Heritage</i> (2021)
Osung Dorje	A traditional bow maker who preserves cultural heritage by training and employing craftsmen with disabilities, while supporting individuals facing challenging life circumstances.	Zhang (2014)
Wang Jintang	A craftsman who inspired local communities to acquire artisanal skills and establish workshops focused on producing violins and other stringed instruments. This initiative has significantly boosted the income of more than a hundred families, generated employment opportunities, and offered training programs for people with disabilities.	Shan & Lu (2020)
Pan Xiaohong	A craft workshop specializing in car decorations inspired by traditional Uyghur embroidery, providing employment for 58 individuals, including 22 people with disabilities.	Zhao (2020)
Dawa Dakpa	A boiler maker managing a crafts business and offers training workshops for people with disabilities and unemployed individuals from the surrounding area.	Yao (2016)

Source: Own elaboration based on: Mazur-Włodarczyk (2021).

To effectively support crafts-based social economy projects for migrant integration, governments and institutions can implement several key actions. First, they can provide financial support in the form of grants, loans, or tax incentives for social enterprises employing migrants. Second, encouraging public-private partnerships can help scale these projects and maximize their impact. Integrating traditional crafts into vocational training programs could improve employment opportunities for migrants. Additionally, governments can fund cultural programs such as festivals, exhibitions, or craft fairs that promote cross-cultural dialogue and showcase migrant craftsmanship. It is also important to create legal policies supporting the growth of social enterprises that employ migrants, as well as provide social support programs, such as healthcare and housing, to enable migrants to fully participate in the labor market. Public awareness campaigns that highlight the contributions of migrants in craftsmanship can improve their social perception, and international collaboration can facilitate knowledge exchange and expand the reach of these initiatives. These actions could help integrate migrants, promote cultural heritage, and support economic growth through social crafts-based projects (OECD, 2023).

The Table 10 provides a comprehensive snapshot of key refugee integration programs across Europe, showcasing the wide variety of approaches and areas of focus that aim to support the social, economic, and cultural integration of refugees. These programs highlight the multifaceted nature of refugee inclusion efforts, which span from providing practical housing solutions to creating coordination hubs and establishing intercultural councils. Each of these

programs targets different aspects of the integration process, recognizing that successful inclusion is not a one-size-fits-all approach, but rather a combination of strategies that address the diverse needs of refugees (*Promoting Refugee Integration and Inclusion: Empowering Municipalities Across Europe Integration Policy Brief August 2024*, 2024).

One critical area of focus is the provision of housing, which remains a key challenge in many host countries. Programs aimed at improving access to secure, affordable housing play a crucial role in helping refugees settle into their new communities and begin rebuilding their lives. Municipalities and local governments often collaborate with international organizations like UNHCR and NGOs to provide housing solutions, whether through direct assistance or facilitating access to the housing market. By ensuring that refugees have access to stable accommodation, these programs contribute to a sense of security and belonging, which is essential for their overall well-being (*Promoting Refugee Integration and Inclusion: Empowering Municipalities Across Europe Integration Policy Brief August 2024*, 2024).

Coordination hubs, such as those seen in various European cities, are another essential element of successful integration programs. These hubs bring together multiple stakeholders, including municipal authorities, international organizations, civil society, and refugee communities, to ensure that services are delivered in a coordinated and comprehensive manner. By offering centralized locations where refugees can access information and services, such as legal assistance, healthcare, and education, these hubs reduce barriers to access and improve the efficiency of support systems. They also foster a more seamless integration experience by providing clear referral pathways and promoting cooperation across different sectors.

Intercultural councils are another important feature of refugee integration efforts, as they help facilitate dialogue between refugee and host communities. These councils provide a platform for both groups to share experiences, address challenges, and collaborate on building mutual understanding and respect. Through intercultural dialogue, these councils promote social cohesion, helping to break down cultural barriers and dispel misconceptions. By actively engaging with both refugees and local residents, these councils create an inclusive environment that fosters a sense of community and shared identity.

The success of these integration programs underscores the importance of multi-level governance, where municipalities, international organizations, and civil society work together to address the complex needs of refugees. Effective refugee inclusion requires not only the commitment of local governments but also the support and expertise of national and international actors. Collaboration between these stakeholders ensures that resources are used efficiently, and that integration efforts are sustainable and impactful. Moreover, the involvement of civil society organizations adds a layer of expertise and a community-based perspective, ensuring that programs are responsive to the actual needs of refugees.

Ultimately, the diverse approaches highlighted in the Table 10 demonstrate that refugee integration is a dynamic and ongoing process. By addressing various dimensions of integration—ranging from housing and legal support to cultural exchange and community

engagement—these programs contribute to the creation of inclusive societies where refugees can thrive. The continued success of these initiatives depends on the ongoing collaboration of all stakeholders involved, as well as the adaptability of these programs to respond to emerging challenges in the ever-evolving landscape of migration.

Table 10.

The refugee integration programs across Europe

Country	Municipalities	Area	Objective
Greece	Athens	Holistic integration support/ Enhancing municipal-level integration capacity/ Effective inclusion of refugees/ Effective multistakeholder coordination	The Athens Coordination Centre for Migrant & Refugee Issues program supports efficient collaboration between local authorities and various stakeholders to ensure the successful integration of refugees and migrants while fostering social cohesion. Founded in 2017, ACCMR became Greece's first municipal-led coordination hub, facilitating collaboration between the City of Athens, the central government, civil society, and international organizations. Together with the Migrants' Integration Centre, it forms the foundation of Athens' efforts to integrate migrants and refugees. By May 2024, ACCMR had brought together over 190 members on its digital platform, which maps more than 300 services and activities promoting inclusion throughout Athens. The center's four working committees hold monthly meetings focused on Education, Livelihoods, Gender, and Intercultural activities. ACCMR provides essential tools and resources to its staff, ensuring coordinated operations across the city with clear referral systems and effective multilevel cooperation to improve integration support. It has also played a crucial role in coordinating emergency responses, including during the COVID-19 pandemic and the influx of refugees from Ukraine
Poland	Multiple, in the Mazowieckie, Świętokrzyskie, Podkarpackie, Małopolskie, Silesia, Lubelskie voivodeships (provinces)	Affordable Housing Solutions	In collaboration with Habitat for Humanity, UNHCR assists national and local governments in enhancing their ability to provide secure, affordable, and dignified housing solutions for vulnerable groups in Poland. This partnership aims to enable Poland to tackle housing challenges effectively and support the integration of refugees through sustainable housing options.
Bulgaria	Nationwide	Housing	Aiming to improve housing availability, the national project maps municipal housing stock and works to enhance housing conditions for refugees through collaborations with local municipalities. By the end of 2022, the Shelter for Humanity Foundation/Habitat Bulgaria, in partnership with the Ministry of Regional Development and Public Works (MRDP), carried out a study on the management of municipal housing in Bulgaria. The research gathered data from all 265 municipalities across the country, including the district administrations of Sofia. The findings showed that nearly 40% of Bulgaria's housing stock remains vacant, with municipalities owning just 0.8% of the total housing units.

Cont. table 10.

Italy	Bari, Milan, Naples, Palermo, Rome, Turin, Bologna, Genoa, Ravenna	Holistic Integration Support	<p>The Integration Charter is an agreement signed by cities dedicated to the social, cultural, and economic integration of asylum seekers and refugees. Initially signed by six major Italian cities—Bari, Milan, Naples, Palermo, Rome, and Turin—it was later joined by the municipalities of Bologna, Genoa, and Ravenna. Spazio Comune or "integration hubs," were established with the purpose of uniting key local institutions and service providers to assist refugees in accessing information and services, supporting their integration into Italian society.</p> <p>Spazio Comune centers are managed by municipalities with support from UNHCR. Cities that have signed the Integration Charter (IC) have been encouraged to participate in the program, and centers are now operational in Bari, Naples, Rome, Turin, and Milan. These centers provide a range of services, including legal assistance, municipal registration, employment support, healthcare, and housing information. They also host UNHCR initiatives such as Community Matching, Partecipazione Azione, Welcome (<i>Welcome. Working for refugee integration</i> <i>The Global Compact on Refugees</i> UNHCR, n.d.), and Community Outreach Volunteers, and help connect individuals to additional services and projects. Under this model, municipalities establish a governance system to streamline intake processes, case management, and referrals, ensuring comprehensive support tailored to the needs of each individual or family.</p>
Cyprus	Limassol	Coordination, Access to funding, Developing holistic integration support	<p>Cyprus is creating intercultural councils, regional networks, and sustainable funding mechanisms to promote long-term refugee integration and social inclusion.</p> <p>The Developing Intercultural Integration Policies project aimed to create an inclusive society by actively involving local stakeholders. Notable successes included the establishment of intercultural councils and the introduction of initiatives such as language courses and vocational training for immigrants. The project benefited from the involvement of the Union of Cyprus Municipalities (UCM) and the Union of Cyprus Communities (UCC), whose expertise helped address operational and legal challenges. Additionally, Regional Intercultural Networks in each district mapped the civil society landscape and developed actionable two-year plans to improve community outreach. Although the project has concluded, a new initiative, the 2023 Enhancing Structures and Policies for Intercultural Integration in Cyprus (<i>Intercultural integration in Cyprus - Intercultural Cities Programme</i>, n.d.), is currently in progress. This initiative builds on previous efforts, continuing with strategies such as regular reviews, sustainable funding mechanisms, and ongoing evaluation to ensure the long-term effectiveness of intercultural integration efforts.</p>

Cont. table 10.

Moldova	Multiple municipalities	Holistic integration support/ Enhancing municipal-level integration capacity/ Effective inclusion of refugees/host communities in planning and service delivery	The Cities of Solidarity initiative aims to foster refugee integration in Moldova by supporting local municipalities in creating integration action plans and setting up community service centers.
Lithuania	Akmene	Holistic integration support, Effective monitoring of integration outcomes.	Akmene District is focused on community outreach, refugee integration support, and monitoring, involving local authorities and Nordic-Baltic integration actors to improve refugee outcomes. Beginning with ad hoc activities in 2014 to support Ukrainians arriving from Crimea, the municipality has established a more structured approach by appointing a dedicated team and an integration coordinator. This effort was further strengthened through the leadership of mayors and vice-mayors involved in Nordic-Baltic cooperation, who took study trips to Finland and Sweden to enhance their skills and gain insights into the integration tools and methods used in the Nordic countries. The dedicated team spans various sectors, including social services, healthcare, education, welfare, IT, communication, employment agencies, business associations, and local NGOs. Additionally, a targeted outreach strategy was developed, involving six community leaders (<i>seniūnijos</i>) throughout the municipality. This initiative has been instrumental in engaging Ukrainian families and setting up individual monitoring to track integration progress and tailor responses. The success of these efforts has been highlighted in local media, showcasing Ukrainians making Akmene their home. (<i>Akmene</i> , n.d.)
Finland	Jakobstad, Larsmo, Kronoby, Nykarleby, Pedersöre	Long-term intermunicipal collaboration on integration	In the Jakobstad region, the goal is to enhance regional cooperation among five municipalities to provide a comprehensive and integrated approach to refugee reception and long-term integration. The collaboration among the five municipalities started in 2010, aiming to create a more integrated and holistic approach to refugee reception and integration through a regional perspective. The refugee reception and integration services are guided by (i) a shared cooperation agreement that outlines the regional framework for integration efforts, and (ii) the Integration program for 2022-2025, which has been endorsed by each municipal council. These integration efforts are further supported by projects addressing various issues, including the inclusion of refugees in the labor market (<i>Integration Works - Jakobstad</i> , n.d.)

Cont. table 10.

Slovakia	Bratislava, Zilina	Holistic Integration Support	<p>Slovakia is working to establish integration service hubs in cities like Bratislava and Zilina to provide refugee services and ensure coordinated local responses.</p> <p>In Slovakia, municipalities have played a crucial role in responding to refugees arriving from Ukraine, as well as those in mixed or onward movements. Bratislava, in particular, has taken a proactive approach by coordinating the Assistance Centre Bottova - Blue Dot Hub - (<i>Blue Dots - UNHCR Slovakia</i>, n.d.), which brings together various stakeholders, including government authorities such as the Border and Alien Police (responsible for issuing TP documentation) and the Migration Office (Ministry of Interior), as well as international organizations like UNHCR offering registration and protection counseling. National NGOs also contribute by providing essential support in areas like accommodation, healthcare, child care, psychosocial assistance, legal counseling, community activities, and educational services. To address the growing need for coordination and support, Bratislava established a new integration department within its municipal government. Other municipalities in Slovakia have also appointed dedicated staff, including Ukrainians, to manage refugee response at the local level. UNHCR's involvement with Slovak municipalities has been vital in ensuring refugees' access to social services and other support. Additionally, the city of Zilina in northern Slovakia operates an integration and community center ("Lighthouse") that serves as a hub for community-based protection and inclusion activities.</p>
Romania	Brasov	Holistic Integration Support	<p>The goal is to support the economic inclusion, community engagement, and social cohesion of refugees through a community-led center in Brasov, offering services like counseling and educational activities.</p> <p>AMDDDB CATTIA/KATYA (Metropolitan Agency for Durable Development Brasov) is a non-governmental organization set up as an intercommunity development agency, established by cities, towns, and villages within the Brasov metropolitan area. During the emergency response phase (April 2022 - August 2023), it operated as a Blue Dot, providing a wide range of services, including basic needs support, information, counseling (such as assistance with obtaining temporary permits and accessing healthcare), and child-friendly spaces. Currently, it functions as a community center focused on offering counseling, livelihood and economic inclusion services, educational and child protection activities, as well as promoting social cohesion.</p>

Cont. table 10.

Baltic and Nordic Countries	Multiple municipalities	Multilevel coordination to enhance the integration potential of municipalities	<p>The For-In project is based on extensive regional and national partnerships, designed to leverage existing initiatives in the Baltic countries and the vast experience of the Nordic countries. Its goal is to enhance the capacity of local authorities, civil society, refugee and immigrant communities, and other stakeholders involved in integration efforts.</p> <p>Over the past decade, the Baltic States have consistently refined their integration policies by creating targeted national programs, action plans, and strengthening the capacities of local authorities. Alongside the For-In project, a Pan-Baltic initiative for integration stakeholders has supported collaboration between local practitioners and national integration actors across the Baltic countries.</p> <p>Further information:</p> <ul style="list-style-type: none"> - Two-year integration project kicks off across the Nordic and Baltic region – UNHCR Northern Europe, - Nordic-Baltic project 2021-2023 FOR-IN, - Pan-Baltic Experience Exchange Seminar in Vilnius, - Best practices in hosting Ukrainian refugees in the Baltic States.
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Source: Own elaboration based on: *Promoting Refugee Integration and Inclusion: Empowering Municipalities Across Europe Integration Policy Brief August 2024* (2024).

Overall, this paper brings a novel contribution to the academic discussion by emphasizing the multifaceted role of crafts in migrant integration—beyond individual well-being and economic self-sufficiency—to include cultural preservation, community building, and structural participation. It fills a gap in the existing literature by framing crafts-based initiatives within the broader context of the social economy and demonstrating their impact through both theoretical analysis and practical case studies.

While the study provides valuable insights into crafts-based social economy projects for migrant integration, the limitations related to sampling bias, geographic scope, and lack of long-term data suggest the need for further research to strengthen the generalizability and depth of the findings. Another limitation of the study is its focus on successes, without addressing potential obstacles such as funding instability, scalability issues, or cultural resistance. This is a topic that could be the basis for the next stage of research.

The use of snowball sampling, while useful for identifying relevant case studies, may introduce bias as it relies on recommendations from a small group of initial participants. This could lead to an overrepresentation of specific types of programs, potentially overlooking others that may also be effective in migrant integration. Although the study examines case studies from four programs, this geographic limitation may not fully capture the diverse ways in which crafts-based social economy projects can address migrant integration in other regions. The challenges and successes identified may not be universally applicable. The study primarily focuses on qualitative analysis, which is invaluable for understanding the dynamics and impacts of these programs. However, without long-term quantitative data, it is difficult to assess the sustained impact of these programs on both migrants and host communities over time. Each program included in the study has unique characteristics and implementation models.

While this diversity provides a broad view, it also means that comparisons across programs can be difficult, especially in terms of scalability and transferability to other contexts or regions.

Future research directions should include comparative studies across different cultural and regional contexts to better understand the universal and culturally specific aspects of crafts-based integration. Longitudinal studies could explore the long-term impact of involvement in such initiatives on the social mobility and identity formation of migrants. Finally, interdisciplinary studies combining migration studies, cultural policy, and social entrepreneurship would deepen the understanding of how crafts intersect with various dimensions of inclusion.

6. Conclusion

In conclusion, refugee integration programs across Europe are diverse and multifaceted, addressing a variety of needs ranging from housing and legal support to employment and community engagement. These initiatives aim to ensure that refugees are able to successfully integrate into their new communities, enhancing their social inclusion and well-being. Among these, crafts-based social economy projects, such as MADE51, Knit for Peace, The Refugee Company, and INTERCRAFT, have emerged as innovative and effective pathways for migrant integration. These initiatives provide economic empowerment, promote cultural exchange, and facilitate community-building, enabling migrants to contribute meaningfully to their host societies. MADE51 connects refugee artisans with global markets, providing both a platform for economic independence and a means to preserve cultural heritage. Knit for Peace encourages volunteers to knit handmade garments, fostering social inclusion and intergenerational connections while supporting displaced communities. The Refugee Company focuses on entrepreneurship and craftsmanship, offering refugees opportunities to build sustainable businesses and integrate into the local economy.

Together, these initiatives demonstrate the power of crafts to bridge the gap between migrant and host communities, creating inclusive environments where migrants can develop skills, gain employment, and form social connections. For these models to thrive, ongoing policy support, sufficient funding, and strong partnerships between governments, NGOs, and businesses are essential. With such support, crafts-based projects can continue to foster economic inclusion, intercultural dialogue, and sustainable integration for migrants.

While these crafts-based initiatives have shown considerable promise in facilitating migrant inclusion, there are several limitations to their impact. One major challenge is the scalability of such programs, as they are often dependent on local partnerships and resources, limiting their reach to broader migrant populations. Additionally, the reliance on volunteer participation in initiatives like Knit for Peace may limit the sustainability of these programs without consistent

funding and institutional support. Furthermore, while these projects contribute to economic self-sufficiency, they may not fully address other critical needs of migrants, such as legal aid, housing, or healthcare. Finally, the success of these programs can be influenced by political climates and the willingness of host countries to provide inclusive and supportive environments for migrant communities.

Future research could explore the long-term impact of crafts-based social economy projects on migrant integration, specifically examining how these initiatives affect migrants' social mobility and overall well-being. Studies could also investigate the scalability of these models across different geographic regions and migrant populations to identify the key factors that make them successful in various contexts. Furthermore, research could delve deeper into the intersection of policy support and the sustainability of these initiatives, analyzing the role of government, business, and civil society in sustaining these programs. Finally, comparative studies between crafts-based initiatives and other forms of social economy projects could provide valuable insights into the most effective approaches for integrating migrants into host societies. Another issue worth investigating is craft-based skills, their specificity, transferability across borders - to new places, adaptation of techniques to new materials, and how works created with their help connect different cultures.

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THE CAD TOOL IN MANAGING THE DESIGN PROCESS OF MACHINERY AND EQUIPMENT AS A ROAD TO INDUSTRY 4.0

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Purpose: The work aims to emphasize the importance of using the CAD tool in managing the design process of a selected mechanical device. The research includes comparing selected parameters from the use of innovative materials with traditional construction materials, such as steel, aluminium, or plastics.

Design/methodology/approach: As part of the research, a 3D model of the body of the selected device was designed and an analysis was carried out tightened by this element from commonly used materials and innovative construction material, which is carbon fibre. The use of the CAD tool allowed us to identify the benefits and restrictions resulting from the implementation of innovative material at the stage before production. In addition, the impact of carbon fibre structure on the distribution of stress and its strength properties in various operating conditions was analyzed.

Findings: The purpose of the work was to examine key parameters for the operation of the selected device without incurring real production costs. The obtained results gave a basis for analysis in the field of introducing and effective use of carbon fibre as a material used to build a given device.

Research limitations/implications: The main obstacle to the wider use of carbon fibre is its high price. This is related to both production costs and limited accessibility on the market. The price of carbon fibre elements significantly exceeds the cost of components, steel or aluminium. It has been shown how a tool such as CAD can lead to a reduction in production costs already at the design stage.

Practical implications: Research results are the first scientific approach indicating the possibility of using innovative materials in construction applications other than the automotive industry. By defining its efficiency and profitability. In addition, they confirm the need for further research on the processes of optimizing the cost of designing data of machinery and devices using a tool such as CAD in response to Industry 4.0 challenges.

Originality/value: The originality of the study lies in the innovative approach to the use of CAD software in managing the design process of individual parts of agricultural machines in order to reduce production costs.

Keywords: management of the design, analysis and research process, CAD tool, Industry 4.0.

Category of the paper: Scientific work.

1. Introduction

Promoting the idea of Industry 4.0 and the constant need to improve existing technological processes to increase the importance of management of the design process itself. One of the sectors of the economy that felt the effects of such changes is the garden equipment market. More and more often machines and devices are designed in such a way as to have their "digital twin" (Bołoz, 2020). For example, mushroom manufacturers implement ERP systems to improve the management of all company resources management, aimed at optimizing all processes of a given company. In particular, the accent is laid on the production module, implementing changes, they use min. The same components in several selected machines strive to minimize production costs.

In addition to organizational innovations, innovation in the material area is more and more often sought in this sector. One example is the use of carbon fibre. Considering that, as indicated by the observations of market reality, carbon fibre composites are widely used in industries such as motoring, aviation or sports industry, where the strength and reduction of mass are crucial (Kalinowski, 2024). However, despite its innovation, the potential of carbon fibre in the gardening industry remains relatively indefinite. At the same time, forgetting that the crucial for the management process of the cost aspect can be identified thanks to the use of tools such as CAD at the design stage.

The work aims to conduct simulation tests regarding the possibility of using carbon fibre as an innovative construction material in the construction of machinery and gardening equipment using the CAD tool already in the design process. The work focuses on showing the advantages of carbon fibre composite in the construction of gardening machines and analysis of the example of a specific element of the device (Bołoz, 2020). The use of this tool already at the design stage creates grounds for assessing its properties compared to traditional materials, taking into account the challenges related to the current management of the design process. The presented considerations are designed to answer the question of whether carbon fibre can be an attractive alternative to traditional materials and what benefits and limitations result from its use in gardening devices. The results presented in the work can contribute to a better understanding of the essence of the use of tools such as CAD in managing the design process of selected machines and devices.

2. Literature review

As indicated by the literature on the design process management should also take into account, apart from economic aspects, technological aspects, including material aspects.

Carbon composites, which are formed by sinking carbon fibres in a polymer warp, are a material with exceptional mechanical properties, which means that they have great potential, e.g. in the construction of modern mowers. They are characterized by very low mass and very high mechanical strength (Drobny, Hetmańczyk, 2012). Corrosion resistance is another advantage that makes carbon composites perfectly cope in difficult garden conditions, where devices are exposed to moisture, rain or chemicals. The density of the carbon composite is on average 1750 kg/m^3 , which makes it a material much lighter than steel ($7500\text{--}7900 \text{ kg/m}^3$) and aluminium (2700 kg/m^3) (Long et al., 2021). Young Module Carbon Fiber has a power of 253 GPa, while the composite reinforced with carbon fibre has 145 GPa, which gives it an advantage over traditional materials in the field of stiffness and resistance to deformation (Gębarowska, 2025). The carbon composite is on average six times more durable than steel, while at the same time reduces weight four times. The coefficient of thermal expansion of carbon composites is about 0.1-0.2, which means that they show minimal lateral deformation under load (Fejdyś, Łandwajt, 2010). In addition, carbon composites, although very resistant to stretching, are less resistant to point damage, such as impacts that may occur during intensive work in the garden (Kubiński, 2012). Despite these restrictions, in the opinion of the authors, carbon composites can be an interesting alternative to traditional materials such as steel or aluminium, especially in technologically advanced gardening devices for demanding users (Klas, 2024). Therefore, from the strict process approach, it seems an important issue to learn all the advantages and disadvantages of this material at the design stage by starting the final production.

In short, carbon fiber parts are among the most technologically advanced elements in the high-tech industry aligned with the idea of Industry 4.0. Their production requires precision, advanced materials and modern processes. The fourth industrial revolution, also known as Industry 4.0, is essentially a digital thread from start to finish, from idea to production. No company fully grasps what Industry 4.0 is and how it works, but it is certain that it consists of many interconnected elements. Only then will the concept of Industry 4.0 be effective and practical in the workplace, and CAD software is an important part of this process. CAD software has all the advantages to meet the growing demand for intelligent design and digital transformation and to help engineers in the next stages of digital technology development and implementation in practice of such advanced materials as carbon fibers.

3. Material and methods

3.1. Research Program

The research part analyzed the possibilities of making a mower body pushed from the carbon fibre composite. Traditional materials such as steel, aluminium and plastics were

compared, which can bring the benefits of carbon fibre. To assess the potential of this modern material in the construction of horticultural machinery, data was analyzed from entities dealing with the service of such devices, it was subjected to detailed analysis and the conclusions were formulated on the possibility of improving the structure by introducing carbon fibre composites.

The next stage of the research part was the use of the CAD Autodesk Inventor tool in the design process of the mower body model. The stress analysis module (MES - Finite Element) was used to examine the properties of materials currently used in the construction of gardening machinery and compare them with carbon fibre composite. The analysis allowed the assessment of the body's behaviour in the conditions of static forces, as well as dynamic, such as vibrations formed during engine operation. The obtained results allowed us to estimate the costs of producing elements from various materials and compare them for the profitability of implementation into serial production- without incurring unnecessary costs for creating pre-production models.

For the analysis, a part of the gardening machine was chosen, which is the mower body due to its key role in the functioning of gardening machines. The machine body is an element connecting all components of the device, which is why the selection of the right construction material in this case is crucial. The choice of this element for analysis was not accidental. Considering that one of the largest manufacturers of this category of machines is considering the use of 3D printed parts from carbon fiber to personalize its product in accordance with the idea of Industry 4.0.

3.2. Source data for the analysis of the research problem

From data from one of the Polish service companies specializing in the sale of garden parts and devices. It follows that one of the most common faults concerns the rupture of the mower housing (Fig. 1).



Figure 1. Damage to the mower body as a result of dynamic loads.

Source: own study.

According to data analysis, long-lasting vibrations, to which gardening devices are exposed, can cause local cracks, which over time transform into greater structural damage. The microcracks in the material tend to deepen, which ultimately leads to permanent damage.

One of the main causes of this phenomenon is insufficient fatigue strength of the material, which is particularly important for elements exposed to intensive dynamic loads.

3.3. Modeling and analysis of the MES element in Autodesk Inventor

The mower body itself was designed in Autodesk Inventor (Fig. 2) as a faithful mapping of the existing mower model. Before starting the design, a careful selection of the appropriate reference model was made, whose three-dimensional reproduction allows for precise analysis of the impact of the proper selection of material on the durability and strength of the structure. The purpose of this approach was to ensure reliable and real results during future strength simulations, which is crucial in the process of assessing the properties of materials and their applications in technical constructions without incurring unnecessary costs for creating pre-production models.

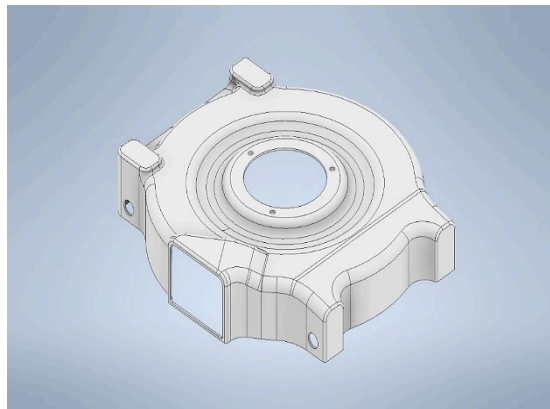


Figure 2. Model of a pushed mower body made in Autodesk Inventor - isometric view.

Source: own study.

The body of the body is based on a thorough reproduction of the geometry of the original structure, taking into account all the details, such as dimensions, shape, mounting holes and reinforcing ribs. It is important to emphasize that all analyses are performed in the design environment without incurring costs for field research on pre-production prototypes.

4. Results and discussion

4.1. Modeling and analysis of the MES element in Autodesk Inventor

The first step to creating a stress analysis for the pushed mower body structure is to determine the bonds. The designed body uses stationary bonds in places where the holes are found through which the wheel axles pass (Fig. 3). These bonds simulate stable body adhesion. In the analyzed model, the mower in the places of the holes is found for mounting wheels, which are still relative to the body.

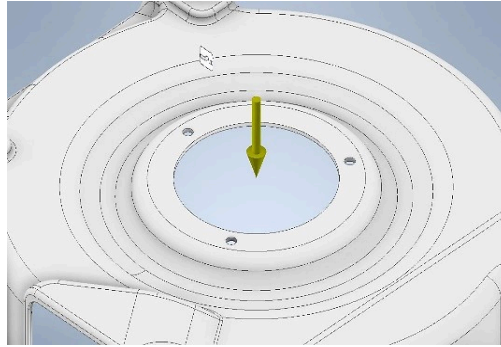


Figure 3. Model of a mower pushed with solid bonds.

Source: own study.

For comparison of building materials used for the construction of gardening machinery and equipment with a carbon composite, the stress analysis module available in the CAD tool in Autodesk Inventor was used.

It was assumed that the weight of the engine is 10 kg, which corresponds to 100 N (when accelerating the gravity acceleration value $g = 9.81 \text{ m/s}^2$). To take into account the dynamic loads resulting from engine vibrations during operation, a 1.5 dynamic factor was adopted for static analysis, which increases the value of the inclusion force to 150 N. Such a procedure simulates additional overloads that may occur in the actual operating conditions of the device. The value of 220 mm on the Y axis in the remote force editing window means that the point where the remote force works is moved by 220 mm along the Y axis relative to the reference point in the model. The value of the 1.5 factor was used to estimate the additional dynamic load. In real operating conditions, the engine generates vibrations that increase the temporary load of the structure. Because the Autodesk Inventor program only analyzes static loads, the addition of a coefficient allows you to simulate such overloads. Gear ratio 1.5 means that the value. The load has been increased by 50% about the static load, i.e. to the principles used in the strength of the structure. The project uses optimal mesh settings shown in Fig. 4.



Figure 4. View of the component mesh on the pushed mower model.

Source: own study.

The last step before joining the simulation was the choice of material for the analyzed model. As part of the research, a stress analysis of the designed pushed mower body was carried out, using four different materials: steel, aluminium, plastic (ABS) and carbon fibre composite.

Due to the nature of the design, focusing on the endurance analysis of the body, the mechanical and strength properties of the material are of key importance. Thermal properties were omitted as no impact on the simulation.

4.2. Assessment of simulation results

Von Mises's stress is a value that allows you to predict when the plastic material begins to deform permanently. The von Mises's stress value is calculated from the formula (Nikulin, 2016):

$$\sigma_{von\ Mises} = \sqrt{\frac{1}{2}[(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_1 - \sigma_3)^2]} \quad (1)$$

where: $\sigma_1, \sigma_2, \sigma_3$ – main stresses.

According to von Mises's theory, plastic material begins to deform permanently at a point where the reduced stress reaches the value of the material stress limit. Most often, the boundary of plasticity is taken as a stress limit. The essence of this phenomenon was presented (Fig. 5).

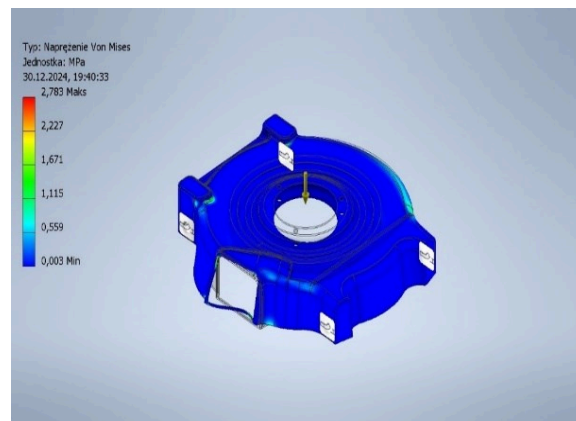


Figure 5. Distribution of von Mises stresses for a mower made of carbon fibre.

Source: own study.

According to the analysis von Mises's stress for all tested materials is in the range of 2.6-2.8 MPa. These values are much lower than the plasticity of each of the analyzed materials, which means that the mower body does not undergo permanent deformations under the pressure of the working engine, regardless of the material used. The similarity of the results is because von Mises's stress is largely dependent on the geometry of the structure. In this case, the mower body has been designed in such a way as to evenly distribute the loads and move them efficiently. Thanks to this, the stresses remain low for each of the materials, which confirms the properly selected structure. The lowest von Mises stress value (2.681 MPa) was achieved for ABS plastic. This material, despite the lowest elasticity module among the analyzed materials, is characterized by good tensile strength, which allows for effective load transfer static. At the same time, his ability to suppress vibrations can be beneficial in applications with vibrations, which in the case of a mower can have practical significance. The safety factor is a parameter determining the degree to which the permissible load or stress

of the material must be exceeded to damage. The safety factor determines the pattern (Pokojski, et.al., 2022):

$$\delta = \frac{R_m}{K_r} \quad (2)$$

where:

δ – safety factor,

R_m – tensile strength (maximum stress),

K_r – permissible stress.

The role of the security factor is to ensure the reliability and safety of the structure by taking into account potential and unforeseen situations, such as design errors and the heterogeneity of materials. Executive inaccuracies or changes in working conditions. The value of the safety factor equal to 1 determines the moment when the actual stress reaches the permissible limit of the material. For this reason, this factor should be greater than 1. In this case, the structure has a reserve of strength, which ensures that the material will not be damaged even in the case of unforeseen loads. Figure 6 shows the safety distribution of the carbon fibre mower body.

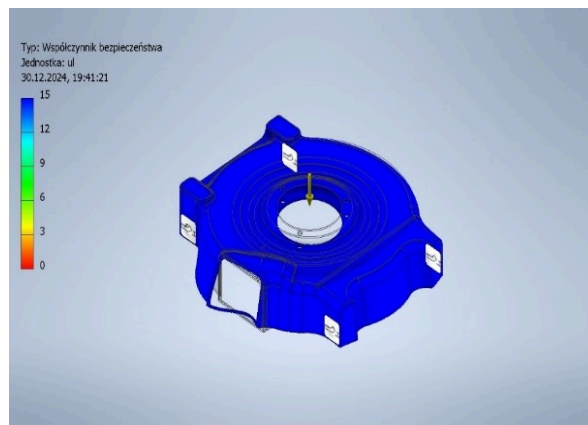


Figure 6. Distribution of the safety factor for the carbon fibre mower body.

Source: own study.

The value of the safety factor reaches the lowest value in the case of ABS plastic. The minimum value is 7.46. This means that in the most burdened design, the actual stress is only 1/7.46, i.e. about 13% of the maximum permissible material strength. The displacement of stress analysis describes the change in the location of each point of the object under the influence of loads. In the structure of the mower body, displacement is one of the key parameters that, visibly shows the differences between the analyzed materials.

The results of stress analysis indicate that the body made of steel, due to the high Young module, which is a measure of material stiffness, showed the least susceptibility to deformation caused by the pressure of the working engine. The displacement result equal to 0.008815 mm confirms the high stiffness of the material and its resistance to deformation under the influence of loads. In the case of aluminium, which has a smaller elastic module than steel, the displacement is 0.02656 mm, which is a result more than twice as high as in the case of

steel. Finally, the body made of aluminium provides sufficient stiffness and ensures a good weight ratio to stiffness. The body made of ABS plastic is moved much more than bodies made of other materials. It is 0.8026, i.e. a value almost a hundred times higher than the displacement of steel. This result clearly shows that this material is susceptible to deformation and despite its low mass and attractive price, it is not able to match the materials construction such as steel or aluminium. Carbon fibre is characterized by a high Young module with a very low mass. Its displacement calculated by stress analysis is 0.01326, which is a slightly higher result than in the case of steel, which in this comparison was the best. Compared to other materials, the carbon fibre composite used in the structure of the mower body showed a displacement about twice as small as in the case of aluminium and about 60 times smaller than the plastic body (Fig. 7).

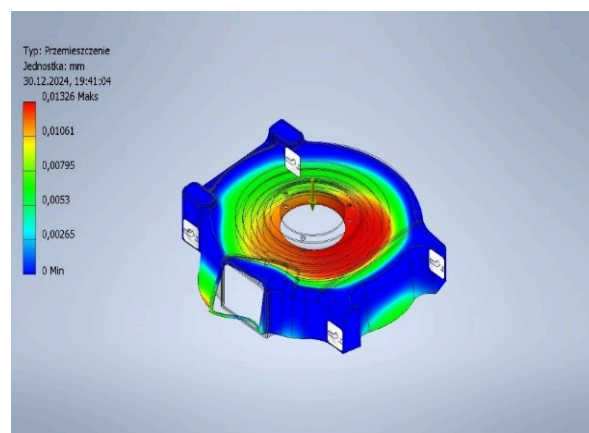


Figure 7. Distribution of displacement for a carbon mower.

Source: own study.

The high level of Young Module with the Carbon Fiber composite makes this material combine lightness with very good deformation resistance. This result confirms that carbon fibre is a great alternative to traditional materials. It is important to emphasize that all mentioned data was obtained at the design stage, which indicates a rational approach to the implementation of new material solutions.

5. Conclusion and discussion

In the modern competitive market, a strong need to implement the latest concepts and management methods is noticed. Innovations in the activities of enterprises should relate not only to the organization of production or management systems but also include ways of implementing individual modules, including the design module mode. In the era of the ongoing Industry 4.0 revolution, no one should have doubts that the culmination of the machine design process is visualization and optimization using specialized CAD software. As part of the last

stage, a 3D element of the element is prepared, which can be used to produce a given component or part. At this stage of summaries, it should be remembered that the implementation of the project itself, for example, is a key, but still preliminary stage of production. Based on tests, it is possible to modify the element and optimize its parameters before starting the production cycle. Importantly, without unnecessary costs related to the construction of many prototypes. Observations of market reality indicate that carbon fibre composites have great potential as a modern construction material in the production of gardening machines and equipment. The analyses presented show that carbon fibre is characterized by an excellent ratio of mass to stiffness. This is especially important for devices that require manual service because the smaller mass greatly facilitates their use. In addition, carbon fibre, unlike steel and aluminium, is a corrosion-resistant material. ABS material, although also resistant to corrosion and the lightest of the analyzed materials, however, shows much less stiffness. This property makes this material more susceptible to deformation and cracks, which limits its use in constructions requiring durability and stability.

It is important to emphasize that the main obstacle to the wider use of carbon fibre is still its high price. In particular, in the segment of gardening machines, where this parameter plays a key role, this can be a significant limitation. The presented research can be a response to this postulate. In practice, CAD data ensures higher product quality at lower development costs and increased efficiency, which enables faster production and time to market. By using CAD data, engineers will spend less time designing products or parts due to the wide availability of knowledge, materials and suggestions. Thus, the cited analyses can be an important postulate supporting the key role of CAD tools in managing the design process of machinery and equipment as a path to Industry 4.0.

To sum up, the presented considerations certainly do not fully exhaust the essence of research issues. Further research on the subject should focus on answering the question of whether the CAD tool will allow the structure of the full process, and design processes and will promote examining the full potential of carbon fibres. In this sector of machines and devices, or will be only a tool verifying the possibilities of Implementation and replacement of current materials with these new ones with the corresponding requirements for Industry 4.0.

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ECOLOGY IN THE WORKPLACE: KEY VALUE OR REDUNDANT LUXURY?

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Purpose: In the face of the global challenges of climate change, environmental degradation and increasing consumption of natural resources, the question of whether a green approach in the office is a core value or an unnecessary luxury is gaining importance. Integrating sustainability principles into the daily operations of companies not only affects the image of the company, but also contributes to improving the quality of life of employees and protecting the environment. The purpose of this article is to identify and evaluate key environmental values that influence workplace operations and employee behavior in the context of sustainability.

Design/methodology/approach: In addition to the analysis of the subject literature, this study uses the results of a survey of 174 SMEs operating in the Częstochowa county. A chi-square-based empirical analysis workshop used the T-Chuprov convergence coefficient.

Findings: The study showed that trust, commitment and environmental responsibility form a triad of values that determines employees' approach to environmental protection. Acceptance of this triad contributes to sustainable development and reduces the negative impact of a company's activities on the environment. Ignoring them, on the other hand, can lead to so-called employee betrayal, i.e. lack of recognition of environmental values in the workplace.

Originality/value: The study draws attention to issues of ecology as a value in organizations. The added value of the study is the determination of the importance of ecological values in the activities of modern enterprises, as well as the indication of recommendations for SME enterprises in the field of ecological activities.

Keywords: values, sustainability, ecology, responsibility.

Category of the paper: Research paper.

1. Introduction

It is a widely accepted truth that organizations contribute to environmental deterioration as a result of a number of factors related to their activity. Industry, manufacturing, transportation and consumption, associated with occupational activities, generate a significant amount of waste, pollution and greenhouse gas emissions (Robertson, Barling, 2013; Rodríguez-García et al., 2019). These negative effects of economic activity are often the result of mismanagement

of resources, overexploitation of the environment, and lack of adequate regulation (Farooq et al., 2022). Faced with these challenges, many organizations are beginning to recognize the need to incorporate sustainability and responsible environmental practices into their organizational processes (Gao et al., 2017; Kühner et al., 2024). In addition, more and more companies are engaging in projects to protect biodiversity and natural resources, and publishing transparent reports on their environmental impact (Richards, 2022). These efforts are not only a response to stakeholder expectations (El-Kassar, Singh, 2019; Zhou, Jin, 2023), but also a strategy for long-term development that can bring both economic and reputational benefits (Kelly, Moen, 2020; He et al., 2021; Ones, Dilchert, 2012). Decisions to incorporate the green factor into the company's structures can be the result of a multi-faceted analysis that includes both external and internal factors, taking into account the long-term strategy and the values the company intends to promote. According to Hashami (2023), adopting ecologically sustainable (responsible) methods, also known as “green business practices”, is now crucial for an organization, thus becoming its core value. As a result, today's companies need to rethink their existing business models in order to adapt to the new reality, in which environmental responsibility is becoming a key element of growth strategies and of gaining competitive advantage (Chaudhary, 2020; Cheema-Fox et al., 2020).

This article helps fill that gap by examining whether green activities are really the key to an organization's future, or just a temporary trend that will soon give way to other priorities. To fill this gap, this study focuses on ecology as a value. Therefore, it was important to determine the importance of ecological values in the activities of modern companies. Studying people's values can help managers design management strategies that align with them (Jones et al., 2016).

2. Theoretical Background and Hypotheses

The steady increase in sustainability-oriented activities over the past decade suggests that managers are beginning to see the business case for the green factor (Gómez-Bezares et al., 2016). The moral argument for environmental responsibility is based on the fundamental premise that any individual who contributes in some way to the destruction or degradation of the environment, has an obligation to take corrective action. A key problem in the context of this responsibility is the specificity of natural resources, which often have no clear owner. It uses the principle of the so-called “common goods”, meaning that the use of these resources by one person does not necessarily preclude their use by others (Sheehy, 2023). As far as companies are concerned, environmental responsibility takes on special significance. Companies, as entities that produce and consume natural resources, have a huge impact on the condition of the environment. This responsibility extends from resource management practices

to how waste and emissions are handled (Subramanian, Sures, 2023). In such a context, modern companies should focus on integrating environmental aspects into every stage of their operations (Przychodzen, Przychodzen, 2013). For this reason, companies have begun to increase their environmental awareness, to carry out environmental protection activities and increase investment in environmental protection, while actively adopting environmental responsibility as an organizational value (Klemke-Pitek, Majchrzak, 2022).

There is no doubt that values are the foundation for effective strategy implementation, affecting the quality of interactions between the organization and its environment, including customers, employees and other stakeholders (González-Ordóñez; 2024). Values can serve as guides that shape how an organization conducts its business and how it is perceived in the community (Argandona, 2003). It is a kind of moral compass that indicates what is important and desirable in a company's operations. These values are stable because they are often embedded in the organizational culture, tradition and personal experiences (Zbiegień-Maciąg, 2005). Companies guided by a strong value system are less likely to engage in activities that may be perceived as unethical, thus fostering reputation and trust among stakeholders. This approach is conducive to increasing profitability, boosting productivity and stimulating innovation. In practice, this means that organizations that care about their values are often more open to new ideas and methods of operation, allowing them to adapt to changing market conditions (Bugdol, 2007; Macey, Schneider, 2008).

Environmental values can be divided into three broad categories, including: core values, ideas or principles related to nature or society that are considered important by individuals or groups; contextual values – assigned, preference-based, context- and attitude-dependent; relational values, which take the form of both core and contextual values (Kuster et al., 2024). These three categories of environmental values help to better understand the diverse ways in which employees perceive and engage with environmental issues, which is key to effectively protecting the environment and promoting sustainable development. According to Bugdol (2007), lack of respect for values is the cause of employee betrayal, which means violation of organizational values, principles and ideas, loss of faith in the activities undertaken by the organization, or involvement in competitive activity. Employees may feel that their private values are in conflict with what the organization stands for, which in turn may result in a potential desire to withdraw from active participation in its activities (Lohuis, 2008). In addition, loss of faith in the activities undertaken by the organization occurs when employees notice a low level of transparency in management, inconsistency in decisions made, or lack of respect for their input and opinions. In such an atmosphere, there is a growing risk that individuals who feel undervalued or ignored will seek alternative career paths, including employment with competitors (Wolor et al., 2022). Ecology as an organizational value thus refers to the integration of sustainability and environmental principles into an organization's strategies, processes and culture (Guardani et al., 2013). It is also development of green

workplace behavior, defined as the degree to which employees perform the required tasks in a way that conserves resources and protects the environment (Zhang et al., 2021).

Given the above, it can be assumed that ecology (environment) must be taken as a new value: environmental protection – a value understood on the one hand as a stream of resources, and on the other – as costs of lost opportunities (Kaczmarek, 2011). This study poses the following hypotheses:

H1: Employees' recognition of environmental values leads to increased voluntary environmental behavior in the workplace.

H2: Absence of environmental values in the workplace leads to a number of negative consequences for both employees and the organization itself.

3. Research Methodology, Research Subject and Research Sample

The main objective of this study was to identify and assess key environmental values that influence workplace operations and employee behaviors. For the proper conduct of the study, a research model was developed (Figure 1) which took into account the key variables and their interrelationships.

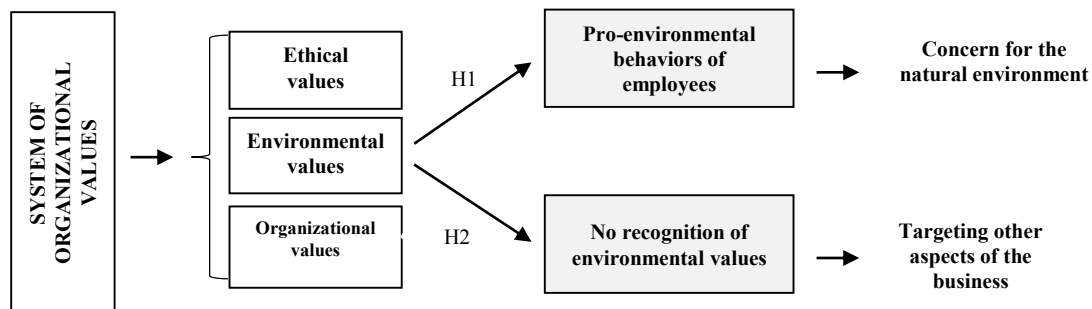


Figure 1. Research model.

Source: own research.

An opinion poll was used in order to gather data. The research tool used in the study was a survey questionnaire (PAPI and CAWI) addressed at 174 companies. The subjects of the survey were both managers (45.5%) and non-management employees (54.5%). The survey primarily involved companies in the SME sector (73%). To analyze the relationships among the variables included in the study, the T-Chuprov convergence coefficient was introduced based on the chi-square and their statistical significance was verified.

4. Results and Discussions

In order to realize the purpose of the study, a set of ecological values was first identified that provide the foundation for further activities and analysis. These values were selected based on studies by Chan et al. (2016), Arias-Arévalo et al. (2017), Bieling et al. (2020), Kuster et al. (2024). The results of the resulting analyses are shown in Figure 2.

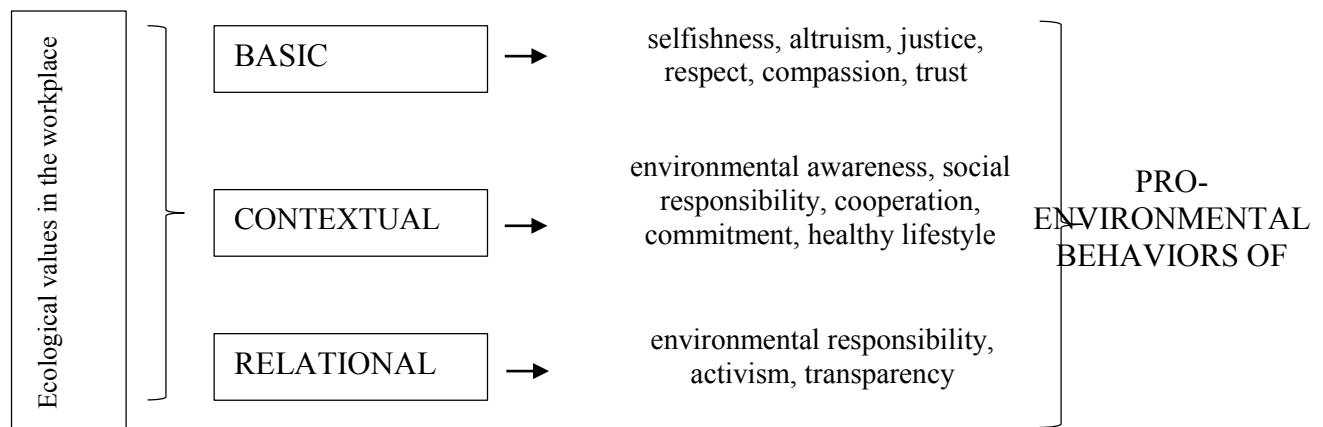


Figure 2. Environmental values in the organization.

Source: own research.

The environmental values presented should be considered as individual beliefs and standards that promote sustainability, environmental protection and ecological responsibility in the organization (Arias-Arévalo et al., 2017). The study determined which of the values that emerged could be considered key in the context of environmental protection (Figure 3). It can be said that trust, commitment and environmental responsibility form a triad of values that determines employees' approach to environmental protection.

As Drucker (1999) rightly noted, “organizations are not built on strength, but on trust”. This is because trust is the foundation of all interactions, both at the individual (employee) and social levels. Its level depends on management's decision-making philosophy, activities, structures and expectations of employees toward mutual benefits, leading to loyalty and dutifulness of employees (Sunil Kumar, Sumitha, 2023). In the context of environmental protection, trust refers to belief in the intentions and actions of others, as well as the organization in which they work. Commitment, in turn, refers to employees' activity and willingness to act to protect the environment. This requires them not only to be aware of environmental problems, but also to actively participate in solving them. This fact is confirmed by a study by Renwick et al. (2013) or Paille et al. (2017) according to which green employee engagement prompts employees to take actions that support sustainability.

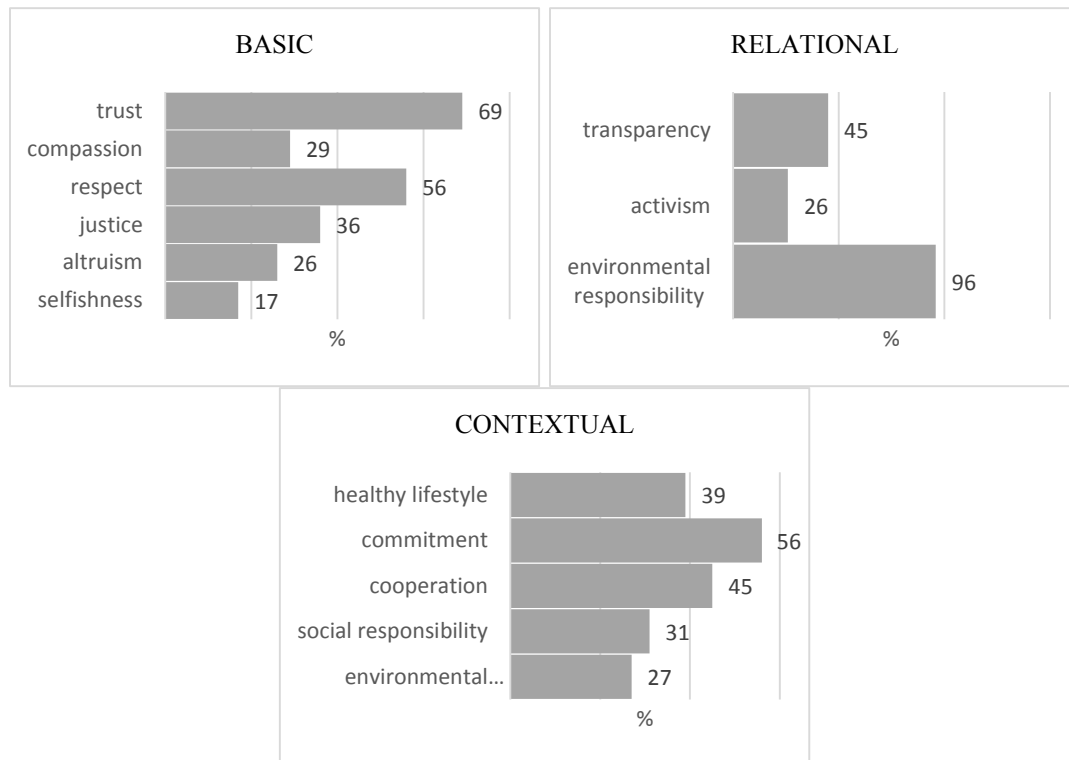


Figure 3. Ecological Value Systems in the Organization.

Source: own research.

Environmental responsibility as a value involves recognition that every action generates certain consequences that affect the state of ecosystems, health and quality of life. Essentially, employees' green behavior can range from everyday green behavior to initiating green ideas or actions (Chou, 2014).

The results showed that in the case of H1, the null hypothesis should be rejected in favor of the alternative hypothesis, while the reverse is true for hypothesis H2 (Figure 4).

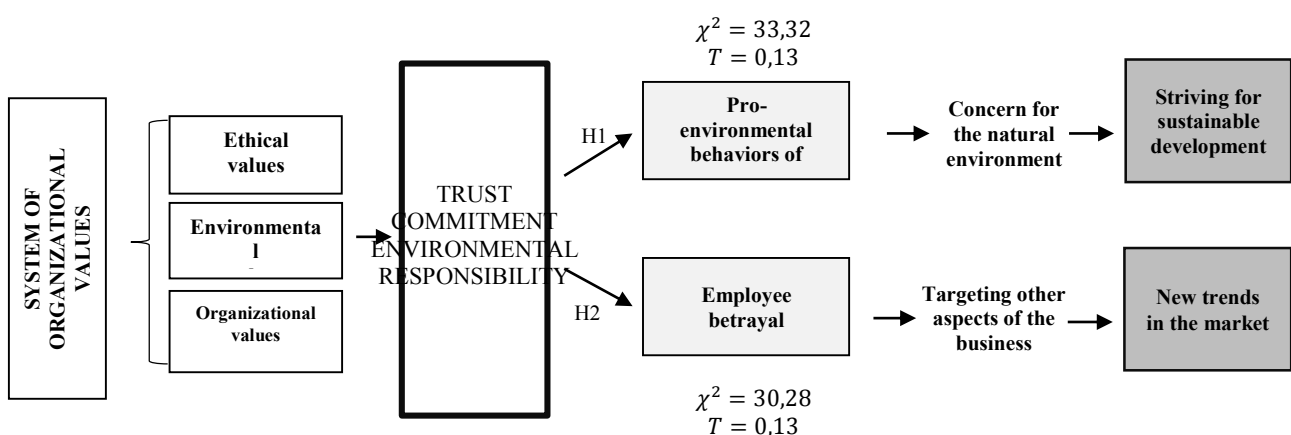


Figure 4. Model Ecological Values in the Organization.

Source: own research.

In view of the above, it can be concluded that employee recognition of environmental values, especially trust, commitment and environmental responsibility, leads to increased pro-environmental behavior of employees ($\chi^2 = 33,32; T - \text{Czuprowa } 0,13$). Employees who recognize the importance of environmental activities and feel that their contributions are valued and that they have an impact on the organization's decisions, become more inclined to take environmentally friendly actions. On the other hand, however, the lack of support from managers can lead to discouragement and a sense of powerlessness among employees (referred to as employee betrayal), which can lead them to take actions in violation of the principles of sustainable growth and environmental protection despite the fact that they may be obliged to comply with them ($\chi^2 = 30,28; T - \text{Czuprowa } 0,13$).

5. Summary

Ecology in the workplace is becoming increasingly important in the context of economic development around the world. It refers to companies' commitment to operate in a way that not only earns them a profit, but also minimizes negative environmental impacts and supports conservation efforts. In the course of the research, a triad of environmental values was identified, the recognition of which contributes to sustainable development and minimizes the negative impact of the company's activity on the environment. While a failure to recognize them can lead to employee betrayal, understood as a lack of recognition of environmental values in the workplace, in the long run it can result in serious consequences for both the company itself and the surrounding environment. Arguably, this is due to the stricter environmental regulations imposed by the European Union. On the other hand, in the face of increasing social and legislative pressure, companies that ignore green values may face not only legal problems, but also risk to reputation and loss of trust from customers and business partners. For this reason, SME companies should adopt a sustainable approach to operations. Among the recommendations are: implementing an environmental management system to help monitor and minimize the impact of the company's activities on the environment, developing an environmental responsibility policy that defines environmental goals, guidelines and operating procedures, regularly monitoring and reporting on the results of environmental activities so that progress can be assessed and necessary changes can be made, involving employees in environmental activities, informing stakeholders about environmental activities and the company's approach to sustainability.

Despite several theoretical and practical implications, this study has some limitations. First, it focuses only on ecology as a value, without concentrating on specific environmental activities in the workplace. Second, the data collected in the survey was only in the form of a survey, and should be expanded in order to identify specific pro-environmental activities in each of the companies surveyed. Finally, future studies should take into account the views of all employees, not just their representatives.

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LATENT PROFILE ANALYSIS OF BEER CONSUMERS WITH THE APPLICATION OF R SOFTWARE

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Purpose: The goal of the paper is to analyze beer consumer preferences by applying latent profiles analysis.

Design/methodology/approach: Latent profile analysis (LPA) is used to identify the latent (unknown) profiles that are present. The main difference between latent profile analysis and well-known decompositional approach (e.g. conjoint analysis, discrete choice methods, etc.) is that LPA estimates the latent profiles, while in decompositional approach, profiles are prior known, and evaluated by customers.

Findings: The results identified two latent clusters, each with distinct preferences. Cluster 2 exhibited higher means for alcohol content, additional flavors, pasteurization, and filtration, whereas Cluster 1 showed stronger preferences for packaging, serving size, and beer color. The best model was determined based on the Bayesian Information Criterion (BIC), selecting the VVI model, where variances vary within and between classes, while covariances are set to zero.

Research limitations/implications: Latent profile analysis provides the information on latent profiles, but the determination of optimal number of profiles is challenging. We must rely in statistical criteria (e.g. AIC, BIC). Including too many latent profiles may lead to overfitting, capturing noise, rather than meaningful profiles. Also LPA assumes that, given the latent profile, observed variables are independent of each other. LCA is also sensitive to sample size. Many papers suggest to use at least 500 observations. Despite these limitations, LPA remains a valuable tool when applied carefully, with proper model validation and robustness checks.

Practical implications: The findings of this study provide valuable insights for breweries and marketers seeking to refine their product offerings and promotional strategies. By understanding the distinguishing characteristics of the identified clusters, businesses can develop targeted marketing campaigns and optimize their product portfolios to align with consumer preferences.

Originality/value: The paper uses a latent profile method that is not widely-known in Poland, and it is not a common method for preference analysis compared to decompositional approach (e.g. conjoint analysis, discrete choice methods, etc.).

Keywords: latent profile analysis, R software, preference analysis.

Category of the paper: research paper.

1. Introduction

Research on consumer behavior is conducted to improve the processes of adapting a company's offerings to buyers' expectations. In addition to known needs, potential needs must also be considered.

The study of consumer preference structures is based on the measurement and modeling of preferences (Bąk, 2000, pp. 71-72; Zwerina, 1997, p. 2). Preference measurement emphasizes the quantification of preferences. Thus, measurement allows preferences to be described numerically by constructing a measurement scale that enables a quantitative reflection of the relationships between evaluations of specific products (Bąk, 2000, pp. 71-72; Zwerina, 1997, p. 2). Preference modeling, on the other hand, is associated with explaining the process of consumer behavior, which results in the evaluation of offered products and, ultimately, the selection of one of them. These models serve as behavioral patterns for different consumer groups regarding the choice of specific products (Bazarnik et al., 1992, p. 85).

Preference measurement uses historical observations and anticipatory data describing consumer intentions. Consequently, we distinguish between revealed preference analysis methods and stated preference analysis methods (see Figure 1).

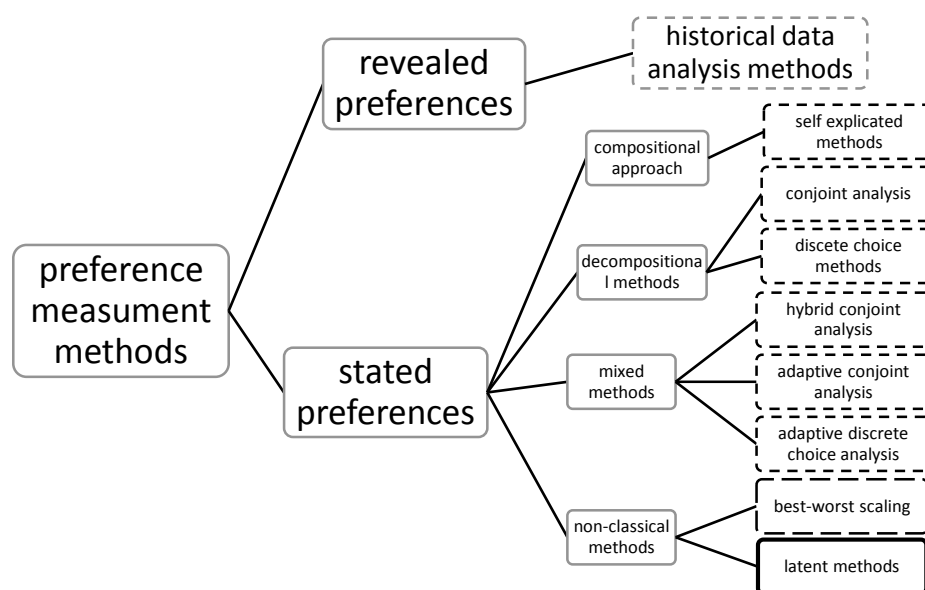


Figure 1. Types of preferences.

Source: Own elaboration based on Bąk, 2003, p. 212; Zwerina, 1997, pp. 2-3; Green, Srinivasan, 1990; Zwerina, 1997; Train, 2009; Aizaki, Fogarty, 2023.

Revealed preferences (RP) reflect actual market decisions made by consumers. The basis for analysis is statistical material collected through data registration on consumers' actual market choices. Other sources of such data include a posteriori interviews and surveys regarding consumers' past market choices. Thus, revealed preference research methods rely on historical data.

Stated preferences (SP), in contrast, pertain to consumers' hypothetical market behaviors. These research methods are mainly based on a priori data collected through surveys or interviews, which serve to register behaviors (intentions) expressed by consumers at the time of the survey or interview.

Consumer preference studies can be conducted using various methods. In the **compositional approach**, the idea of Fishbein's attitude model is utilized, along with assumptions related to the expected value model, where the total utility of a multidimensional profile is a weighted sum of evaluations of variable levels, and the weights express the importance of individual variables (Walesiak, Bąk, 1997, p. 14; Zwerina, 1997, p. 3). Compositional models are a class of multivariable models, examples of which include regression models and discriminant analysis (Hair et al., 2019, pp. 562-563). Researchers using compositional models collect respondents' ratings of various product or service attributes and then aggregate these ratings into overall preferences. In other words, analysts "compose" respondents' preferences based on their evaluations of each attribute of a product or service.

In the **decompositional approach**, consumer preference analysis is conducted using conjoint analysis and choice-based methods (Bąk, 2000, p. 76). Decompositional models belong to a class of models that "decompose" consumers' total preferences. Using decompositional models, respondents are presented with a set of profiles, typically in the form of hypothetical or real products or services (Hair et al., 2019, p. 558). Statistical methods and computer algorithms are then used to decompose total preferences and estimate part-worth utilities (Bąk, 2004, p. 42).

In the **mixed approach**, models are formulated that combine features of both the compositional and decompositional approaches. This includes hybrid conjoint analysis models and adaptive conjoint analysis. Both methods employ two-phase preference measurement procedures (Bąk, 2004, p. 44). The first phase involves direct evaluations of attributes and their levels, while the second phase consists of assessing selected pairs or subsets of product or service profiles.

Discrete choice methods, unlike conjoint analysis, allow for the estimation of both part-worth and total utilities at an aggregated level across the entire studied group. Therefore, direct consumer segmentation cannot be conducted. To estimate utilities at the segment level within discrete choice methods, latent class models are used.

In recent years, numerous studies have been published on latent class analysis and finite mixture models. These models include one or more unobservable, latent variables that represent the characteristics of interest.

Due to different distributions of observable and latent variables, we can distinguish various latent variable models (Vermunt, Magidson, 2003, p. 1).

According to Bartholomew and Knot (Bartholomew, Knott, 2002, p. 3), four main types of models can be distinguished (see Table 1).

Table 1.
Classification of latent variable models

Observable Variable	Latent Variable	
	Continuous	Categorical
Continuous	Factor Analysis	Latent Profile Analysis
Categorical	Latent Trait Analysis	Latent Class Analysis

Source: Vermunt, Magidson (2003), p. 1.

There are three main areas of analysis using latent class models: segmentation, variable reduction, scale construction, and dependent variable prediction (Magidson, Vermunt, 2002, p. 2). Three primary types of latent class models can be distinguished (Magidson, Vermunt, 2002, p. 2):

- a) Latent Class Cluster Models.
- b) Latent Class Factor Models.
- c) Latent Class Regression and Choice Models.

A latent class regression model, also known as a latent class segmentation model, is characterized as follows (Magidson, Vermunt, 2002, p. 5):

- a) it is used to predict a dependent variable as a function of predictors,
- b) it includes a latent variable with R categories, each representing a homogeneous population (class, segment),
- c) a different regression model can be estimated for each latent segment,
- d) it classifies characteristics into segments and simultaneously estimates regression models for each segment.

Advantages of this approach include (Magidson, Vermunt, 2002, pp. 5-6):

- a) **Relaxing traditional assumptions:** Unlike conventional models where $R = 1$ is assumed, this approach allows separate regression models for each segment.
- b) **Diagnostic statistics:** These allow for determining the optimal value of R .
- c) **Model flexibility:** If $R > 1$, the model can be extended with additional explanatory variables to improve the accuracy of the analysis and segment assignment.

Latent class models account for consumer preference heterogeneity at the segment level (Zwerina, 1997, p. 75; Huber, Orme, Miller, 1999, p. 6). Studies using latent class models assume that the examined sample consists of a finite number of consumer groups with similar preferences, while significant differences exist between groups. These groups are not known a priori but are "latent" because neither the membership of individual consumers in specific segments nor the number of groups is known (Bąk, 2004, p. 134).

In multivariate statistics, latent class models belong to the group of mixed distribution models (Domański, Pruska, 2000, pp. 30-36). Mixture distributions are created by a defined number of component distributions, with each component's contribution determined by a mixing parameter. The sum of the mixing parameter values equals 1.

In segmentation studies using latent class models, the mixing parameter is interpreted as the segment size. The primary goal of model estimation is to determine the number and size of individual segments.

The procedure for constructing and estimating a latent class model is as follows (Bąk, 2004, pp. 134-135):

- a) Defining the conditional distribution of a respondent's preferences (given the respondent's membership in a specific segment).
- b) Determining the unconditional distribution of a respondent's preferences (a weighted sum of conditional distributions, where the weights are the estimated probabilities of segment membership).
- c) Formulating the likelihood function (a product of individual preference distributions, assuming independence), with empirical preferences and unknown parameters as its arguments.
- d) Estimating the model (estimating parameters and segment sizes).
- e) Computing the a posteriori probabilities of respondents' segment membership.

The **Expectation-Maximization (E-M) algorithm** is more commonly used in software for estimating multivariate mixture distributions than other optimization algorithms (e.g., Newton-Raphson), due to its good convergence properties and ease of implementation (Wedel, Kamakura, 1998, p. 81).

The main advantage of the E-M algorithm is the **monotonic improvement** of the likelihood function value as the number of iterations increases. This procedure is also highly **versatile** and can be applied to various mixed distribution models. In decomposition methods, the E-M algorithm can be used for estimating **metric latent class models** (traditional conjoint analysis models, strong preference measurement scales) and **non-metric latent class models** (discrete choice models, weak preference measurement scales).

A crucial issue in estimating latent class models is **determining the optimal number of segments**.

The most commonly used selection criteria include (Kasprzyk, 2009, pp. 292-294; Shen, Sakata, Hashimoto, 2006, pp. 3-4):

- a) AIC (Akaike, 1974),
- b) AIC3 (Bozdogan, 1994, modification of AIC),
- c) CAIC (Constant AIC, Bozdogan, 1992),
- d) BIC (Bayesian Information Criterion, Schwarz, 1978),
- e) ABIC (Sample-adjusted BIC, Scolve, 1987),
- f) NEC (Normalized Entropy Criterion, Celeux and Soromrinho, 1996),
- g) ICL BIC (Integrated Classification Likelihood BIC, Biernacki, Celeux, Govaert, 2000).

The model is selected based on the criterion yielding the **lowest value**.

2. Latent profile analysis

Latent profile analysis (LPA) is a latent variable modelling technique is also known as latent class cluster analysis (Vermunt, Magidson, 2002; Williams, Kibowski, 2016), finite mixture modeling (McLachlan, Peel, 2000). Several papers and books present an introduction to latent class analysis (LCA), latent profile analysis, and latent trait analysis (LTA) – e.g. Vermunt and Magidson (2002), Williams and Kibowski (2016), Muthén (2001), Muthén (2004), McLachlan and Peel (2000).

In latent profile analysis the goal is very similar to latent class analysis and in some context to cluster analysis in general. LPA aims to detect unknown (latent) clusters that might be there in the data set, and each of these clusters describes a latent profile (profile that is unknown before). The main difference between LPA and cluster analysis is that the LPA is a model-based approach, while cluster analysis in general is not.

LPA is a latent variable mixture model, where the term latent refers to a latent categorical variable that indicates cluster memberships for objects. This latent variable has K levels that relate to clusters (categories). The main assumption is that the observed sample is drawn from a heterogeneous population that is a mixture of K profile-specific distributions (6). LPA also assumes that the observed indicator variables are distributed normally within each latent profile (5). Besides that, LPA assumes local independence, which implies that the indicators are uncorrelated within the identified latent classes (7, 8).

When more than one continuous cluster indicator is used in the LPA, the multivariate representation of the model is (Pastor et. al. 2007):

$$f(\mathbf{y}_i|\boldsymbol{\theta}) = \sum_{k=1}^K \pi_k f_k(\mathbf{y}_i|\boldsymbol{\mu}_k, \boldsymbol{\Sigma}_k), \quad (1)$$

where:

$f(\mathbf{y}_i|\boldsymbol{\theta})$ – is the distribution of cluster indicator \mathbf{y}_i , with given the model parameters $\boldsymbol{\theta} = (\pi_k, \boldsymbol{\mu}_k, \boldsymbol{\Sigma}_k)$,

π_k – non-negative weights that sum up to one,

$\boldsymbol{\mu}_k$ – mean vector,

$\boldsymbol{\Sigma}_k$ – covariance matrix.

Pastor et al. (2007) shows that while looking at the mean vector and covariance matrix we can have different LPA models:

- a) The A model, where variances are estimated across profiles, and the covariances are constrained to be zero:

$$\begin{bmatrix} \sigma_1^2 & 0 & \dots & 0 \\ 0 & \sigma_2^2 & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \dots & \sigma_r^2 \end{bmatrix}. \quad (2)$$

- b) In The B model, which allows for the variances to be freely estimated across profiles, the covariances are constrained to be zero:

$$\begin{bmatrix} \sigma_{1p}^2 & 0 & \cdots & 0 \\ 0 & \sigma_{2p}^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \sigma_{rp}^2 \end{bmatrix} \quad (3)$$

- c) The C model where variances are still constrained to be the same across the profiles, the covariances are estimated, but like variances are also constrained to be the same across profiles:

$$\begin{bmatrix} \sigma_1^2 & \sigma_{12} & \cdots & \sigma_{1r} \\ \sigma_{21} & \sigma_2^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{r1} & \sigma_{r2} & \cdots & \sigma_r^2 \end{bmatrix} \quad (4)$$

- d) The D model which specifies for the variances to be freely estimated across profiles and the covariances to be estimated equally across profiles:

$$\begin{bmatrix} \sigma_{1p}^2 & \sigma_{12} & \cdots & \sigma_{1r} \\ \sigma_{21} & \sigma_{2p}^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{r1} & \sigma_{r2} & \cdots & \sigma_{rp}^2 \end{bmatrix} \quad (5)$$

- e) The E model that specifies variances to be equal across the profiles, but the covariances to be freely estimated across profiles:

$$\begin{bmatrix} \sigma_1^2 & \sigma_{12p} & \cdots & \sigma_{1rp} \\ \sigma_{21p} & \sigma_2^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{r1p} & \sigma_{r2p} & \cdots & \sigma_r^2 \end{bmatrix} \quad (6)$$

- f) The F model where the variances and the covariances can be freely estimated across profiles:

$$\begin{bmatrix} \sigma_{1p}^2 & \sigma_{12p} & \cdots & \sigma_{1rp} \\ \sigma_{21p} & \sigma_{2p}^2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{r1p} & \sigma_{r2p} & \cdots & \sigma_{rp}^2 \end{bmatrix} \quad (7)$$

These different specifications of covariance matrices can't be obtained from classical well-known cluster analysis. If we have the covariance matrix that is shown by eq. 3, then clustering techniques can be applied (Pastor et al., 2007, pp. 17-18). In latent profile analysis, the model parameters are being estimated with maximum likelihood estimation via EM algorithm.

The logarithmic value of log-likelihood is often used in latent modelling as it's mathematically tractable. The final log-likelihood for a model and estimates of its parameters is used as a measure of model fit, where higher values indicating better fit.

In the case of maximum likelihood models, Akaike's information criterion (AIC) (Akaike, 1973) and Bayesian information criteria (BIC) (Schwartz, 1978) are usually used to select the best models.

3. Beer consumer analysis

The online questionnaire was designed to analyze beer consumer preferences, and the following attributes and levels were selected (see Table 2).

Table 2.

Attributes and their levels

Attribute	Levels
alcohol	no-alcohol
	low alcohol (2% to 4%)
	average (4% to 6%)
	strong (over 6%)
packaging	can
	bottle
	keg
Serving	0.33l
	0.4l
	0.5l
beer type	white
	light
	dark
taste	no additional taste added
	additional taste added (i.e. lemon)
pasteurization	pasteurized
	not pasteurized
filtration	filtered
	not filtered

Source: own elaboration.

As papers and simulations done by Spurk et al. (2020), Nylund et al. (2007), and Tein et al. (2013) suggest that a sample of around 500 respondents should be reasonable, based on past research and rules of thumb, our paper uses the sample of 510 respondents from Poland. The sample was collected via convenient sampling as well as snowball sampling. Although such a sample can't be used to test any statistical hypothesis, it can show general changes (Szreder, 2010).

510 respondents (convenience sample with snowball sample) evaluated each level for each attribute on a scale from 1 (not important) to 5 (very important). Although convenience sampling and snowball sampling do not allow the testing of statistical hypotheses about the whole population, they allow find of general changes and trends in the population.

General statistics for the whole sample are shown in table 3.

Table 3.*General statistics for the sample*

Variable and levels		Sample
Gender	male	231
	female	279
Age	18-27	283
	28-35	68
	36-43	103
	44-60	47
	over 60	9
Education	primary	25
	lower secondary	17
	upper secondary	352
	higher	116
Domicile	village	176
	city up to 20k.	94
	city 20-100k.	103
	city 101-199k.	43
	city over 200k.	94

Source: own elaboration.

While convenience and snowball sampling provided practical means to recruit participants, these methods inherently limit the generalizability of our findings. Convenience sampling, by relying on readily available individuals, increases the likelihood of selection bias and may not fully capture the diversity of the broader population (Etikan et al., 2016).

Similarly, snowball sampling relies on social networks, which can lead to homogeneity in the sample, as participants may recruit others with similar characteristics or experiences (Noy, 2008). This can introduce bias and reduce the external validity of the study (Heckathorn, 2011).

Additionally, these non-random sampling techniques are susceptible to self-selection bias, as individuals who choose to participate may have specific motivations or perspectives that are not representative of the wider population (Palinkas et al., 2015).

Despite these limitations, steps were taken to mitigate bias by seeking diverse participant recruitment and clearly situating our findings within these methodological constraints.

To address these concerns, we have taken steps to encourage diverse recruitment and have acknowledged these limitations in our discussion. Future research employing probabilistic sampling methods, such as stratified or random sampling, may enhance the generalizability of findings (Bryman, 2015). Future research employing probabilistic sampling methods could further enhance the robustness and generalizability of results.

The average value for each attribute was calculated and all latent profile models were applied, estimated, and compared using the BIC criterion. Mclust package of the R software and mclust function were used for computation (Fraley et al., 2024).

The mclust function allows us to consider four model types:

1. EEI, where variances may vary within the class but not between classes. Covariances are fixed to 0 within and between classes.
2. EEE, where variances and covariances may vary within the class, but not between classes.

3. VVI – where variances may vary within and between classes, covariances are set to 0.
 4. VVV, where both variances and covariances may vary within and between classes.
- Results for different model types and 1 to 20 latent clusters are shown in Table 4.

Table 4.
Selection of the best model according to BIC

Number of clusters	model type			
	EEI	EEE	VVI	VVV
2	-2959,88	-3039,87	-2944,94	-3106,98
3	-2971,42	-3040,71	-2976,04	-3204,6
4	-2974,87	-3042,95	-3019,49	-3352,23
5	-2992,81	-3077,8	-3077,56	-3508,05
6	-3017,82	-3105,06	-3131,37	-3637,46
7	-3033,91	-3128,48	-3177,27	-3737,25
8	-3062,29	-3126,15	-3228,11	-3929,53
9	-3085,69	-3146,25	-3268,18	-3988,87
10	-3117,75	-3181,39	-3321,08	-4143,21
11	-3146,61	-3216,08	-3383,18	-4304,18
12	-3184,88	-3254,76	-3436,02	-4470,11
13	-3212,86	-3289,21	-3491,3	-4594,37
14	-3235,53	-3318,38	-3548,36	-4703,55
15	-3266,09	-3334,8	-3576,33	-4871,17
16	-3286,77	-3341,26	-3614,82	NA
17	-3326,77	-3396,73	-3666,24	NA
18	-3353,87	-3392,74	-3728,32	NA
19	-3385,74	-3416,78	-3784,07	NA
20	-3414,76	-3462,81	-3828,04	NA

Source: own computation with the application of the Mclust package for R software.

According to BIC the best one is the VVI model (BIC value is equal to -2944.937) where variances may vary within and between classes, covariances are set to zero for 2 latent clusters. Table 5 contains mean values for all variables and two latent clusters.

Table 5.
Profile means for all variables

Variable name	Cluster 1	Cluster 2
Alcohol	5.528	6.090
Packaging	2.495	2.395
Serving (volume)	3.558	3.065
Beer type	1.500	1.355
Add-ons	2.104	2.164
Pasteurization	0.488	0.939
Filtering	0.955	1.201

Source: own computation with the application of the Mclust package for R software.

Cluster 2 contains 121 respondents and has the highest means for alcohol, add-ons, pasteurization, and also filtering. Cluster 1 contains 129 respondents and has the highest values for packaging, volume, and color. If we would like to consider the three most important variables we can see (Table 4) that alcohol, volume, and packaging have the highest means for both clusters.

The class allocation in LPA is probabilistic in nature. Each subject in the data is assigned a probability for each of the estimated classes, based on their pattern of scores on the input variables. These probabilities can be inspected in the z-matrix (see Table 6 for uncertainty means).

Table 6.
Mean values for latent profiles

Group	Probability (profile 1)	Probability (profile 2)
1	0.841	0.159
2	0.078	0.922

Source: own computation with the application of the Mclust package for R software.

Probabilities are relatively high for group 2 and the first profile. In the case of group 2, these probabilities were relatively more stable in the case of profile 2.

4. Final remarks

This study applied Latent Profile Analysis (LPA) to segment beer consumers based on their preferences. Data was collected through an online questionnaire, analyzing attributes such as alcohol content, packaging, serving size, beer type, additional flavors, pasteurization, and filtration. A sample of 510 respondents from Poland was used, and various latent profile models were estimated using the Mclust package in R software.

The results identified two latent clusters, each with distinct preferences. Cluster 2 exhibited higher means for alcohol content, additional flavors, pasteurization, and filtration, whereas Cluster 1 showed stronger preferences for packaging, serving size, and beer color. The best model was determined based on the Bayesian Information Criterion (BIC), selecting the VVI model, where variances vary within and between classes, while covariances are set to zero.

Overall, the study provides valuable insights into beer consumer segmentation using LPA and demonstrates the effectiveness of R software in conducting such analyses. While the findings are insightful, the sampling method (convenience and snowball sampling) limits the generalizability of the results. Future research could involve a more representative sample and additional attributes to refine consumer segmentation further.

According to Statistics Poland (GUS) in 2020-2024 there were 340 breweries (large, small, craft, manufacturing). In Poland we can see that beer is gaining more and more popular. Breweries indicated that diversified hops is an essential element of beer production, as it allow to provide of different beer types. Also a rising popularity of non-alcoholic¹ and low-alcohol beers² (16% of beer market in Poland) and beers with add-ons is an interesting change in beer consumption (The Office of Competition and Consumer Protection, 2024, pp. 16-19). Besides

¹ They are called sometimes NoLo (no alcohol, low alcohol).

that small breweries (11% of the market) are becoming more popular as they offer more customer-oriented products. This is confirmed by our research where alcohol, serving (volume), and packaging are key factors for both profiles.

The findings of this study provide valuable insights for breweries and marketers seeking to refine their product offerings and promotional strategies. By understanding the distinguishing characteristics of the identified clusters, businesses can develop targeted marketing campaigns and optimize their product portfolios to align with consumer preferences.

Cluster 2, which exhibits the highest means for alcohol content, add-ons, pasteurization, and filtering, represents a consumer segment that values premium and craft beer attributes. This group is likely to be drawn to artisanal and high-quality beer offerings that emphasize unique ingredients and refined brewing processes. Marketing efforts targeting this cluster should highlight the craftsmanship, ingredient quality, and innovative brewing techniques employed in the production process. Additionally, emphasizing the purity and safety aspects associated with pasteurization and filtration can enhance brand appeal. Digital marketing strategies, including storytelling about the brewing process and collaborations with influencers in the craft beer industry, could further engage this audience.

Conversely, Cluster 1, characterized by the highest values for packaging, volume, and color, represents consumers who prioritize visual appeal and quantity. This group is likely to be more responsive to packaging innovations, larger serving sizes, and eye-catching designs. Breweries catering to this segment should invest in aesthetically appealing and sustainable packaging, as well as limited-edition designs to create a sense of exclusivity. Promotions that emphasize value, such as bulk purchasing incentives or variety packs, could enhance sales among these consumers. Retail placements in high-visibility areas and point-of-sale displays can also be effective in capturing their attention.

Furthermore, the three most important variables—alcohol content, volume, and packaging—demonstrate that both clusters share common factors influencing purchase decisions. This suggests that an integrated marketing approach could balance these elements to appeal to a broader audience. Breweries could segment their product lines, offering high-alcohol-content craft beers with premium packaging for Cluster 2, while simultaneously developing visually appealing, high-volume products for Cluster 1.

Lastly, probability analysis indicates relative stability in preferences for Cluster 2 across profiles, suggesting a strong brand loyalty or consistent demand pattern. Breweries can leverage this insight by fostering long-term relationships through loyalty programs, exclusive member offerings, and targeted communications that reinforce their commitment to quality and innovation. In contrast, the variability observed in Cluster 1 suggests a need for dynamic marketing strategies that capitalize on seasonal trends and promotional campaigns to maintain consumer interest. By integrating these insights into their marketing and product development strategies, breweries and marketers can enhance consumer engagement, drive sales, and build stronger brand loyalty within their respective target segments.

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TAX CONSOLIDATION: TOOL OF CREATION RELATIONAL RENTS, AND INTERFIRM PERFORMANCE

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Purpose: the aim of the study is to identify the conditions and effects of using the tax consolidation tool by cooperating enterprises. We expect that the implementation of such an intention will allow us to capture the profit-creating role of this tax system tool.

Design/methodology/approach: this objective was undertaken using the literature review method supplemented by an analysis of the content of legal regulations in Polish tax law relating to tax consolidation. In particular, in the empirical layer, the analysis was carried out on normative acts regulating the taxation of related entities and tax groups, according to the legal status at the end of 2024.

Findings: it was established that the consolidation of business entities for the purpose of joint tax settlements can bring measurable benefits for these entities, both financial and organizational. However, in the organizational scope, the level of benefits can hardly be considered satisfactory. The need for mutual adjustment required by high interdependence means that adaptation will probably take longer than in the case when adaptation efforts are more autonomous.

Research limitations/implications: a limitation of the presented results is the lack of support for the findings made in (quantitative or qualitative) empirical studies among specific entities that have used or could have used the tax consolidation tool. The study is the result of preliminary work on the issue of tax consolidation in the context of achieving relational rent.

Practical implications: the research results may be support for companies that are facing the evaluation of cooperation relations, but also for those that are considering the possibility of using tax consolidation tools.

Social implications: the study informs about one of the instruments of public policy.

Originality/value: the problem addressed is not entirely new but rarely addressed in the literature in the presented approach; the article is addressed to scientists and practitioners.

Keywords: interorganizational relationships; relational rent; consolidation tax; interfirm performance.

Category of the paper: Technical paper; General review.

1. Introduction

The transformations that have been taking place in the environment in recent years, primarily in the area of digitalization and deepening interdependence, are fundamentally changing the conditions in which companies operate and, consequently, the paradigm of management sciences (Alexy et al., 2018; Zhao et al., 2020; Brenk et al., 2025). These trends emphasize the need to open organizational systems, go beyond the traditional boundaries of activity, in fact facilitating the creation of value on the path of close interactions with partners, redirecting the optics of achieving competitive advantage from a specific enterprise to the cooperative arrangements of companies (interorganizational relations) (Schleimer, Faems, 2016; Weber; Heidenreich, 2017; Zott, Amit, 2010). In the conditions of an intentionally created space of relations, the functioning of a company gives it the opportunity to participate in projects that go beyond its individual resource potential and achieve benefits (Grönroos, Ravald, 2011; Lambert, Enz, 2012), thanks to the effect of inter-organizational synergy, which in the literature is identified with relational rent (Wójcik-Karpacz, 2012, p. 53). This is jointly generated by the parties in the relationship and none of them (the parties to the relationship) can generate them on their own (acting in isolation). They can only be generated through joint actions (Haugland et al., 2021).

The literature indicates that generating relational rent between cooperating parties most often occurs through exchange, integration or investment in assets specific to this relationship, knowledge and resources or capabilities and through the use of an effective mechanism for coordinating this relationship in order to reduce transaction costs achieved through cooperation with the partner (Ghosh, John, 2005). Less attention is paid to the deepening of benefits that companies can achieve by improving the governance mechanism of the relationship by using a tool in the form of tax consolidation. The effects of this tool can put companies (parties to this relationship) in a more advantageous position compared to those companies that settle their tax liabilities individually and therefore in a non-consolidated manner, even when assuming that they operate in a cooperative arrangement. The expected consequence is the achievement of higher results.

The aim of the study is to identify the conditions and effects of using the tax consolidation tool by cooperating enterprises. We expect that the implementation of such an intention will allow us to capture the rent-generating (in the relationship of cooperation) role of this tax system tool. In addition, it will allow us to indicate the circumstances that must occur in the legal environment, but also in the business models of the parties to the relationship, so that this tool is appropriately attractive.

This objective was undertaken using the literature review method supplemented by an analysis of the content of legal regulations in Polish tax law relating to tax consolidation. In particular, in the empirical layer, normative acts regulating the taxation of related entities and tax groups were analyzed, according to the legal status at the end of 2024.

In the article, an attempt was made to eliminate the most common shortcoming in research on inter-organizational relations, in the form of a narrow (often one-sided) view of the conditions and benefits of using tools for achieving relational rent. As a result, this issue is usually perceived from the perspective of a specific enterprise (set of enterprises) or generally entities in the environment. In this case, in order to expand knowledge about the analyzed phenomenon, it was decided to view tax consolidation in two formats. The first one, in which enterprises were considered as the central point of consideration. They are in fact the main beneficiaries of potential benefits from the use of this tool for creating relational rent. The second one, which was focused on the fiscal system, including controlling entities. It is in this area that the practice of using this tool, i.e. tax consolidation, is shaped. At the same time, it was noted that the issue of tax consolidation in the literature is usually approached from the perspective of the impact of this method of tax settlement on the economy of a given country (e.g. Onji, 2013), and not from the point of view of specific enterprises – participants of the consolidation arrangement, which in our opinion is a novelty in the approach to the foundations of relational rent.

2. Literature review

a. Relational rent: possibilities of generating it by using the tax consolidation tool

Enterprises create cooperation relations in order to increase the benefits achieved through the exchange taking place in them (Czakon, 2007, p. 118), which they could not achieve acting alone (outside the cooperation system). These relations can therefore be described as systems that: (Banks, 2009; Burger-Helmchen et al., 2011; Nuttavuthisit, 2010; Klimas, 2015b; Piwoni-Krzeszowska, 2013)

- are dynamic and evolutionary relations or interactions,
- assume mutually beneficial exchange with entities in the environment,
- are a tool for implementing the strategy of co-creating value,
- are a tool for mutual creation and reproduction of value using both the logic of the value chain and the logic of the value network,
- they serve to create jointly added value, going beyond the added value traditionally assumed as the purpose of cooperation.

Importance of cooperation increases in a situation of high uncertainty of the environment. The growing complexity and dynamics of the environment have long been noted in the literature (Barringer, Harrison, 2000; Krupski et al., 2009; Czakon, 2012), and some authors even indicate that contemporary conditions can be described as a strategic inflection point, after which diametrical, discontinuous changes in the environment occur (Klimas, 2015a). From the perspective of management theory, the currently observed paradigm shift from enterprise management to relationship management can be considered a determinant of passing through a strategic inflection point (Czakon, 2012; Klimas, 2014). In turn, companies experiencing the aforementioned inflection point often move towards establishing inter-organizational relations, which in new contextual conditions will enable them to achieve not individual (independent of the cooperation system) but relational (together with partners) competitive advantage (Stańczyk-Hugiet, Stańczyk, 2013). This allows us to perceive environmental conditions as a strong premise for initiating inter-organizational cooperation. Therefore, in changing, complex, unpredictable and ambiguous circumstances of the environment, companies show a greater tendency to tighten relations with external partners (Czakon, 2007, p. 98), expecting that by acting together they will reduce costs related to both production and administration costs (Haugland et al., 2021). In other words, if at least two companies decide to cooperate – and they usually do so because of the expected benefits – they assume that together they will be able to operate in a less costly way than if they acted alone (Wójcik-Karpacz, 2012, p. 49). For this reason, cost reduction is perceived as an important measure of the results of interfirm relationships (Ghosh, John, 2005). More broadly; there is no doubt that the beneficial nature of the company's relations with its market partners can be assessed by means of the surplus of benefits – measured in cost or result units – accruing to the company as a participant in mutual exchange, and which it could not achieve if it acted separately and independently. This can only be achieved through cooperation relationships, thanks to which the tangible and intangible resources of enterprises complement each other in such a way that an inter-organizational synergistic effect becomes possible (Wójcik-Karpacz, 2013).

Inter-organizational cooperation can enable organizations to access new markets, technologies, products and capabilities, as well as provide multidimensionally understood satisfaction from such a relationship (Palmer, 2000). This satisfaction can have a positive impact on results. The literature points out that participants satisfied with the relationship strive to maintain/increase the benefits obtained from the relationship than dissatisfied ones, who often complain about the low level of benefits from the investments made and often declare a desire to terminate such a relationship (Matanda et al., 2016). It is worth adding that it is companies that achieve satisfactory results that help maintain a positive image of the cooperative system. If companies, acting together, are more profitable (profitable) or more competitive than if they acted separately, it can be said that an inter-organizational synergy effect has occurred between them. Its appearance is equivalent to the fact that the benefits resulting from cooperation are greater than those that can be achieved independently (St. John,

Harrison, 1999). Kotarbiński confirmed this by claiming that synergy will occur if and only if the acting entities, if they cooperate, achieve more than if they acted individually (Wójcik-Karpacz, 2013). All the more so because the behavior of a given element within the system is different than that expressed in isolation (Bertalanffy, 1984, p. 99).

The occurrence of a synergy effect in this form allows us to treat the cooperation relationship as a specific and difficult to imitate resource of the enterprise, although its use is only possible with the involvement of the partner. If we take into account the effects of this type of relationship, it can be considered a source of relational competitive advantage. Hence, synergy is one of the most important phenomena occurring between cooperating enterprises. It is an expression of resources crossing organizational boundaries and establishing routine practices and procedures between the parties to the relationship that enable achieving the above-mentioned synergistic effect identified with relational rent.

Relational rent derived from the theory of relationships is a joint income that does not come exclusively from a single enterprise. Considering the characteristics of the partners, relational rent can be created through a combination of exchanges (Lee et al., 2014). These complex connections within long-term cooperation create a shortage of resources and develop a barrier to the imitation of relational rent (Sweeney, Park, 2010; Zhang, Wang, 2018).

One of the paths leading to the creation of synergy is the appropriate management of the relationship (St. John, Harrison, 1999), which can be both a source of relational rent and a cause of the company's success. The appropriate level of coordination necessary to achieve synergy can be achieved by using many tools, one of which is a formalized tax consolidation mechanism. Tax consolidation is therefore not an independent source of relational rent, as indicated by Dyer and Singh (1998). It should be viewed solely as a beneficial tool of the mechanism of effective coordination of relations. Thanks to consolidation, the participants of the relationship (only acting together) can achieve greater results, which can undoubtedly be described as benefits from the relationship established between them.

The category of "tax capital group for the purposes of corporate income tax" has been functioning in Polish regulations for years. Within this tax, this is a solution that allows several commercial law companies to act as a single taxpayer. In the goods and services tax, such a solution is only just beginning to function. Currently, only capital companies can use the possibility of tax consolidation, because the regulations do not provide for the inclusion of family ties as a basis for several business entities to act as a single taxpayer.

b. Tax consolidation: conditions and possibilities of achieving synergy effects under Polish tax law

Defining the areas and methods of practical use of cooperation in the activities of enterprises is not a new phenomenon. Analyses in this area have a tradition of several decades in Poland (assuming the year 1989 as the beginning of the process of rebuilding the market economy) and new areas are constantly emerging in which economic entities could gain by joining forces

(Suszyński, 1992). One example of an organizational solution that has been used in the Polish economic reality for years is the existence of several economic entities as one consortium. The purpose of establishing a consortium is most often joint action in the implementation of a specific economic undertaking, which due to its financial potential exceeds the capabilities of a single entity (Matusiak, 2011). Thanks to such cooperation, entities whose size or experience is not sufficient to independently implement a large contract can participate in it. Joining the forces of entrepreneurs does not have to be limited only to the needs of implementing large contracts (in particular in the area of large public procurement). Acting as a group may also be justified in other areas.

Consolidation of business entities for tax purposes, generally speaking, comes down to grouping two or more entities in order to declare and pay taxes as one taxpayer. That is, separate business entities, for tax settlement purposes, act as one group, one taxpayer. With this assumption, internal transactions between group members usually remain neutral from the point of view of their tax liabilities. The fact that some entities in the group generate tax profits, while others may incur losses in a given year, also loses its significance. The tax systems of the European Union countries have long offered the possibility of grouping entities for tax purposes, although the scope and conditions of this grouping are not fully harmonized. Member States provide for the possibility of grouping to a different extent (in different taxes) and on different terms. Similar consolidation processes also take place outside the EU countries (Dabner, 2015). The possibility of tax consolidation is considered to be one of the factors taken into account by international organizations when deciding on the location for conducting business. Being a tax group may involve certain simplifications in settlements and savings, which from the point of view of entrepreneurs significantly improve the conditions for conducting business activity. The privilege of settling as a group could be treated as a kind of bonus for the development of related enterprises. (This approach to lower tax as a bonus for meeting certain conditions is already used in the literature (Takahashi, Yamada, 2022). Conveniences for entrepreneurs consisting in acting as a tax group are usually reserved for entities meeting certain conditions, the basic one of which is usually the condition regarding capital ties of entities in the group. From the point of view of the tax policy of countries allowing such joint taxation of entities, taxation of a tax group is a solution that increases the attractiveness of their tax systems. Although this solution should not always be treated as an effective mechanism for tightening the tax system. The approach itself and its accuracy are not the subject of this article, it is only worth signaling that this issue deserves a separate analysis, because based on a look at even one EU member state (Germany), it can be seen that a large number of tax groups is not associated with low interest in using taxation in tax havens (Fuest, Hugger, Neumeier).

3. Method

This objective was achieved by using the literature review method supplemented by the analysis of the content of legal regulations in Polish tax law relating to tax consolidation. The use of this method results from the initial stage of research on this phenomenon from the perspective of enterprises, and knowledge on this subject in the literature is highly dispersed (Ćwiklicki, 2020). In particular, it was decided to focus on journals from databases maintained by key publishers (including Elsevier, Emerald, Springer, Wiley-Blackwell, Taylor & Francis). This review was supplemented with literature in Polish, which was available via the BazEcon, EBSCO-host databases and books available in library resources and legal acts available via professional databases. The selection of content published mainly in scientific journals is dictated primarily by the greater currency of data presented there and a transparent review system ensuring high credibility of the presented content. In the empirical layer, the analysis was carried out on normative acts regulating the taxation of related entities and tax groups, according to the legal status at the end of 2024.

4. Results

a. Tax capital group in corporate income tax in Poland

According to the provisions of Article 1a of the Corporate Income Tax Act, a tax capital group (TCG) is a group of at least two commercial law companies with legal personality that are in capital relationships. Such a group must meet a number of conditions, the most important of which is that such a group may only be formed by limited liability companies, simple joint-stock companies or joint-stock companies with their registered office in the territory of the Republic of Poland, if:

- the average share capital attributable to each of these companies is not lower than PLN 250,000,
- one of the companies (the dominant one) has a direct 75% share in the share capital or in this part of the share capital of the other companies,
- these companies have no arrears in state tax payments.

The agreement on the establishment of a tax capital group must be concluded by the dominant company and the subsidiaries, in writing, for a period of at least 3 tax years and be registered by the head of the tax office (CIT Act). The above-mentioned conditions refer to the legal status in force in 2022. In the past, some requirements to be met have changed, but the historical approach is not the subject of this article, so they have not been described in detail. The main benefits of settling as a tax capital group in CIT usually include: tax savings,

in the event of tax losses incurred by some members, a reduction in the workload of group members, because the activities are performed by one entity - the parent company, and no need to fulfill documentation obligations in the field of transfer prices for transactions within the group.

It should be emphasized that over the years, tax capital groups have not enjoyed huge interest from taxpayers in Poland. In 2004, there were five tax capital groups, in 2005 there were eight, and in 2006 – 13. Analysis of individual taxpayer data published by the Ministry of Finance indicates that this trend has not reversed dramatically in recent years either. According to data for 2012, there were 28 tax capital groups, while according to data for the last published period (2020), there were just slightly more than twice as many tax capital groups – 61. It is also in vain to look for a change in the number of these groups at the turn of 2017/2018. Although the regulations were somewhat relaxed at that time, at the same time the legislator provided for a sanction in the form of a retroactive settlement mechanism for groups that lose their status (CIT Act). This low interest in tax capital groups in CIT in Poland is of course justified, which will be discussed later in this article. The main factors discouraging the creation of such groups in the past were usually listed as: the consequences of violating the conditions for recognizing companies as a tax capital group and the condition of achieving a minimum level of profitability by group members.

b. Tax group in the goods and services tax in Poland

In Poland, the functioning of tax groups for the purposes of settling the goods and services tax has no tradition yet. The provisions in this area appeared in the act on this tax only in 2022 and will come into force in 2023. The coming years will show how much interest this solution will enjoy, and this issue is worth being interested in, because the importance of indirect taxes is constantly growing, which according to some researchers is a positive phenomenon. They consider that indirect taxes reduce inequalities better than direct taxes (Ciminelli et al., 2019). It is worth noting that the possibility of joint taxation in VAT has been long awaited, especially since such solutions are used in EU countries. The institution of VAT groups (German: Organschaft) was initiated in Germany as a result of the case law of the Financial Court of the Weimar Republic (German: Reichsfinanzhof – RFH) from the 1920s and then introduced into the Turnover Tax Act in 1934, which at that time allowed avoiding the tax cascade of the multi-phase gross turnover tax. In 1968, after the value added tax structure came into force, the idea of VAT groups was maintained (Sarnowski and Salera, 2021). In Poland, in accordance with the provision of Art. 15a sec. 1, a taxpayer, within the meaning of the Goods and Services Tax Act, may also be a group of entities that are financially, economically and organizationally related, which conclude an agreement to establish a VAT group. Under this act, a VAT group may be created by taxpayers who have their registered office in the territory of the country and those who do not have their registered office in the territory of the country, to the extent that they conduct business activity in the territory of the country through a branch

located in the territory of the country (VAT Act). The essence of this solution is that the entities included in it become a single taxpayer for VAT purposes (and therefore instead of several taxpayers, there is one taxpayer representing all entities included in the VAT group). A VAT group may be created by entities that are financially, economically and organizationally related at the same time. What do these connections consist of in practice? It is assumed that (Dziadura, 2022):

- financial connection – occurs if one of the taxpayers who is a member of the VAT group directly holds more than 50% of the shares (stocks) in the share capital or more than 50% of the voting rights in the control, decision-making or management bodies, or more than 50% of the right to participate in the profit of each of the other taxpayers who are members of this group;
- economic connection – means the same nature of the main activity of the group members or the complementarity and interdependence of the activities conducted or the conduct of activities wholly or largely used by the group members;
- organizational connection – manifests itself in the fact that legally or actually, directly or indirectly, the entities in the VAT group are under common management or organize their activities wholly or partially in agreement.

As can be seen from the above, the legislator approached the issue of connections between entities in a group in quite a detailed way, indicating as many as three types of necessary connections. Such a solution is not an original concept of the Polish tax office. Similar conditions can be found in the legislation of other EU countries. The possibility of recognizing several entrepreneurs as a single VAT payer in individual member states results directly from Council Directive 2006/112/EC. Each member state, after consulting the advisory committee for value added tax, may recognize as a single taxpayer persons established in the territory of the same member state who, while being independent in legal terms, are closely linked in financial, economic and organizational terms (Directive 2006/112/EC). Observations to date regarding the approach of member states to this standard indicate that the requirements of economic, financial and organizational connections are considered to be met in very different factual situations. It is not yet known what approach the Polish fiscal apparatus will take. What can be noticed today is that the requirements regarding economic and organizational connections are quite vague and use terminology that does not yet have one established understanding, or this understanding is different from that adopted by the legislator. Example. Potential group members, when assessing the fulfilment of the condition of economic connections, must obtain an unambiguous answer stating that their main economic activity is of the same nature or complements and interdependent or that the conduct of their activity is used in whole or to a large extent by the group members. In order to obtain an answer to the question of whether the activity is of the same nature, it is first necessary to determine what the nature of conducting business activity is. Analyzing the case law in this area, one can come to the conclusion that when referring to the nature of the conducted activity, courts most often

indicate the profit-making nature and the permanent nature of the activity (judgment of the Provincial Administrative Court, 2018). This is probably not how the fiscal apparatus will understand the fulfilment of the condition of the same nature of activity. Given the lack of unambiguity of this term, it can be predicted that the identified ambiguities will pose a potential threat of a dispute between entrepreneurs and tax authorities.

The next important question is how to organize the decision-making process so that it is recognized in the light of the law as organizing an action wholly or partially in concert. There are no guidelines in this respect. The regulations do not provide an answer to the question of what the action and documentation of action in concert should consist of and what a partial agreement actually is. The identified interpretation problems are a consequence of the method adopted in Poland to specify the conditions listed in Article 11 of Directive 2006/112/EC. It results from the provision of the directive that entities, being independent in legal terms, must be closely linked in financial, economic and organizational terms. In the VAT Act, meeting the condition of close financial links is defined as a percentage (50%), while meeting the other two conditions (economic and organizational links) is defined descriptively, imposing rather ambiguous criteria to be met. In addition to the doubts already mentioned above, there are also other concerns: what does it mean to exploit to a large extent, what does it mean to be under common management indirectly, legally or in fact, and whether we understand a direct or indirect relationship as for the purposes of transfer pricing.

The original solution, not resulting from the above-mentioned EU directive, is to introduce the obligation to keep detailed records in electronic form. The obligation resulting from art. 109 sec. 11 g of the Act to additionally record transactions in the group is difficult to understand and seems excessive, because the tax administration has had access to information on taxpayers' transactions, including issued invoices, transaction dates and amounts, for several years now via JPK files.

Another requirement for a VAT tax group is that these entities have their registered office in the territory of our country. Taxpayers who do not meet this criterion will also be able to create such a group, but to the extent to which they conduct business activity, using the intermediation of a branch located in the territory of Poland. This condition is also a consequence of taking into account the provision of art. 11 of the directive cited above. It seems clear and its understanding should not cause interpretation difficulties.

c. Conditions for being a tax group

Before recognizing the conditions that must be met so that, under Polish tax law, several entities can act as a group in Poland and settle as one taxpayer, it is necessary to first determine which specific tax is of interest to entrepreneurs. This issue is important because, depending on the type of tax, the conditions to be met are different. Below (see. table 1) we have listed some of the requirements for creating tax groups in CIT and VAT and highlighted the differences in the conditions to be met in individual taxes.

Table 1.*Conditions for being a tax group*

Requirements to be fulfilled	Tax Capital Group in CIT	VAT Tax Group
Required level of equity participation	One of the companies (the dominant one) has a direct 75% share in the share capital or in that part of the share capital of the other companies	One of the taxpayers who are members of the VAT group directly holds more than 50% of the shares (stocks) in the share capital or more than 50% of the voting rights in the control, decision-making or management bodies, or more than 50% of the right to participate in the profit of each of the other taxpayers who are members of that group
Contract notification	The agreement is subject to notification by the parent company to the head of the tax office competent for its registered office, at least 45 days before the beginning of the tax year adopted by the tax capital group.	A VAT group representative shall submit a registration application to the head of the tax office competent for that representative, together with an agreement on the establishment of the VAT group, before the date of performance of the first activity specified in Art. 5.
Reporting changes	The parent company is obliged to report to the head of the tax office: <ul style="list-style-type: none"> – changes to the agreement and changes in the share capital of the companies forming the group, – changes in the factual or legal status resulting in a violation of the conditions for recognizing the group as an income tax payer within 30 days of the occurrence of these circumstances 	The VAT group representative is obliged to report to the head of the tax office any changes in the factual or legal status resulting in a breach of the conditions for recognising the VAT group as a taxpayer, within 14 days of the date on which such changes occur.

Source: Own study based on the provisions of tax laws.

As it results from the above, different conditions must be met to act as a tax capital group in CIT, and different to act as a tax group in VAT. This situation may be somewhat surprising, because what distinguishes these two taxes and taxation by them that would require differentiation of conditions for joint taxation of economic entities in each of these taxes. One of the important elements determining joint taxation in both taxes is the existence of links between entities. However, the scope and nature of these links are not defined in the same way for both taxes. It is worth recalling here that the issues of the existence of links between entities, in the provisions of Polish tax law, have been given much attention mainly for another reason. This reason is the need to regulate the issues of applying transaction prices between entities, in a situation where these entities are not strangers to each other. For these purposes, the legislator defined the existence of links between entities completely differently than for the purposes of joint taxation, as illustrated in the table below.

Table 2.
Relationships between entities in terms of CIT and VAT

Relationships relevant to transfer pricing	Relationships relevant from the point of view of joint settlement in CIT	Relationships relevant to joint VAT settlement
<p>Related entities are:</p> <ul style="list-style-type: none"> a) entities of which one entity exercises significant influence over at least one other entity, or b) entities over which it exercises significant influence: <ul style="list-style-type: none"> - the same other entity, or - the spouse, relative or affinity up to the second degree of a natural person exercising significant influence over at least one entity, or c) a company that is not a legal person and its partner, or a company referred to in art. 1 sec. 3 item 1, and its general partner, or a company referred to in art. 1 sec. 3 item 1a, and its partner, or d) a taxpayer and its foreign establishment, and in the case of a tax capital group - a capital company that is part of it and its foreign establishment. <p>Exerting significant influence means: having directly or indirectly at least 25% of: shares in capital or voting rights in control/constitutional/management bodies, as well as shares or rights to participate in profits. Exerting influence also means the actual ability of a natural person to influence the making of key economic decisions, or being married or having a relationship or affinity to the second degree.</p>	<p>Entities in association are: commercial law companies with legal personality that are in capital associations. The average share capital attributable to each of these companies is not less than PLN 250,000. One of the companies has a direct 75% share in the share capital or in that part of the share capital of the other companies.</p>	<p>Related entities are: entities between which there are joint financial, economic and organizational connections. Taxpayers are considered to be financially related if one of the taxpayers who is a member of the VAT group directly holds more than 50% of the shares (stocks) in the share capital or more than 50% of the voting rights in the control, decision-making or management bodies, or more than 50% of the right to participate in the profit of each of the other taxpayers who are members of that group. Taxpayers are considered to be economically linked if:</p> <ul style="list-style-type: none"> - the subject of the main activity of the VAT group members is of the same nature, or - the types of activity carried out by the VAT group members are complementary and interdependent, or - a VAT group member conducts activity from which other VAT group members benefit in whole or in large part. <p>Taxpayers are considered to be organizationally linked if:</p> <ul style="list-style-type: none"> - legally or factually, directly or indirectly, they are under the same management, or - organize their activities in whole or in part in agreement.

Source: Own study based on the provisions of tax laws.

We therefore have a clear understanding that in tax law regulations, the issue of connections between business entities is an important issue from the point of view of the reliability of the declared tax bases. However, as the above list indicates, there is no single universal definition of related entities. Consequently, the analysis of the existence of connections cannot be performed once and constitute the basis for various needs, i.e. for the preparation of transfer pricing documentation and joint taxation in several taxes. The lowest threshold of connections is provided for in the regulations on transfer pricing. It is enough for one entity to have 25% of the shares in the capital of the other to consider these entities as related. However, this is not enough to consider the condition of connections as met for the purposes of joint taxation in VAT and CIT. Perhaps it would be necessary to determine in which tax the conditions regarding connections are the most restrictive and strive to meet them, and then they will also be met for

the other needs. Theoretically, this seems possible, but in practice it does not guarantee success. The highest required level of connections appears in the regulations on tax capital groups in CIT, i.e. 75%. If one entity has more than 75% of the share in the capital of the other, this is enough to consider these entities as related also for the purposes of transfer pricing and the tax group in VAT. Unfortunately, this is not enough to consider the existence of these connections as sufficient for joint taxation in both CIT and VAT, because in VAT, in addition to financial connections, there must be two other types of connections (economic and organizational) and all three types of connections must occur together. Which, in turn, is not required when meeting the conditions for joint taxation in CIT. It is hard not to notice that for the purposes of the taxpayer's obligations, connections are understood much more broadly than for the purposes of using the privileges. It is enough to have, directly or indirectly, at least 25% of the shares in the capital of the other entity to be obliged to prepare transfer pricing documentation. However, this level of connections is definitely not enough to use the right to joint taxation. In order for joint taxation to be possible in VAT, it is necessary to have directly at least twice as many shares (50%), and for the purposes of joint taxation in CIT, as many as three times as many shares (75%). This state of affairs raises legitimate questions about the symmetry of conditions for the purposes of the taxpayer's obligations and privileges. Since for the purposes of transfer pricing we consider that with capital ties at the level of 25% of capital or voting rights, entities cease to treat each other as foreign and apply settlement principles that they would not apply if they were not so related, why can't such an approach be applied consistently for other needs resulting from tax laws? The issue of complications for taxpayers due to the lack of clarity in the concept of related entities should also be emphasized.

d. Consequences of violating the terms of the tax group

Both the Corporate Income Tax Act and the Goods and Services Tax Act provide for specific consequences for violating the rules of tax group operation. In the case of tax capital groups in CIT, several fundamental reasons for the group's termination can be indicated: (Nogacki, 2021)

- change in the factual or legal status,
- operation of the group for less than three tax years,
- violation of the share of income in revenues,
- joining another capital group.

These violations give rise to specific consequences. The assessment of the effects of violating the principles of the existence of a capital group is not the subject of this article, therefore these consequences have been signalled without their detailed analysis. Entities included in the group, in the event of the above violations, must take into account not only the loss of the status of a member of the tax group, but also the necessity to settle income tax retroactively, i.e. for the period from the second tax year preceding the day of loss of this status. The situation is similar in the case of a tax group in VAT. It is difficult to predict today what will be the most common causes of violations of the group, but the provisions of the VAT

Act clearly state that a VAT group loses the status of a taxpayer on the day preceding the day of occurrence of changes in the factual or legal status resulting in a violation of the conditions for recognising the VAT group as a taxpayer. This means that if, in the opinion of the tax authority, such a violation occurred several or a dozen or so months earlier, the group members will be obliged to settle separately for the entire period.

Table 3.

Examples of benefits of tax consolidation

Type of obligation	Independent entities	Entities in a tax capital group	Entities in the VAT group
Local transfer pricing documentation	Related entities are required to prepare electronic local transfer pricing documentation for the tax year, in order to demonstrate that transfer prices were established on terms that would be established between unrelated entities. Taxpayers usually outsource such documentation to specialist entities, and the cost of the documentation, depending on its complexity, is at least PLN 20,000 and may exceed PLN 100,000.	The obligation to prepare local transfer pricing documentation does not apply to controlled transactions between companies forming a tax capital group.	Not applicable
Deducting losses	A taxpayer may deduct a loss incurred in a tax year from the income earned in subsequent years.	It is possible to reduce the corporate income tax liabilities of a capital group within one year, because the income of the PGK is calculated as the sum of the income and losses of the parent company and its subsidiaries.	Not applicable
Minimum tax (from 2025)	Income tax, which is due if the break-even point of 2% (ratio of income to revenue) is not reached.	In the case of a PGK, the minimum tax threshold is calculated in relation to the entire PGK, so a loss-making position of one of the group companies does not mean that a new tax has to be paid.	Not applicable
Turnover between entities	Transactions with each entity must be documented with invoices	Transactions within the group do not have to be documented with invoices	Turnover within the group is not subject to VAT and is not documented with invoices, and the split payment mechanism or verification of the contractor in the list of taxpayers no longer applies.
JPK (Standard Control File)	Each entity is required to submit JPK separately.	Not applicable	The taxpayer is the VAT group as a whole, so one collective JPK is submitted, instead of separate JPKs for each entity.

Source: Own study based on the provisions of tax laws.

5. Conclusion and discussion

The conducted study allowed to identify the conditions and potential benefits of using tax consolidation as a tool for creating relational rent. As it was established, consolidation of economic entities for the purpose of joint tax settlements can bring measurable benefits for these entities, both financial and organizational. However, in the organizational scope, the level of benefits can hardly be considered satisfactory. The number of obligations, records of formalities that must be fulfilled before the formation or during the existence of the group exceeds the actual ones that can be considered necessary from the perspective of the fiscal apparatus. The need for mutual adjustment required by high interdependence means that adaptation will probably take longer than in the case when adaptation efforts are more autonomous.

It was also noted that achieving benefits from using this tool in a cooperation relationship is not easy, because the cooperation arrangement is often exposed to problems arising from the fair, not necessarily even, division of the generated value. This is all the more important when it is noted that the necessary condition for the effectiveness of cooperation is the mutual commitment of participants, which allows to limit the risk of tensions between partners and, consequently, minimize the risk of premature severance of existing relationships (Nuttavuthisit, 2010). In turn, the emergence of tensions may be a factor inspiring the perception of disproportions in tax burdens between taxpayers (or, in other words: inequalities in the approach to individual taxpayers) or even a sense of their deepening. These issues are already observed by researchers (e.g. Ciminelli et al., 2019).

The provisions of Polish tax law in Poland do not provide a clear position on the level of capital ties that determine the approach to the relationship between two economic entities as a group. There is a noticeable lack of universal criteria for determining the ties between entities and the consequences of using them for different needs. For the purposes of introducing the obligation to prepare additional documentation of transactions between entities, the criteria differ from the criteria for joint taxation, and the latter are also different for individual taxes. It also seems justified to observe that from the provisions cited in the article, understood as an offer for economic entities, no single coherent fiscal concept emerges. A concept that would be the result of research on short- and long-term fiscal effects for the State. Such consequences of consolidation concepts should be noticed (Erceg, Linde, 2013). It should be expected that the popularity of joint settlement in CIT within tax capital groups will grow in the coming years. Such predictions result from taking into account two fundamental facts. The first of these is the change in force in Poland since 2021, which consists in recognizing limited partnerships as independent taxpayers of income tax. So far, a number of capital groups have achieved a tax effect similar to PGK by using limited partnerships in their structures. This allowed conducting specific business ventures within separate entities while consolidating tax results at the level of

the partner of such limited partnerships (Szysz, Kamińska-Kubiak). The second is the relaxation of some of the conditions for creating tax capital groups as part of the package called the Polish Deal. Among other things, the requirement for the profitability of group members has been waived, the requirement to conclude an agreement on the creation of a group in the form of a notarial deed has been waived, the average amount of share capital that companies forming a group must have has been reduced from PLN 500,000 to PLN 250,000.

The possibility of joint taxation in the goods and services tax is a beneficial solution for entrepreneurs. Unfortunately, the perspective of reducing workload in connection with settling as a group outlined in this way was immediately significantly narrowed by introducing the need for special recording of transactions in the group for these purposes and informing the office about them. Additional factors discouraging the use of settlements in this form are the unclearly defined conditions for the connections of entities in the group, which was described in this article. The quality and usefulness of the current solutions offered by the Ministry of Finance in the field of tax groups should also be assessed in terms of the degree of intuitiveness of the solutions used. This criterion is gaining importance for obvious reasons. Given the multitude of tools, products, applications used on a daily basis, the taxpayer (entrepreneur) has the right to expect that the instructions and related regulations, instructions and warnings take this intuitiveness into account, are consistent, and logical. When establishing tax law norms in the field of tax settlements as a tax group, the lack of specific intuitiveness of these norms is noticeable. As indicated in this article, different conditions must be met for each of the taxes and their fulfilment must be reported at a different time. When promoting voluntary forms of fulfilling taxpayers' obligations, this is a significant complication that taxpayers guided by a certain intuitiveness may not expect. Failure to take into account such aspects brings measurable negative effects, which can be seen by assessing the solutions developed in the Ministry of Finance for the purposes of collecting motorway tolls. It can be assumed that the authors of both the eTOLL system concept itself and the IT tool for paying motorway tolls did not treat intuitiveness as an important assessment criterion. This electronic toll collection system, in force since 2021, clearly did not take into account that other solutions have become common in many already operating applications and payment systems (Act on Toll Motorways..., 2021). This is probably why the application made available for free use by the Ministry of Finance is rated low by users. On a scale of 0 to 5, this rating is at 1.4 (Play Store, 2021). It is obvious that when performing their duties, taxpayers should be guided by their knowledge of the law, not intuition. However, due to the extensiveness of the provisions that make up Polish tax law, expecting all entrepreneurs to have such full knowledge of the regulations would be excessive. Fulfilling all the obligations of entrepreneurs in the field of taxes has for years required not only a large time commitment, but also specialization, and in practice, the legal acts that make up the Polish tax system have long ceased to be the main source of tax knowledge for taxpayers (both for the general public and for entrepreneurs).

The presented results based on the analysis of source materials open up a discussion on the perception of tax consolidation in terms of benefits from cooperation for individual participants of this arrangement, and not only as a positively assessed fiscal effect on the scale of the economy, which is usually emphasized in the literature on the subject (Dobridge, 2021). The results of research on a very large sample conducted by Onji (2013; 2024) showed the existence of a strong relationship between consolidation decisions and incentives in the tax system and tax revenues paid by consolidated entities. All the more reason to assume that the discussed tax tool may be important for creating relational rent through better (more favorable) coordination of relationships.

The fundamental limitation of the presented findings is the lack of support for the findings made in (quantitative or qualitative) empirical studies among specific entities that have used or could have used the tax consolidation tool. For this reason, this study is rather of a contributory nature and is the result of preliminary work on the issue of tax consolidation in the context of achieving relational rent. The article also does not adequately consider the potential drawbacks of consolidation, such as the risk of tax avoidance, conflicts among group members, or government control. These issues may, however, be intriguing avenues for further research.

We are fully aware of the fact that the arguments presented in the article do not close but, on the contrary, open up space for discussion on the topic of tax consolidation. First of all, they are a strong inspiration for conducting extensive research in the future among companies using this tool, but also among tax authorities, in order to empirically verify the issues observed.

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ALTERNATIVE METHOD OF FISCAL STABILITY ASSESSMENT

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Purpose: The purpose of this article is to propose an alternative method for analyzing the fiscal stability presented by the stability of the general government debt-to-GDP ratio. This presented method based on a model that takes into account different fiscal rules and we compare this method with classical methods used by institutions, with particular emphasis on the methods used by the European Commission.

Design/methodology/approach: The article compares selected classical methods for assessing stability—stability indicators and Debt Sustainability Analysis (DSA) used by the European Commission—with the proposed alternative method of assessing the local stability of the debt-to-GDP ratio using a model that describes an open economy. This model consists of three equations: the multiplier equation, the law of motion for debt and the fiscal rule incorporating various fiscal variables.

Findings: Using the proposed alternative method for assessment of fiscal stability, it can be noted that replacing the general government debt/GDP ratio that take into account in the convergence criteria with another instrument in the fiscal rule, we may obtain different results regarding local debt stability.

Practical implications: The presented alternative method of fiscal stability assessment aims to attract the attention of institutions and entities analyzing debt stability to the importance of fiscal rules and the type of fiscal instrument in the analysis of fiscal stability.

Originality/value: In the classical methods of fiscal stability assessment used by researchers and by various institutions, with particular emphasis on the European Commission, there is a lack of analyses of the impact of the instrument included in fiscal rule on fiscal stability represented by the stability of the debt/GDP ratio. The proposed alternative method of fiscal stability assessment fills this research gap. This added value of this article is addressed to institutions that study the fiscal stability. The proposed alternative method may be considered by the European Commission, the IMF, the Fiscal Council, and the government.

Keywords: fiscal stability, targeting rule, stability indicators, general government debt to GDP ratio.

Category of the paper: Research paper.

1. Introduction

There are many methods for assessing fiscal stability used by international institutions, such as the European Commission and the International Monetary Fund, as well as by national institutions. The European Commission presents the results of fiscal stability analyses in the reports: Debt Sustainability Monitor, e.g., *Debt Sustainability Monitor 2022* (Directorate-General for Economic and Financial Affairs, 2022) and *Debt Sustainability Monitor 2023* (Directorate-General for Economic and Financial Affairs, 2023). The International Monetary Fund publishes the results of fiscal policy analyses and its impact on economic stability in the Fiscal Monitor (International Monetary Fund. (n.d.)). Taking notice of fiscal risks, the IMF also presents fiscal stability in various countries as well as information on financial stability in the world and in individual regions in the reports such as: World Economic Outlook (WEO) (International Monetary Fund. (n.d.)), Global Financial Stability Report (GFSR) (International Monetary Fund. (n.d.)) i Regional Economic Outlook (International Monetary Fund. (n.d.)). Moreover, all European Union Member States outside the euro area are obliged to prepare the Convergence Programme and update it annually. This is part of the budgetary surveillance process in the European Union. The programme is prepared in accordance with the guidelines for the stability and convergence programme of the EU Member States. In Poland, this programme is part of the Multiannual State Financial Plan (Ministry of Finance (n.d.)) prepared on the basis of the Public Finance Act. The annual update of the Convergence Programme includes a forecast of basic macroeconomic and fiscal variables for the next three years. This document also presents the main objectives of the government's economic policy and actions to achieve them.

The results of fiscal stability analyses are also presented in numerous scientific studies (see e.g. Marín-Rodríguez et al., 2023; Baharumshah et al., 2017; Hansen, Imrohoroglu, 2023; Wyplosz, 2011).

Taking into account the Article 5 of the Directive of the Council of the European Union (Council Directive 2011/85/EU of 8 November 2011 on requirements for budgetary frameworks of the Member States), according to which the Member States are obliged to apply their specific numerical fiscal rules, many authors analyse the rule-based fiscal policy and the fiscal stability and the sustainability of the general government debt (see e.g. Heimberger, 2023; Kopits, Symansky, 1998). The stability analysis is particularly important because the rules-based decision-making approach allows for enhancing prudence and objectivity in the implementation of fiscal and monetary policy (see e.g. Barbier-Gauchard et al., 2021; Wieland, 1996).

However, in exceptional situations it is possible to activate the general escape clause and suspend the application of fiscal rules in European Union countries. In 2020, due to the significant economic slowdown across the EU caused by the pandemic, the Ecofin Council

approved a temporary deviation in the budgetary policies of EU member states from the EU Council recommendations regarding budgetary policy, provided that this deviation does not threaten the medium-term stability of public finances. Taking into account the general escape clause activated by the European Commission and the escape clause for the stabilising expenditure rule, the stabilising expenditure rule was suspended in Poland in 2020. This allowed for the implementation of measures to minimize the negative effects of the crisis and to increase spending necessary to support healthcare systems, the population and the economy. However, despite the possibility of suspending fiscal rules in various exceptional situations, such as the pandemic, the energy and gas crises in Europe, the economic slowdown, and increasing inflation, it is still important to ensure stable public finances while also taking into account the economic growth and price stability.

When analyzing the stability of the general government debt to GDP ratio, it takes into account the fiscal targeting rules (see e.g. Reicher, 2014). The importance of general government debt and the significance of growth and of productivity were studied by Afonso and Jalles (2013) and Auerbach and Gorodnichenko (2012).

If fiscal policy has a multiplier effect, for example due to distortionary taxes or Keynesian consumption behaviour, a trade-off between debt stability and stability of output or inflation is likely. The presence of distortionary taxation may affect the interaction between monetary and fiscal policy rules in terms of stability. The significance of fiscal rules and the fiscal multiplier has been studied from various perspectives by many researchers (see e.g., Barnichon et al., 2022; Canzoneri et al., 2016; Caselli, Wingender, 2021; Corsetti et al., 2016; Debrun, Jonung, 2019; Przybylska-Mazur, 2016; Woodford, 2011).

However, new exceptional situations and the lack of global stability highlight the need to modify previously considered fiscal instruments and the need to analyze the impact of the type of fiscal instrument on the stability of variables such as debt and output.

The purpose of this article is to propose an alternative method for analyzing the stability of the general government debt-to-GDP ratio based on a model that incorporates different fiscal rules as well as to compare this method with classical methods used by institutions with particular emphasis on the methods used by the European Commission.

The presented paper fills a research gap by comparing various methods of assessing fiscal stability, with particular emphasis on the proposed alternative approach. Previous studies have not analyzed the impact of fiscal instruments on the stability of general government debt. The findings presented in this paper fill this research gap.

2. Methods

Among the methods of fiscal stability assessment, we can distinguish the alternative method presented in the article, as well as the methods previously used by various institutions, which we will refer to below as classical methods. In the subsection on classical methods, a brief overview is provided of the fundamental approaches used by the European Commission to assess the stability of the general government sector.

Taking into account the existence of different definitions of fiscal stability used by various institutions, it is necessary to provide a definition of fiscal stability before analyzing this problem.

2.1. Classical methods of fiscal stability assessment

The most commonly used definition of fiscal stability by various institutions is based on the concept of solvency, understood as the government's ability to settle future liabilities. The formal condition for solvency is derived from the government's intertemporal budget constraint. The definitions and principles of fiscal stability used by the European Commission are included in the Stability and Growth Pact.

The European Commission defines fiscal stability in the context of ensuring sound public finances, which are essential for long-term economic growth and stability.

In defining fiscal stability, the European Commission takes into account:

- budget balance, which is achieved when the general government deficit-to-GDP ratio does not exceed 3%;
- general government debt - Member States should maintain the government debt-to-GDP ratio below 60%,
- sustainable fiscal development, which includes the government's ability to finance its current obligations and future expenditures, such as pensions and healthcare, without excessive borrowing,
- risk identification and management – identifying potential fiscal risks, such as economic fluctuations, financial crises and off-balance-sheet liabilities, and introducing appropriate preventive measures,
- efficiency of expenditure – general government expenditure should be efficient and contribute to economic growth and improvement of citizens' quality of life.

Thus, the European Commission defines fiscal stability as a state in which general government finances are managed in a sustainable, predictable and transparent manner, including budget balance, control of general government debt and effective management of fiscal risk. The goal is to ensure the long-term economic and financial stability of the European Union Member States.

When assessing the stability of the general government sector, the European Commission takes into account different time horizons using fiscal stability indicators: the indicator S_0 in the short-term analysis, the indicator S_1 in the medium-term analysis and the indicator S_2 in the long-term analysis. When analyzing the stability of the general government sector, the European Commission also uses deterministic debt level projections for a ten-year horizon and stochastic debt projections for a five-year horizon.

The indicator S_0 is a composite indicator of fiscal stress. This indicator is a binary indicator that allows for identifying the risk of potential fiscal stress in the next year, based on fiscal and structural variables that have proven to be effective in detecting situations of impending fiscal stress in the past. The indicator S_0 , which is an early warning indicator, requires setting endogenous critical risk thresholds for individual variables on the basis of which the composite fiscal stress indicator is calculated. This process aims to minimize the sum of the number of fiscal stress signals sent ahead of no-fiscal-stress episodes (false positive signals – type-I error) and the number of no-fiscal-stress signals sent ahead of fiscal stress episodes (false negative signals – type-II error). That maximizes the signaling power of the indicator. The indicator S_0 is calculated as a weighted share of variables that have reached their critical thresholds, with weights given by their signaling power. The higher the share of individual variables whose values are greater than or equal to their specified threshold, the higher the value of the indicator S_0 . This indicator is a measure of overall short-term risks to fiscal stability. High values of this indicator signal an increase in overall stability risks.

The S_1 and S_2 indicators are fiscal gap indicators that provide information on the size of the necessary adjustment in the primary structural balance in order to satisfy the intertemporal budget constraint with the imposed transversality condition, which ensures that the debt cannot be financed according to the financial pyramid scheme in the medium-term and long-term horizons, respectively. The higher the value of the S_1 and S_2 indicators, the greater the fiscal risk and therefore the need for greater fiscal adjustment.

The indicator S_1 also provides information on medium-term fiscal challenges by measuring the consolidation effort that would be needed to reduce the general government debt-to-GDP ratio to 60%. It should be noted that for countries with an initial general government debt-to-GDP ratio below 60%, including Poland, the component related to the necessary adjustment is negative.

Since it is widely considered that fiscal policy is sustainable in the long run if the present value of future primary balances equals the current level of debt, this is equivalent to satisfying the government's intertemporal budget constraint.

The indicator S_2 defines the immediate and one-time permanent fiscal adjustment, i.e., the initial fiscal effort needed to stabilize the general government debt-to-GDP ratio in the long term, using the projections from the Ageing Report regarding expenditures on pensions, healthcare, long-term care, and education. This fiscal gap indicator determines the overall long-term risk classification. If the value of the indicator is less than 2, it can be stated that there is

a low level of risk in the long term. If the value of the indicator is in the interval $[2, 6]$, then there is medium risk, while the value greater than 6 indicates a high level of risk.

The European Commission also assesses long-term risk using Debt Sustainability Analysis (DSA) calculating both deterministic and stochastic debt level projections.

When using indicators to assess stability, one can see the problem that the indicators are subject to high uncertainty because they strongly depend on the initial assumptions, including the structural balance. Uncertainty regarding the indicators is also related to frequent revisions of potential GDP estimates and the output gap, as well as to changes in interest rates. Therefore, the European Commission is carrying out a sensitivity analysis to changes in the initial budgetary position and a sensitivity analysis to changes in the costs of aging. Furthermore, to take into account uncertainty related to macroeconomic conditions, stochastic debt projections are used in the assessment of fiscal stability.

2.2. Alternative method of fiscal stability assessment

In the article, an alternative method for assessing fiscal stability is proposed. This method is based on an open economy model consisting of three equations: the multiplier equation, which links the primary surplus to the output gap, a first-order approximation to the law of motion for the general government debt and a fiscal rule.

In assessing fiscal stability, the government debt-to-GDP ratio was studied. The definition of stability used in the analyses is as follows: stability is understood as a state in which the considered variable leads to the fulfillment of the law of motion in a non-explosive manner. In addition, we can note that two types of fiscal stability exist: global stability and local stability, which are defined as follows:

We say that the solution X_t of the law of motion is globally stable if and only if $\lim_{T \rightarrow \infty} \theta^T X_T = 0$ for every θ , such that $|\theta| < 1$.

However assuming that x_t is a local linear approximation of the sequence $X_t - \bar{X}$ for some \bar{X} , we say that the sequence $(X_t)_t$ is locally stable if and only if the solution x_t of the law of motion satisfies the following condition $\lim_{T \rightarrow \infty} \theta^T x_T = 0$ for every θ , such that $|\theta| < 1$.

The small open economy model used to assess fiscal stability includes consumers, producers, and the government. The model used for the analysis is based on the assumptions that the economy is open, taxation is distortionary, and consumers have access to a complete set of financial assets. However, they cannot hedge against the labor supply decisions. Additionally, it is assumed that prices, global interest rates, and global economic conditions are given.

We assume that consumers determine the optimal values of consumption C_t and labor expressed in the number of working hours H_t in period t by solving the following problem:

$$E_t \sum_{\tau=0}^{\infty} \delta^{\tau} \cdot [\ln(C_{t+\tau}) - \frac{\varphi H_{t+\tau}^{1+\frac{1}{a}}}{1+\frac{1}{a}} - \lambda_{t+\tau}(C_{t+\tau} + P_{t+\tau}^T \cdot A_{t+\tau} - P_{t-1+\tau}^T \cdot A_{t-1+\tau} - W_{t+\tau} H_{t+\tau}(1 - T_{t+\tau} + V_{t+\tau}) + \varphi_{t+\tau})] \rightarrow \max \quad (1)$$

where:

E_t – expected value in period t ,

$C_{t+\tau}$ – consumption value in period $t + \tau$,

$H_{t+\tau}$ – number of working hours in period $t + \tau$,

$P_{t+\tau}^T$ – transpose of the asset prices vector in period $t + \tau$,

$P_{t-1+\tau}^T$ – transpose of the asset prices vector in period $t - 1 + \tau$,

$A_{t+\tau}$ – vector of asset quantities in period $t + \tau$,

$A_{t-1+\tau}$ – vector of asset quantities in period $t - 1 + \tau$,

$W_{t+\tau}$ – gross remuneration per hour in period $t + \tau$,

$T_{t+\tau}$ – tax rate in period $t + \tau$,

$V_{t+\tau}$ – share of the tax-exempt part in labor income in period $t + \tau$,

$\varphi_{t+\tau}$ – income exempt from taxation in period $t + \tau$ paid not by the employer including, among others, income from various government programs,

δ – discount factor,

$\lambda_{t+\tau}$ – Lagrange multiplier in period $t + \tau$,

φ, a – parameters.

We assume that producers produce in each period t according to a linear production function $Y_t = Z_t \cdot H_t$ maximizing profit, where Y_t is output in period t , Z_t is productivity rate in period t and H_t is number of working hours in period t .

In addition, we assume that the government takes into account the law of motion for the general government debt B_t in period t :

$$B_t = \frac{1+i_{t-1}}{1+\pi_t} \Gamma\left(\frac{B_{t-1}}{\bar{Y}_{t-1}}\right) B_{t-1} - S_t \quad (2)$$

where:

$\Gamma\left(\frac{B_{t-1}}{\bar{Y}_{t-1}}\right)$ is a function representing the risk of default on the general government debt,

B_t represents the general government debt in period t ,

B_{t-1} represents the general government debt in period $t - 1$,

\bar{Y}_{t-1} represents the potential GDP in period $t - 1$,

i_{t-1} represents the nominal interest rate in period $t - 1$,

π_t represents the inflation rate in period t ,

S_t represents the budget balance, $S_t = T_t Y_t - G_t$,

Y_t represents the GDP in period t ,

T_t represents the tax rate in period t ,

G_t represents the general government revenues in period t .

The above model characterizing the open economy can be written in a reduced form using the following three equations:

- the multiplier equation that relates the primary surplus to the output gap:

$$y_t = - \frac{a}{1 - \bar{T} - a\bar{T}} (s_t - v_t) \quad (3)$$

or equivalently

$$y_t = y_t^* - m \cdot s_t \quad (4)$$

for the multiplier $m = \frac{a}{1 - \bar{T} - a\bar{T}}$ and the output gap correction factor $y_t^* = m \cdot v_t$ where

$y_t = \frac{Y_t - \bar{Y}_t}{\bar{Y}_t}$ is the output gap defined as the relative deviation of GDP Y_t from potential

GDP \bar{Y}_t , $s_t = \frac{S_t - \bar{S}_t}{\bar{Y}_t}$ is the ratio of the deviation of the budget balance S_t from the trend

\bar{S}_t to the potential GDP, \bar{T} represents the tax trend and $v_t = V_t$ is the absolute deviation of the work gap from the trend;

- the first-order approximation for the law of motion for the general government debt: Assuming that the first-order approximation for the law of motion for the general

government debt $\Gamma\left(\frac{B_{t-1}}{\bar{Y}_{t-1}}\right) = e^{c_t^* + c \cdot \frac{B_{t-1}}{\bar{Y}_{t-1}}}$ is of the following form

$$b_t = \frac{1 + i_{t-1}}{1 + g_t} (1 + c \cdot b) b_{t-1} + \frac{1 + i_{t-1}}{1 + g_t} b c_t^* - s_t \quad (5)$$

where:

$b_t = \frac{B_t}{\bar{Y}_t} - b$ is the deviation of the general government debt-to-potential GDP ratio from the reference value b ,

c_t^* – the coefficient influencing the rate of change of the general government debt-to-potential GDP ratio in period t ,

c – the coefficient influencing the rate of change of the general government debt-to-potential GDP ratio and g_t represents the economic growth rate in period t ;

- fiscal rule, which is an instrument limiting the scope of fiscal policy; this rule takes the form of quantitative limits concerning primarily:
 - the permissible budget balance,
 - the general government debt,
 - the growth or level of budget expenditure.

This equation is a fiscal rule specified by the fiscal policymaker, which sets b_t or s_t as a function of other variables. Depending on the type of fiscal rule taken into account, we can consider different fiscal systems.

Below, we present the results of the analysis of the general government debt stability under different fiscal systems, which involves adopting various fiscal rules, i.e., taking into account the quantitative limits of fiscal instruments.

2.2.1. Fiscal rule taking into account the debt-to-GDP ratio

Applying the fiscal targeting rule that takes into account the general government debt-to-GDP ratio, we aim to achieve the exogenous target B_t^* . The target can be written as $B_t^* = \frac{B_t}{Y_t}$.

Assuming that the target deviation $b_t^* = B_t^* - b$ from the established value b satisfies the equation

$$b_t^* = b_t - b y_t \quad (6)$$

we can write the law of motion for b_t^* in the following form:

$$\begin{aligned} b_t^* = & \frac{1 + i_{t-1}}{1 + g_t} (1 + c \cdot b) b_{t-1}^* + \frac{1 + i_{t-1}}{1 + g_t} (1 + c \cdot b) b y_{t-1} + \\ & + \frac{1 + i_{t-1}}{1 + g_t} b c_t^* - b y_t - s_t \end{aligned} \quad (7)$$

Thus, considering the exogenous, locally stable sequence $(b_t^*)_t$, which is not identically zero, and the model consisting of equations (4), (7), (6), the sequence $(b_t)_t$ is locally stable at b if and only if $\left| \frac{-m \frac{1+i_{t-1}}{1+g_t} (1+c \cdot b) b}{1-m \cdot b} \right| < 1$ or equivalently, when $m \cdot b < \frac{1}{\frac{1+i_{t-1}}{1+g_t} (1+c \cdot b) + 1}$.

2.2.2. Fiscal rule taking into account the debt-to-potential GDP ratio

In the fiscal rule taking into account the general government debt-to-potential GDP ratio, the debt level is of particular importance due to the predetermined level of potential GDP. Applying the fiscal targeting rule that takes into account the general government debt-to-potential GDP ratio, the aim is to achieve the exogenous target B_t^{**} . Therefore, the target can be written as follows: $B_t^{**} = \frac{B_t}{\bar{Y}_t}$.

To analyze the local stability, we assume that the target deviation $b_t^{**} = B_t^{**} - b$ from the established value b satisfies the equation

$$b_t^{**} = b_t \quad (8)$$

Then, the law of motion for b_t^{**} is of the following form:

$$b_t^{**} = \frac{1 + i_{t-1}}{1 + g_t} (1 + c \cdot b) b_{t-1}^{**} + \frac{1 + i_{t-1}}{1 + g_t} b c_t^* - s_t \quad (9)$$

Thus, taking into account the exogenous, locally stable sequence $(b_t^{**})_t$, which is not identically zero, and the model consisting of equations (4), (9), (8), the sequence $(b_t)_t$ is always locally stable.

The above remark suggests that removing GDP from the fiscal rule and replacing this indicator with potential GDP can help ensure stability.

2.2.3. Fiscal rule taking into account the total balance-to-potential GDP ratio

Stability analysis based on a model that includes the balance or deficit instead of the debt in a fiscal rule is also particularly important, because European Union member states are

required to comply with requirements for general government debt as well as general government deficit.

In the fiscal rule taking into account the total balance-to-potential GDP ratio, the level of the total balance is particularly important due to the predetermined level of potential GDP.

When the total balance is negative, we have a total deficit, and we consider a fiscal rule that takes into account the total deficit-to-potential GDP ratio instead of a fiscal rule that considers the total balance-to-potential GDP ratio.

Applying the fiscal targeting rule that includes the total balance-to-potential GDP ratio, the fiscal instrument considered is the indicator S_t^{**} , which represents the total balance-to-potential GDP ratio.

This indicator satisfies the following equation:

$$S_t^{**} = \frac{S_t - \left(\frac{1 + i_{t-1}}{1 + \pi_t} \Gamma \left(\frac{B_{t-1}}{\bar{Y}_{t-1}} \right) - 1 \right) B_{t-1}}{\bar{Y}_t} \quad (10)$$

To analyze local stability, we use the law of motion for s_t^{**} in the model. Therefore, we consider the deviation of the total budget balance from the trend in the following form:

$$s_t^{**} = s_t - \frac{i_{t-1}}{1 + g_t} b_{t-1} - \frac{1 + i_{t-1}}{1 + g_t} (c \cdot b_{t-1} + b c_t^*) \quad (11)$$

Taking into account the law of motion for debt (5), we obtain that the general government debt must satisfy the following equation:

$$b_t = \frac{1}{1 + g_t} b_{t-1} - s_t^{**} \quad (12)$$

Thus, given the exogenous, locally stable sequence $(s_t^{**})_t$, which is not identically zero, and the model consisting of equations (4), (12), (11), the sequence $(b_t)_t$ is always locally stable if and only if the nominal growth rate $g_t > 0$.

This implies that setting the total deficit as the target leads to a stable debt path when the nominal growth rate g_t is positive

2.2.4. Fiscal rule taking into account the primary balance-to-potential GDP ratio

If the primary balance is negative, then we have a primary deficit and we refer to a fiscal rule that takes into account the primary deficit instead of a fiscal rule that takes into account the primary balance.

Applying the fiscal targeting rule taking into account the primary balance-to-potential GDP ratio, we take into account the primary balance indicator S_t^* relative to potential GDP \bar{Y}_t .

Analyzing the local stability, we assume that the deviation $s_t^* = \frac{S_t^* - \bar{S}_t^*}{\bar{Y}_t}$ of the primary balance indicator S_t^* from the trend of the primary balance \bar{S}_t^* to the potential GDP \bar{Y}_t satisfies the equation:

$$s_t^* = s_t \quad (13)$$

Then the law of motion for b_t is of the following form:

$$b_t = \frac{1 + i_{t-1}}{1 + g_t} (1 + c \cdot b) b_{t-1} + \frac{1 + i_{t-1}}{1 + g_t} b c_t^* - s_t^* \quad (14)$$

Thus, considering the exogenous, locally stable sequence $(s_t^*)_t$ which is not identically zero and the model consisting of equations (4), (14), (13), the sequence $(b_t)_t$ is always locally unstable.

Therefore, setting the primary deficit as a target may lead to serious problems with the stability of the general government debt, and the government may be forced to use inflation to reduce part of the debt.

3. Results

The empirical analysis focuses on studying fiscal stability in Poland. Below, we present the results of fiscal stability in Poland in different time horizons presented by the European Commission, as well as the results of the method proposed in the article.

3.1. Classical methods – European Commission's results for Poland

The analysis conducted in this subsection are based on debt projections and stability indicators developed by the European Commission for Poland and published in the European Commission's latest report - Debt Sustainability Monitor 2023 (Institutional Paper, No. 271, March 2024).

The table below presents the deterministic projection of general government debt-to-GDP ratio for baseline scenario in Poland.

Table 1.

Deterministic projection of general government debt-to-GDP ratio for baseline scenario in Poland

Year	general government debt-to-GDP ratio projection for baseline scenario	Year	general government debt-to-GDP ratio projection for baseline scenario
2021	53,6	2028	62,2
2022	49,3	2029	64,5
2023	50,9	2030	67
2024	54,4	2031	69,4
2025	56,5	2032	71,9
2026	58,1	2033	74,4
2027	60	2034	77,1

Source: Debt Sustainability Monitor 2023 (European Commission, Institutional Paper, No. 271, March 2024).

Moreover, the European Commission publication shows that the debt sustainability analysis (DSA) consists in a set of deterministic projections based on various scenarios. The deterministic projections of debt to GDP ratio for 2034 are: the baseline scenario 77,1%, the historical structural primary balance (SPB) scenario 78,8%, the lower SPB scenario 84,5%, the adverse interest-growth rate differential (r-g) scenario 82,8% and the financial stress scenario 77,6%. The risk level is determined as medium in all scenarios.

However, based on the stochastic projection, the probability of debt-to-GDP ratio exceeding the 2023 level in 2028, is 0,95 and the difference between 90th and 10th percentiles of this ratio is 19,5%. Therefore the risk is determined as low.

The total indicator S_0 for Poland in 2023 calculated by the European Commission is 0.39, which allows to determine a low level of fiscal instability risk in Poland in the short-term horizon. According to the European Commission's analyses in 2023 the indicator S_1 equal to 3,2% of GDP, signals a medium fiscal risk in Poland in the medium-term horizon. Poland belongs to the group of EU member states considered to be at medium risk, as an overall correction of 2-6 percentage points of GDP would be needed to bring the rising general government debt back to 60% of GDP by 2070. The medium-term risk of fiscal instability in Poland is assessed as medium. However, debt is expected to continue rising in the medium term, with the debt-to-GDP ratio exceeding 60%.

For Poland, the indicator S_1 equals 3,2% of GDP and this indicator measures the permanent fiscal effort needed in 2025 to bring the debt-to-GDP to 60% by 2070. The indicator S_1 for Poland is composed of 0,8 percentage points of GDP to absorb the budgetary impact of rising ageing costs, 2,5 percentage points to close the gap between the 2024 structural primary balance and the debt-stabilising structural primary balance. The third component is the debt requirement and is equals to -0,1 percentage points. This component is related to the distance of the current debt-to-GDP ratio to the 60% reference value in 2070. Moreover, in 2023 the total indicator in the medium-term horizon increased compared to 2022. In 2022, this indicator was equal to 2,8, while in 2023, the indicator S_1 for Poland was equal to 3,2.

Using the indicator S_2 to assess fiscal stability, the European Commission stated that in 2023 this baseline overall index for Poland is 3,8 percentage points of GDP, of which initial budgetary position equals 2,7 percentage points of GDP and aging costs are 1,1 percentage points of GDP. For comparison, this overall index for Poland was equal to 3,7 percentage points of GDP in 2022. According to the European Commission's analysis, the indicator S_2 suggests that Poland is at overall medium long-term risk to fiscal stability.

Thus, Poland belongs to the group of EU member states exposed to medium risk, as the overall correction needed to stabilize the debt in the long term is between 2 and 6 8 percentage points of GDP.

3.2. Alternative method - results for Poland

Since one of the methods of assessing fiscal stability presented in this article incorporates a fiscal rule into the analysis, the results of analyses carried out for Poland based on this method are shown below. The theoretical analysis shows that when we take into account the values of the general government debt-to-potential GDP ratio in the fiscal rule, the sequence of the general government debt-to-GDP ratio $(b_t)_t$ is always locally stable. However, when taking into account the values of the general government primary balance-to-potential GDP ratio in the fiscal rule, the sequence of the general government debt-to-GDP ratio $(b_t)_t$ is always locally unstable. Thus, it remains to analyze fiscal stability when we include either the general government debt-to-GDP ratio or the general government total balance-to-potential GDP ratio in the fiscal rule.

For the analysis we took into account annual data for Poland from the period 2003-2023, including GDP (in PLN million) (Central Statistical Office, www.stat.gov.pl), GDP dynamics (Central Statistical Office, www.stat.gov.pl), general government balance (in PLN million) (Eurostat, <https://ec.europa.eu/eurostat/data/database>), general government debt (in PLN million) (Eurostat, <https://ec.europa.eu/eurostat/data/database>), general government debt-to-GDP ratio (Eurostat, <https://ec.europa.eu/eurostat/data/database>) and the reference rate (average annual value calculated on the basis of NBP data, www.nbp.pl). We assumed $b = 0,6$ (the limit for the general government debt-to-GDP ratio of 60%). The parameter c was set as the average relative change in the reference rate. In addition, the values of potential GDP and the trend balance were calculated using the Hodrick-Prescott filter. The obtained results are presented in the tables below.

In Table 2, we present the results of fiscal stability analyses for Poland in the years 2003-2023 when we include the general government total balance-to-potential GDP ratio in the fiscal rule.

Table 2.

Coefficient values used to assess the stability of the general government debt based on the fiscal targeting rule taking into account the general government total balance-to-potential GDP

Year	Coefficient values	Stability of general government debt	Year	Coefficient values	Stability of general government debt
2003	0,039	stable	2014	0,039	stable
2004	0,053	stable	2015	0,044	stable
2005	0,036	stable	2016	0,03	stable
2006	0,062	stable	2017	0,052	stable
2007	0,068	stable	2018	0,062	stable
2008	0,051	stable	2019	0,046	stable
2009	0,017	stable	2020	-0,02	unstable
2010	0,032	stable	2021	0,069	stable
2011	0,053	stable	2022	0,053	stable
2012	0,015	stable	2023	0,001	stable
2013	0,007	stable			

Source: Own calculations.

In Table 3, we present the results of fiscal stability analyses for Poland in the years 2003–2023 when we incorporate the general government debt-to-GDP ratio in the fiscal rule.

Table 3.

Coefficient values used to assess the stability of the general government debt based on the fiscal targeting rule taking into account the general government debt to GDP ratio

Year	Coefficient values	Stability of general government debt	Year	Coefficient values	Stability of general government debt
2003	2,184	unstable	2014	2,073	unstable
2004	2,098	unstable	2015	2,052	unstable
2005	2,138	unstable	2016	2,064	unstable
2006	2,062	unstable	2017	2,019	unstable
2007	2,039	unstable	2018	2,000	unstable
2008	2,080	unstable	2019	2,031	unstable
2009	2,175	unstable	2020	2,167	unstable
2010	2,102	unstable	2021	1,966	unstable
2011	2,057	unstable	2022	1,995	unstable
2012	2,149	unstable	2023	2,202	unstable
2013	2,174	unstable			

Source: Own calculations.

4. Discussion

The debt stability analyses prepared by the European Commission show a low level of fiscal instability risk in Poland in the short term. However the indicators S_1 and S_2 signal medium fiscal risk in Poland in the medium-term and long-term horizons.

The calculated deterministic projections of the general government debt-to-GDP ratio for the baseline scenario in Poland indicate an upward trend of this ratio in Poland and exceeding the established reference value of this indicator, i.e. 60%, in 2028.

Moreover, the calculated projections by the European Commission for the general government debt-to-GDP ratio for alternative scenarios—the historical structural primary balance (SPB) scenario, the lower SPB scenario, the adverse interest-growth rate differential (r-g) scenario, and the financial stress scenario—also show that the general government debt-to-GDP ratio will exceed 60% in Poland. Therefore, Poland belongs to the group of countries exposed to medium risk, and an overall correction is required to stabilize the debt in the long-term horizon. This correction of the general government debt-to-GDP ratio is equal to between 2 and 6 percentage points.

It should be noted that the DSA methodology used by the European Commission takes into account the revised fiscal rules in the new EU economic governance framework.

Therefore, using the proposed alternative method of assessing fiscal stability, represented by the stability of the general government debt-to-GDP ratio and based on a model that

incorporates different fiscal rules, we noted that the type of fiscal instrument included in the fiscal rule has an impact on the result regarding the stability of the debt-to-GDP ratio.

If we include the debt-to-potential GDP ratio in the fiscal rule, then the sequence $(b_t)_t$ of the general government debt-to-GDP ratio is always locally stable, i.e. also locally stable in Poland throughout the entire analyzed period 2002-2023.

If we take into account the primary balance-to-potential GDP in the fiscal rule, then the sequence $(b_t)_t$ of the general government debt-to-GDP ratio is always locally unstable, including throughout the entire analyzed period of 2002-2023 in Poland.

If we take into account the total balance-to-potential GDP ratio in the fiscal rule, then the sequence $(b_t)_t$ of the general government debt-to-GDP ratio was stable in Poland during the analyzed period of 2003-2023, except for 2020, when the SARS-CoV-2 coronavirus pandemic began and support programs were implemented, including programs counteracting or limiting the negative economic effects related to the announced lockdown.

However, based on empirical analysis, we can state that taking into account the debt-to-GDP ratio in the fiscal rule, the sequence $(b_t)_t$ of the general government debt-to-GDP ratio was locally unstable in Poland throughout the entire period of 2003-2023.

Taking into account the stability results obtained from the presented alternative method of assessing fiscal stability, institutions such as the European Commission or the IMF can extend the analysis of fiscal stability for individual countries. In addition to macroeconomic indicators such as the general government debt-to-GDP ratio and the general government deficit-to-GDP ratio and the fixed reference values of 60% for the debt-to-GDP ratio and 3% for the deficit-to-GDP ratio, these institutions may also take into account rules including the debt-to-potential GDP ratio or the total balance-to-potential GDP ratio or the primary balance-to-potential GDP ratio when assessing fiscal stability. This approach enables a comprehensive assessment of a country's fiscal stability.

Relating the findings in this article to those of other authors, it can be stated that the reports on fiscal stability published by the European Commission and the International Monetary Fund do not analyze the impact of the type of fiscal rule on the stability of the general government debt. The debt sustainability analysis (DSA) in the European Commission's reports considers the impact of aging-related costs on debt stability and presents various fiscal sustainability scenarios, such as 'historical structural primary balance (SPB)', 'lower SPB', 'adverse interest rate-growth differential (r-g)', and 'financial stress'. The S_1 indicator also incorporates for future aging costs and the debt anchor in EU fiscal regulations.

Marín-Rodríguez et al. (2023) provide an overview of fiscal sustainability research methodologies, highlighting an evolving shift towards interdisciplinary approaches that encompass environmental, social, and political factors. They also identify three emerging trends in fiscal sustainability research: the relationship between fiscal sustainability and economic growth, the methodologies and models for assessing fiscal sustainability, and demographic concerns and their impact on fiscal sustainability. Baharumshah et al. (2017) proposed

a Markov-switching model to assess the sustainability of fiscal policy. Hansen and Imrohoroglu (2023) consider the fiscal implications of an aging population in Japan. Heimberger (2023) assessed the European Commission's reform orientations with regard to using debt sustainability analysis (DSA) as an anchor in EU fiscal rules.

A theoretical discussion of fiscal targeting rules and macroeconomic stability under distortionary taxation, particularly in a small open economy, was conducted by Reicher (2014). He showed that the interaction between the fiscal rule and output can influence whether fiscal policy is stabilizing or passive in equilibrium. The theoretical findings on the stability of general government debt presented in this article, based on the proposed model, align with the findings reported by Reicher (2014).

The research findings presented in this article aim not only to compare the proposed alternative method for assessing stability with classical methods used for assessing fiscal stability but also to highlight the fact that the assessment of fiscal stability can depend on the type of fiscal rule applied.

5. Summary

In this article, we presented the results of a study on fiscal stability analyzed on the basis of the general government debt-to-GDP ratio, taking into account the fiscal rules that incorporate different fiscal instruments such as general government debt-to-GDP ratio, general government debt-to-potential GDP ratio, general government total balance-to-potential GDP ratio and general government primary balance-to-potential GDP ratio. In the article, we presented also the classical methods of assessing general government debt stability, focusing on the methods used by the European Commission for short-term, medium-term and long-term horizons. The results obtained based on the proposed alternative method were compared with the debt stability assessment for Poland made by the European Commission. By performing the empirical analysis based on the proposed alternative method of assessing stability, the local stability of the general government debt-to-GDP ratio in Poland during the period 2003-2023 was studied.

Using the proposed alternative method to assess fiscal stability, the analysis indicated that the assessment of the local stability of the general government debt-to-GDP ratio significantly depends on the type of variable included in the fiscal rule. Moreover, it can be state that removing GDP from the fiscal rule and replacing this indicator with potential GDP can help ensure stability. It has also been noted that adopting the primary balance as a target can result in serious problems with the stability of the general government debt.

Furthermore, we can conclude that taking into account the total balance-to-potential GDP in the fiscal rule leads to stable debt paths. Additionally, the fiscal rule incorporating the total balance-to-potential GDP can be used to identify negative nominal economic growth rates and extraordinary situations

Since Article 5 of the Council of the European Union Directive (Council Directive 2011/85/EU of 8 November 2011 on requirements for budgetary frameworks of the Member States) obliges member states to apply country-specific numerical fiscal rules without specifying which particular rules should be used, it is challenging to discuss in this article the priority of applying a specific type of fiscal rule when assessing the stability of the general government debt-to-GDP ratio. However, considering the practical aspects related to the selection of fiscal rules, it is advisable to adopt a comprehensive approach to the debt stability problem by incorporating various fiscal variables and, consequently, different types of fiscal rules.

However, in the context of stability, the application of a fiscal rule based on the primary balance-to-potential GDP ratio appears less favorable, as it inevitably leads to local instability of the general government debt-to-GDP ratio. To demonstrate the local stability of the general government debt-to-GDP ratio, a fiscal rule based on the debt-to-potential GDP ratio should be applied. However, to make debt stability dependent primarily on the nominal growth rate or the interest rate or the tax trend or the rate of change of the general government debt-to-potential GDP ratio or the reference value of general government debt-to-GDP ratio, a fiscal rule taking into account the total balance to potential GDP or a fiscal rule taking into account the debt to GDP ratio should be considered.

In conclusion, it is worth emphasizing that replacing the commonly used instrument, such as the general government debt-to-GDP ratio, with another fiscal instrument may yield different results regarding local debt stability. In further studies, the obtained results will be verified for other European Union member states.

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FROM KNOWLEDGE TO ENTREPRENEURSHIP: THE CONCEPT OF THE UTILITY FACTORS MODEL IN ECONOMICS AND FINANCE

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Purpose: This study aims to develop the Utility Factors Model (UFM) to assess the utility of academic research and improve knowledge transfer by identifying factors that motivate entrepreneurs to engage with university knowledge and analyzing their attitudes toward economic and financial knowledge transfer. Additionally, it explores how research spillovers foster entrepreneurship and economic development, drawing on the Knowledge Spillover Theory of Entrepreneurship (KSTE).

Design/methodology/approach: A qualitative research approach was employed, incorporating multiple case studies and semi-structured interviews with 44 Polish companies. The study followed a narrative literature review to contextualize knowledge transfer theories. The qualitative data from interviews were analyzed to identify barriers in research utilization, which directly informed the development of UFM.

Findings: The findings reveal several key aspects. Identified barriers include a misalignment between academic research outputs and business needs, limited practical application of theoretical models, and ineffective knowledge transfer mechanisms. The practical application of UFM demonstrates that the model provides structured indicators for assessing the utility of economics and finance research, enabling entrepreneurs to evaluate feasibility, financial institutions to assess economic impact, and policymakers to design informed regulations. Additionally, knowledge transfer mechanisms are enhanced through the integration of theories such as Triple Helix, absorptive capacity, and KSTE, ensuring that research remains accessible and fosters entrepreneurship by structuring knowledge spillovers.

Research limitations/implications: Future research on the empirical validation of UFM in various economics and finance contexts is necessary to refine its adaptability across different industries and policy environments.

Practical implications: The practical contribution provides entrepreneurs, policymakers, university authorities, and financial professionals with a clear framework to integrate academic insights into business strategy, the innovation process, and regulatory decisions. UFM extends knowledge transfer theories by adapting them to the field of economics and finance, showing how research spillovers drive entrepreneurship and innovation.

Originality/value: Unlike traditional knowledge transfer models, UFM incorporates KSTE, emphasizing structured spillovers as a source of entrepreneurial opportunities. It bridges the gap between theory and practice, offering a structured, transparent approach to making

academic research actionable. The study contributes a novel methodology for assessing research impact beyond academic citations and journal rankings, emphasizing real-world usability.

Keywords: knowledge transfer, Utility Factors Model, academic entrepreneurship, research commercialization.

Category of the paper: Conceptual paper.

1. Introduction

Universities often focus on tangible outcomes, such as publishing in highly ranked journals, patents and licenses, which may not adequately reflect the value of insights gained from practical applications (Bercovitz, Feldmann, 2005; Quagli et al., 2015). This can lead to a mismatch between the incentives for scientists and the need to integrate practical knowledge. To address this gap, we propose UFM, which aims to standardize the evaluation of research utility in economics and finance. This model provides a structured approach to assessing how academic knowledge can be effectively translated into real-world business applications. By identifying key utility factors, UFM enables both academics and practitioners to navigate the complexities of knowledge transfer, ensuring that research findings contribute meaningfully to economic and entrepreneurial development. The following sections will elaborate on the conceptual foundation, methodology, and practical implementation of the model. The Economics of Innovation literature has largely overlooked the interplay between formal and informal channels of knowledge transfer between universities and industries. This gap limits the understanding of how knowledge is effectively shared and utilized in practice (Azagra-Caro et al., 2017; Galán-Muros, Plewa, 2016). Knowledge transfer is aimed at creating, capturing, and organizing knowledge to reduce uncertainty in business practices (Olayemi, 2023). It involves both tacit and explicit exchanges, which are often not adequately captured in formal academic research (Ibidunni et al., 2020). From a theoretical standpoint, knowledge conversion theory delineates the processes through which knowledge is created. It underscores the dynamic interplay between tacit and explicit knowledge (Nonaka et al., 2001). For knowledge to be transformed into a valuable entity, it must be anchored in the shared knowledge that exists among individuals, which serves as a fundamental tenet of the theory.

The knowledge is inherently complex and socially constructed (Millar, Choi, 2009). Much of the knowledge generated in practice is tacit and not easily codified, making it difficult to transfer back to the academic framework (Wang, Jiang, 2019). The diversity of knowledge generated in practice can create challenges for academics attempting to assimilate and integrate these insights into existing theoretical frameworks. Causal ambiguity associated with knowledge transfer within firms create difficulties in leveraging best practices from business environments into academic research (Uygur, 2013). Heterogeneity of local knowledge may

impede reverse knowledge transfer (Khoirunnisa, Almahendra, 2021), that involves the flow of knowledge generated in practical settings back to academic institutions, where it can inform and enhance theoretical understanding.

Also, knowledge transfer between academia and practitioners is hindered by barriers in creation, diffusion, adoption, and utilization of research (Gera, 2012). Academia often operates within a framework of peer review and theoretical validation, while industry prioritizes speed, efficiency, and practical applicability (Sjöö, Hellström, 2019). This limiting the potential for knowledge transfer (Finch et al., 2018; D'Este, Perkmann, 2010). Exposure to mainstream economic theories can lead to a disconnect from emerging practices and innovations in the field (Spencer, 2019). Academic researchers prioritize quantitative methodologies over qualitative insights derived from practice. This preference can lead to a lack of appreciation for the rich, contextual knowledge that practitioners possess (Peake, Marshall, 2017). The "Not-Invented-Here" syndrome is a significant barrier to knowledge transfer, particularly in the context of academia. In academia, this can manifest as skepticism towards practical insights derived from industry, which may be perceived as lacking the rigor of academic research (Kathoefer, Leker, 2010).

Academics may struggle to communicate findings in a way that resonates with practitioners unfamiliar with academic jargon or methods (Clough, Adams, 2020). Conversely, practitioners may present insights lacking the rigor expected by academics, leading to skepticism (Clough, Adams, 2020). Knowledge transfer effectiveness depends on technical knowledge differences—both too much and too little can hinder it (Li, Zhu, 2021). The characteristics of the knowledge source (practitioners) and recipient (academics) are vital (Tho, 2017). Economics has historically been a dominant social science, shaping policy and governance (Hirschman, Berman, 2014). However, applying economic principles is often complicated by political, economic, and social contexts, causing divergence between theory and practice (Hallett, 2024). For instance, while economists propose policies based on rational actor models, these recommendations may be altered or rejected when faced with governance realities and societal norms (Hallett, 2024).

When academic research is perceived as irrelevant to business practice, it indicates a failure in direct knowledge transfer between academics and practitioners (Booker et al., 2012). The lack of relevance attributed to academic findings can lead to a situation where valuable insights from business practices are not recognized or utilized within academic circles. This is due to the disconnect between practical insights and theoretical frameworks, the lack of structured communication channels, educational shortcomings, cultural and contextual factors, knowledge management dynamics, methodological preferences, the rapid pace of change, and institutional pressures. Incorporating feedback mechanisms that allow practitioners to inform academic research agendas can ensure that academic work remains relevant and applicable to real-world challenges (Sjöö, Hellström, 2019).

2. Gaps problem

The integration of economic and financial research into practical applications within the economy reveals significant gaps in knowledge, particularly regarding the mechanisms through which this knowledge influences policy and decision-making. Addressing these gaps is essential for enhancing the practical relevance of economic research and ensuring that it effectively informs policy and decision-making processes. The gaps in knowledge regarding how the economy utilizes insights from economic and financial research are multifaceted, encompassing issues of transparency, governance, socio-economic integration, and methodological standardization. The table 1 summarizes the key research gaps identified in this study, the existing approaches to addressing them, and how UFM offers a structured solution to bridge these issues.

Table 1.
Research Gaps and UFM Solutions

Research Gap	Description	Relevant Sources	How UFM Addresses This Gap
Lack of understanding of how economic and financial research influences policy and decision-making	Despite the volume of economic research, there is little clarity on how it translates into real-world policies and decision-making.	Talbot (2018), Elliott (2020)	UFM provides structured utility factors to assess how research impacts policy and decision-making, bridging academia and practice.
Transparency issues in economic modeling and reporting	There are calls for transparency in economic modeling, but uniform standards for reporting are lacking, reducing credibility and applicability.	Zawadzki, Hay (2019), Shkarlet et al. (2019)	UFM introduces standardized indicators to improve transparency in economic modeling and research usability.
Methodological inconsistencies in economic evaluations	Economic evaluations vary in quality and lack standardized methodologies, limiting their usefulness for policymakers.	Hiligsmann et al. (2018), Cacciatore et al. (2020)	UFM supports methodological standardization by offering a systematic framework for evaluating research applicability.
Skepticism towards qualitative data and subjective measures	Economic methodologies often favor quantitative over qualitative insights, restricting the analysis of human and social factors.	Drakopoulos (2019), Munday et al. (2023)	UFM acknowledges the value of qualitative insights and incorporates them into structured assessment models.
Disconnect between economic education and contemporary research	Educational curricula often lag behind modern economic thought, creating a disconnect between research and real-world applications.	Girardi, Sandonà (2017)	UFM promotes the integration of contemporary research into education by aligning research with real-world needs.
Misalignment of research objectives with practical utility	Many economic studies remain theoretical without addressing practical applications, leading to research underutilization.	Wang (2022), Ospina et al. (2015)	UFM ensures research aligns with stakeholder needs by providing structured indicators for real-world application.

Cont. table 1.

Underdeveloped frameworks for assessing research impact	Despite the need for research impact assessment, many evaluation frameworks are incomplete or underdeveloped.	Deeming et al. (2017)	UFM includes clear evaluation criteria to assess research impact, improving decision-making processes.
Limited stakeholder engagement in research application	A lack of engagement with policymakers, practitioners, and communities results in research that does not meet societal needs.	Akbari et al. (2022), Voitenko et al. (2022), Mura et al. (2018)	UFM fosters stakeholder engagement by making research findings more accessible and actionable for businesses and policymakers.

Source: own study.

Despite the extensive body of literature and the vast amount of economic and financial research produced annually, there remains a lack of comprehensive understanding of how these insights are operationalized in real-world contexts, largely due to the lack of simplified and transparent utility factors that can bridge the divide between academia and practice (Talbot, 2018; Elliott, 2020).

The challenges associated with knowledge transfer in economics and finance closely mirror those observed in technology transfer literature. The Triple Helix Model (Etzkowitz, Leydesdorff, 2000) identifies the collaboration between universities, industry, and government as a crucial mechanism for innovation. Similarly, absorptive capacity theory (Cohen, Levinthal, 1990) emphasizes that organizations must develop internal competencies to effectively assimilate and apply external knowledge. In both cases, knowledge transfer is not merely about dissemination but also about structuring the process in a way that makes insights actionable.

In economic and financial research, these barriers are compounded by the predominance of theoretical models that are rarely translated into practical guidelines. Tacit and explicit knowledge exchange (Nonaka et al., 2001) plays a critical role in ensuring that academic findings can be effectively utilized in business contexts. However, without structured frameworks for assessing research utility—to Technology Readiness Levels (TRLs) used in technology commercialization (Mankins, 1995) - the gap between research and its application remains significant.

An alternative perspective on knowledge transfer and its entrepreneurial potential is offered by KSTE (Audretsch, Keilbach, 2007; Acs et al., 2009). This theory bridges the fields of entrepreneurship and endogenous growth, emphasizing that knowledge spillovers—particularly those stemming from universities—serve as a foundation for new business opportunities. Unlike absorptive capacity theory, which focuses on how firms assimilate external knowledge, KSTE highlights that not all knowledge created in organizations is fully commercialized. Instead, residual knowledge diffuses into the ecosystem, where it can be utilized by entrepreneurs to develop innovative business ventures (Shane, 2000). From this perspective, knowledge spillovers function as a key driver of entrepreneurship, distinguishing KSTE from classical theories such as those proposed by Schumpeter (1934) and Kirzner (1973), which focus on opportunity recognition but do not explicitly address the origins of those opportunities. Recognizing the importance of structured knowledge dissemination, tools like UFM can play

a crucial role in systematizing and optimizing these spillovers, ensuring that academic research is effectively leveraged for entrepreneurial innovation.

To provide a structured comparison of different knowledge transfer models, table 2 summarizes their key assumptions, mechanisms, and roles in facilitating knowledge exchange.

Table 2.
Comparison of selected knowledge transfer models

Key Assumptions	Triple Helix Model	Absorptive Capacity Theory	Knowledge Spillover Theory of Entrepreneurship (KSTE)	Knowledge Conversion Theory (SECI Model)	Utility Factors Model (UFM)
Model Objective	University-industry-government partnerships	Firms' ability to absorb and apply external knowledge	Knowledge diffusion fostering entrepreneurship	Transformation of knowledge between tacit and explicit forms	Assessment of research usability
Main Knowledge Transfer Mechanisms	Interaction between academia, business, and government	Learning processes from external sources	Spillovers from universities and R&D institutions	Socialization, externalization, combination, internalization	Structured evaluation of research utility factors
Approach to Knowledge Commercialization	Joint R&D initiatives	Emphasis on internalizing scientific knowledge	Not all organizational knowledge is commercialized	Facilitates knowledge transformation	Focus on practical applicability
Role of Universities	Catalyst for knowledge exchange	Limited role, mainly as a knowledge source	Provides research that enables new business opportunities	Firms codify and integrate tacit knowledge	Develops tools for assessing research value
Role of Enterprises	Engages in partnerships to develop technologies	Firms must develop knowledge absorption skills	Entrepreneurs utilize uncommercialized knowledge	Policies promoting structured knowledge conversion	Uses structured indicators for decision-making
Role of Public Policy	Supports research commercialization policies	Encourages policies enhancing firms' learning capacity	Policies supporting knowledge-based entrepreneurship	Best practice sharing, organizational learning	Shapes policies ensuring effective research implementation
Application Examples	Innovation hubs, technology clusters	R&D strategies, knowledge-intensive firms	Startup ecosystems, innovation-driven enterprises	Collaborative knowledge creation	Economic research impact, academic entrepreneurship

Source: Own study.

The knowledge gaps in the utility value and utilization of economics and financial research, undertaken in this study, relate to the clarity of research objectives and transparency of methodologies. Addressing these gaps is essential for enhancing the practical usefulness of economic research in informing policy and improving economic outcomes. The issue of transparency in economic modeling itself presents a significant gap. Although there are calls for greater transparency in the reporting of economic evaluations and models (Zawadzki, Hay,

2019), the standards for such transparency are not uniformly adopted across the field. This inconsistency undermines the credibility of economic research and limits its utility for policymakers (Shkarlet et al., 2019).

Variable quality and heterogeneity in economic evaluations limit their utility for decision-makers, suggesting a need for improved methodological standards to enhance transparency and comparability (Hiligsmann et al., 2018). A systematic approach to methodology is essential for enhancing the quality of research (Cacciatore et al., 2020). The evolving landscape of economic research necessitates ongoing dialogue about the values and assumptions underpinning economic methodologies. Mainstream economic methodologies often exhibit skepticism towards qualitative data and subjective measures, which can limit the scope of research findings (Drakopoulos, 2019). For example, the work Munday et al., (2023) suggests that qualitative methods can shed light on the costs and benefits of interventions beyond quantitative analysis alone, thereby increasing the practical significance of research findings. This skepticism can create barriers to understanding the full spectrum of economic phenomena, particularly those influenced by human behavior and social factors. Addressing these philosophical and methodological challenges is crucial for enhancing the transparency and applicability of economic research. Moreover, the disconnect between economics education and contemporary research, indicates that educational curricula often lag behind recent advancements in economic thought, further exacerbating the gap between research and its application in real-world scenarios (Girardi, Sandonà, 2017).

Beyond methodological issues, a significant gap exists in aligning research objectives with practical utility. Many economic studies focus on theory without addressing real-world application. Aligning research with stakeholder needs enhances its utility. Research ignoring policymakers, practitioners, and communities' risks underutilization. For example, Wang (2022) explores social entrepreneurship's role in economic growth but lacks practical implementation insights. This misalignment can waste research efforts, as findings may not inform decision-making. An estimated 85% of research has low impact due to poor design or irrelevance (Ospina et al., 2015). Clear research objectives are crucial for practical usefulness. Assessing research impact is vital, yet many evaluation frameworks remain underdeveloped (Deeming et al., 2017). This gap hinders realizing research's economic potential, as institutions struggle to communicate findings effectively.

By prioritizing transparent practices and integrating relevant socio-economic factors, researchers and policymakers can enhance the utility value of their findings. Research suggests that incorporating stakeholder perspectives and community engagement in decision-making processes can lead to more effective and equitable economic policies (Akbari et al., 2022). This approach not only builds trust among stakeholders but also ensures that policies are responsive to the needs of the community, thereby enhancing their utility (Akbari et al., 2022; Voitenko et al., 2022). For example, the role of e-government in promoting transparency is increasingly recognized, as it facilitates the dissemination of information and enhances public accountability (Mura et al., 2018).

3. Relevance

The consequences of failing to address the knowledge gaps in the utility value of economics and financial research can be profound, leading to significant implications for both the academic community and real-world economic applications. These consequences can be categorized into several key areas: wasted resources, diminished trust in research, and ineffective policy-making. One of the most immediate consequences is the waste of resources. It has been estimated that a significant portion of research is of low impact or wasted due to factors such as being unnecessary, poorly designed, or addressing the wrong research questions (Ospina et al., 2015). This inefficiency not only squanders funding and time but also detracts from the potential advancements that could be made if research efforts were more strategically aligned with pressing economic issues. When research fails to fill existing gaps, it leads to a cycle of redundancy where similar studies are conducted without yielding new insights or solutions, further compounding the issue of research waste (Pratt et al., 2019).

The lack of transparency and methodological rigor in research can lead to diminished trust in the findings produced by the academic community. Transparency in the research process is essential for establishing trustworthiness in findings (Massaro et al., 2019). For instance, Gunawan (2024) emphasizes that financial mathematics, which is grounded in transparent methodologies, aids in understanding key financial concepts that are crucial for effective decision-making. Without transparency, the risk of misinterpretation or misuse of research findings increases, potentially leading to poor economic decisions. Transparency is vital for fostering trust among stakeholders. When stakeholders trust the research process, they are more likely to engage with and implement findings, thereby enhancing the overall utility of the research. When researchers do not adequately disclose their methodologies or the limitations of their studies, it raises questions about the validity of their conclusions. This erosion of trust can result in practitioners and policymakers being hesitant to rely on academic research, thereby limiting the impact that well-conducted studies could have on real-world economic practices. The perception that research is unreliable can lead to a reluctance to implement evidence-based policies, which ultimately hampers economic progress (Pratt et al., 2020).

Transparency and utility in the context of economics and financial research influence the effectiveness and applicability of research findings. Research that is perceived as useful can directly inform policy decisions, guide financial practices, and contribute to economic development. Utility is not just about theoretical knowledge but also about equipping individuals and organizations with the tools they need to navigate complex financial landscapes effectively. Practical significance ensures that research results deliver tangible benefits to society. For example, understanding financial products and services can empower individuals to make informed decisions that maximize their utility (Salem, 2023).

Addressing transparency and utility is essential for increasing the impact of research and facilitating informed decision-making in the economic sphere. There is a need to identifying key utility factors that influence the implementation of economic and financial research and creating simplified tools and frameworks that translate complex research findings into actionable insights. This requires engaging stakeholders (through interviews, focus groups, or workshops) to gather insights into their needs and challenges in using research results, and ensuring that created tools are designed their practicality and relevance. On a theoretical basis, this formation of knowledge is grounded in the tenets of knowledge conversion theory, which posits the existence of an interaction pattern between knowledge providers and knowledge receivers (Nonaka, 1994).

Therefore, the main purpose of this study is to develop the Utility Factors Model (UFM) as a theoretical framework for evaluating the utility of academic research and improving knowledge transfer. It seeks to identify the key factors that motivate entrepreneurs to engage with academic knowledge and integrate it into their business operations, analyze their attitudes toward the transfer of economic and financial research and the challenges they face in applying academic insights, and develop a structured model that enhances knowledge translation while facilitating the integration of research findings into business and policy-making processes. Additionally, the study examines the role of research spillovers in fostering entrepreneurship and economic development, drawing on insights from the Knowledge Spillover Theory of Entrepreneurship (KSTE).

4. Methods

To explore knowledge transfer within economics and finance extensive literature study were applied using a narrative reviews method, encompassing a wide range of studies and providing a comprehensive summary along with interpretation and critique (Greenhalgh et al., 2018). A narrative literature review was carried out to gain an overview of the available evidence in this field, considering the potential for systematic bias. The narrative review is well-suited for emphasizing a holistic understanding of a phenomenon, serving as a starting point for understanding what has been studied and what still needs to be explored. It is sometimes classified as a type of systematic review of qualitative information (Siddaway et al., 2019). The value of a narrative review lies in its aim to develop new theories or conceptualizations by integrating studies with different themes or methodologies (Baumeister, Leary, 1997).

Moreover, qualitative research was selected for its effectiveness in describing, understanding, and interpreting phenomena, offering a comprehensive insight into various influencing factors (Merriam, 2009). Empirical investigations were conducted using a methodology consisting of multiple case studies (Yin, 2018) incorporating data

categorization, data contextualization and preliminary within-case analysis. The author used theory as a framework to structure the collected consistent with earlier recommendations (Yin, 1994). The theory presented at the outset of the study has been empirically validated, thereby establishing a foundation for analytical generalisation. Data collection was performed through computer-assisted web interviews. The study population was homogeneous, with a well-structured and focused research scope, allowing the saturation point to be reached after 44 interviews with Polish companies, as noted in Szulczewska-Remi (2024). The company selection process was guided by an aggregated profitability index, with principal component analysis (PCA) used to reduce dataset dimensionality while preserving key information (IBM, 2021). The study included companies from 19 different sectors, ranked by profitability from highest to lowest within each sector. To ensure a balanced representation, three companies per sector were selected: one with high profitability, one with average profitability, and one with low profitability, resulting in an initial sample of 57 companies. However, due to a limited number of firms engaged in academic collaboration, several interviews remained incomplete (Szulczewska-Remi, 2023). To address this, a second phase of data collection included 44 additional companies, chosen based on recommendations from Polish commercialization intermediary institutions (Technology Transfer Offices and Special Purpose Vehicles) with prior university collaboration experience. The study was conducted during the first two quarters of 2023. Of the selected companies, 40 were Polish and the remaining 4 were enterprises with majority of Polish capital. In terms of average annual employment, two companies employed up to 1001-7000 employees (full time employment), four companies 251-1000 employees, eleven companies 51-250 employees, sixteen companies 11-50 employees and eleven companies up to 10 employees. Most of the companies had a medium level of company's internationalization ($n = 18$, international operations), followed by low ($n = 14$, purely domestic operations) and high ($n = 12$) level of internationalization (mainly international operations). Most of the companies had experience of prior cooperation with universities ($n = 33$, on one occasion and $n = 14$, on regular basis). In most cases, respondents indicated cooperation with universities ($n = 20$) and technical universities ($n = 13$), followed by universities of economics ($n = 7$).

The semi-structured interviews were conducted in accordance with a pre-established research methodology, which included two questions (see Table 3). One of these questions was open-ended, allowing respondents to provide detailed responses. The qualitative data collected from these interviews were analysed to identify key barriers in knowledge transfer, which subsequently informed the development of UFM. This structured approach ensured that the model directly addresses real-world challenges faced by entrepreneurs and financial decision-makers, aligning theoretical constructs with practical business needs.

The methodological approach, combining qualitative research with multiple case studies, provided a nuanced understanding of how economic and financial knowledge is perceived and utilized by entrepreneurs. The structured interviews highlighted key challenges in knowledge

transfer, which directly informed the conceptualization of UFM as a tool to bridge these gaps (table 3).

Table 3.
Research protocol

The knowledge transfer at economics and business universities					
In evaluating the potential for knowledge transfer at economics and business universities, to what extent do you concur with the following statements? Please indicate the degree of your concurrence or otherwise with each statement on a 5-point Likert-type scale, where 5 signifies strong concurrence.					
	1	2	3	4	5
It is within the purview of economics and business universities to implement the results of commissioned studies or solutions based on research findings in companies.					
Economics and business universities are equipped with the capacity to undertake commissioned development work and research on behalf of companies, with the objective of addressing specific market or management issues.					
Economics and business universities are well positioned to provide expertise and opinions to industry.					
Economics and business universities are able to engage in consultancy and training activities.					
In which areas would your company be most interested in the findings of economics and business university research?					

Source: own development.

It was important to acknowledge the limitations of the research as it was possible that some of the visual and non-verbal clues that facilitate contextualising the interviewee, as seen in face-to-face interviews, may have been lost.

5. Results and discussion

In addition to the aforementioned study, an empirical investigation was conducted to gain insight into the knowledge transfer at the economics and business universities. Initially, the potential for knowledge transfer at economics and business universities was analyzed. In the context of this research, consideration was given to a range of higher education institutions, including universities and other business and economic schools referred to as economics and business universities. The majority of respondents indicated that universities of economics and business are capable of implementing the findings of commissioned studies or solutions based on research results in enterprises ($n = 21$). However, the same proportion of respondents expressed no opinion on this matter. Nevertheless, the overwhelming majority of respondents ($n = 32$) indicated that universities of economics are capable of undertaking development work and conducting research on behalf of companies with the objective of addressing specific market or management issues, and that they are able to provide expertise

and insights to industries ($n = 37$). Similarly, the respondents indicated that universities of economics and business are capable of engaging in consultancy and training activities ($n = 35$).

In response to the second question concerning the results of the research conducted at economics and business universities that entrepreneurs would be interested in, the respondents indicated the following types of research:

- “market research” (respondent 2) and “branch market research, and the potential of individual market segments research into the potential of implementing new products and services; and research in sales and business management models” (respondent 3), “exploration and analysis of foreign markets in the context of changing trends and legal and cultural conditions” (respondent 8), “Market analyses and opinions, analysis of business risks with specific projects” (respondent 19), “Market analysis, in particular forecasts and impact of trends, competition analysis, assistance in the development of strategies for new product lines” (respondent 20); “Analysis of foreign markets, analysis and development of business solutions” (respondent 28); “Analysis of potential markets such as transport, energy, renewable energy, own energy installations in the light of the highest rate of return” (respondent 32); “Global market research” (respondent 33);
- “Research targeting opportunities to increase sales volumes and identifying customer market preferences that determine the choice of a particular service/product provider” (respondent 33), “Marketing research on the development of functional foods in Poland and Europe. Research in the area of consumer communication (modern channels for reaching customers, both B2B and B2C)” (respondent 37);
- “tax law, EU and national funding possibilities for companies” (respondent 5);
- “a universal model (IT tool) capable of calculating the profitability of technical projects based on the input of basic financial data was also identified as a potential area of interest. It is evident that the tool must be comprehensible to engineers, rather than economists” (respondent 7), “Development of project profitability on the supplier (company) and customer (client) side” (respondent 24); “An economic analysis of the most profitable areas in the energy industry and analysis of the potential for increasing company value through R&D” (respondent 32).
- “Behavioral economics” (respondent 10);
- “Undoubtedly, ESG issues and HCare (medical market), in conjunction with technology and demographic issues” (respondent 14);
- “Project management, investment efficiency, planning” (respondent 15), “improvement of management and controlling methods” (respondent 19); “due diligence analysis of companies/projects to be purchased” (respondent 20);
- “Economic forecasting” (respondent 21);
- “Impact of AI development and tools based on this technology on local government operations etc :)” (respondent 16); “Research in the area of AI” (respondent 40);

- “The evolution of business models” (respondent 17);
- “In the area of R&D implementation, sustainability replication and exploitation of project results” (respondent 18); “commercialization on international markets” (respondent 25), “commercialization and implementation of R&D results in life-sciences” (respondent 31);
- “youth behaviour patterns/youth ethnographic research/product testing” (respondent 26);
- “In general, universities of economics and business should act as a focal point for other universities, assuming responsibility for the management and distribution of work” (respondent 28).

The conducted research revealed what potential users of economic and financial knowledge consider to have practical value. The diversity of these insights is understandable, due to the variety of respondents themselves. Particularly interesting is the last cited response from an entrepreneur, which, in a way, generalizes the issue of the university's role. Rather than addressing the respondent's specific needs, it critically evaluates universities. The research also shows that respondents perceive economic and business universities as capable of, firstly, providing expert knowledge; secondly, offering advice and training; and thirdly, conducting R&D activities. However, opinions are less consistent regarding universities' ability to implement research findings. The implementation aspect has a utilitarian dimension, and respondents are at least divided in their opinions about the practical applicability of academic research. Importantly, however, they believe that academics have the potential to conduct valuable research. Based on this understanding, we propose the development of a simplified framework for the utility of knowledge generated by universities by introducing a model of key utility factors.

While the focus of this study is on economic and financial knowledge, knowledge from other domains, such as technology, management, and law, also shapes business strategies and innovation. It is important to consider how knowledge from these fields contributes to business decision-making. In practice, entrepreneurs often rely on a combination of different types of knowledge, where technological advancements drive innovation, managerial expertise enhances operational efficiency, and legal insights ensure regulatory compliance. The integration of these knowledge domains suggests that future research should explore how interdisciplinary knowledge transfer can enhance business effectiveness. Additionally, knowledge transfer barriers may vary across industries, in terms of how businesses adopt and utilize academic insights. In the technology sector, a major challenge is the lack of efficient commercialization mechanisms, leading to a gap between theoretical research and market-ready innovations. In the service sector faces difficulties related to the misalignment of academic research with industry-specific needs, where theoretical findings may not directly address practical business challenges. In manufacturing, barriers often stem from high implementation

costs and the need for industry-specific adaptations. Recognizing these differences is essential for refining UFM and tailoring knowledge transfer strategies to industry-specific demands.

The proposed UFM directly supports entrepreneurial activity by providing a structured framework for assessing the real-world applicability of academic research. By systematically identifying utility factors, UFM enables entrepreneurs to evaluate the commercial potential of research findings, reducing uncertainty and bridging the gap between academia and business. This approach is particularly valuable in decision-making related to startup creation, innovation funding, and knowledge-based business models. Furthermore, the model facilitates structured knowledge exchange, allowing businesses to leverage academic insights for product development, market analysis, and operational strategies. The objective of this model is to facilitate a deeper comprehension of the ways in which academic research can be effectively integrated into business practice, thereby enhancing the theoretical understanding of knowledge transfer. The findings confirm that structured knowledge transfer mechanisms, such as UFM, can significantly enhance the practical impact of economic and financial research. This structured approach helps bridge the persistent gap between academia and industry, making research more accessible, actionable, and relevant to business practice. Incorporating KSTE reinforces the idea that knowledge spillovers, particularly those originating from universities, are a key driver of entrepreneurship. UFM helps structure and optimize these spillovers, making academic insights more accessible for business innovation.

6. Utility

The availability and reliability of information are paramount. Several transparent and useful factors can predict utility value in economics and finance research analogously like transparent reporting practices, such as the disclosure of financial statements and economic models, allow stakeholders to make informed decisions based on accurate data (Masry, 2015). The credibility of economic models is significantly enhanced when the underlying data and assumptions are made publicly available, enabling independent verification and reproducibility of results (Cohen, Wong, 2017; Hay, 2019). The manifesto resulting from the considerations presented above comes down to the following issues:

- Striving for enhancing transparency in research methodologies by advocating for standardized reporting guidelines that require researchers to disclose their methods, data sources, and analytical techniques clearly. By fostering transparency, researchers can build trust with stakeholders, making it easier for practitioners to apply research findings in real-world contexts.

- Creating simplified, user-friendly tools and frameworks that translate complex research findings into actionable insights. This aligns with the work of Searles et al. (2016), who emphasize the importance of measuring and encouraging research translation and impact. While UFM is rooted in knowledge transfer and transparency, it also serves as a practical tool for businesses by offering structured indicators that reduce uncertainty and bridge the gap between academic insights and business needs. By developing user-friendly formats, researchers can make their findings more accessible to practitioners, thereby increasing the likelihood of implementation in the real economy.
- Fostering collaboration between researchers and practitioners is essential for enhancing the utility of research. As noted by Haynes et al. (2011), the interaction between policymakers and researchers can significantly influence the utilization of research findings. Establishing partnerships, workshops, and forums where both groups can engage in dialogue will help ensure that research is aligned with the practical needs of the economy, thereby increasing its relevance and applicability.
- Promoting financial literacy and awareness among stakeholders who utilize economic and financial research. By educating practitioners about the utility of research findings and how they can apply them in their work, researchers can enhance the overall impact of their studies.
- Establishing and promoting feedback mechanisms is crucial to assess the effectiveness of research utilization in practice. This could involve collecting data on how research findings are applied and the outcomes of such applications. Understanding the barriers to research utilization can inform strategies to enhance integration into practice (Akerjordet et al., 2012). Feedback loops will allow researchers to refine their methodologies and outputs based on real-world experiences, ensuring continuous improvement.

The long-term perspective is to create a sustainable framework that facilitates the integration of economic and financial research with practical applications. The basic problem is to confirm that a simplified set of effective, accessible, and transparent indicators for economics and finance research, if available, will lead to an increase in the perceived utility of research outcomes for stakeholders. This should lead to facilitate informed decision-making among stakeholders, including academics, policymakers, practitioners, and the general public.

Below is illustrated initial concept of the approach to solving the undertaken research problem (figure 1). The diagram illustrates a theoretical model, which has not yet been tested, addressing the issue of utility value, as discussed in Siemiatowski (2016). Further work on the model concept will be focused on validation and improving the model, considering the empirical verification of utility factors and involving stakeholders.

RESEARCH PROBLEM What has been observed in economic life. A scientific problem, as opposed to current problems solved by, for example, start-ups.		COMPARATIVE ADVANTAGE Are there any, and if so, what, advantages do the results of the project covered by the study have over similar studies? Advantage over other studies with similar research issues.	
RESEARCH METHOD What method will be used to conduct the study to achieve the goals and obtain an answer to the research problem? Scientific method for solving a scientific problem	UNIQUE VALUE/ SOLUTION What unique value/solution can be proposed/bring to the economic life/organization/solve the problem What is the purpose of the project in terms of value for the economy?		STAKEHOLDERS Who does this study concern, where in the economic realities was the phenomenon observed, will the return recipients of the research results be the entities in which the phenomenon was observed?
OBJECTIVES What are the goals to achieve related to the problem studied? Scientific objectives.			IMPLEMENTATION METHODS How to implement the results into the economy, by what methods? A method of reaching recipients in the economy: publications, trainings, conferences, etc.
EXPENSES What expenses are required to conduct the research and develop the conclusions: time, material resources, sources, etc.? In the context of the research problem being solved, it should be considered that the expenses may be higher than the economic effects that can be achieved.		UTILITY What are the potential benefits, if any, that result from solving the research problem and implementing it in the real economy? Usability also in the qualitative dimension.	

Figure 1. Theoretical concept of UFM for research in economics and finance.

Source: own study.

Presented framework should be designed to be user-friendly and accessible, enabling stakeholders to easily understand and apply the findings of research in their decision-making processes. Framework should facilitate the translation of knowledge into practice and finally to established a sustainable ecosystem that supports the ongoing utilization of economic and financial research. It should lead to enhance the relevance and trust of economic and financial research by ensuring that it addresses real-world challenges and needs, clear reporting standards, and open access to data. This requires continuous engagement with stakeholders to identify pressing issues and aligning research objectives with these needs. By doing so, the research can contribute to more effective policy-making and economic strategies that are grounded in empirical evidence.

To effectively implement UFM and bridge the gap between academia, industry, and policymakers, a structured, technology-driven approach is essential. By leveraging AI, automation, and data-driven evaluation systems, businesses, universities, and governments can enhance the usability of academic research, ensuring its seamless integration into decision-making and innovation processes.

Businesses can enhance their use of academic research by developing AI-based evaluation tools that assess studies based on UFM indicators such as feasibility, market applicability, and financial impact. The integration of machine learning algorithms into decision-support platforms would allow companies to automate research assessments and filter studies that align with their strategic objectives. Additionally, structured knowledge intelligence platforms could be used to create digital dashboards where businesses rank, compare, and select the most relevant research based on UFM scores. To ensure long-term adoption, corporate training programs and e-learning courses should equip employees with UFM-based evaluation skills, helping them integrate academic insights into business strategies effectively.

Universities, as key drivers of knowledge creation, should implement text mining tools to pre-analyze research outputs and classify them according to UFM usability factors. Universities could systematically evaluate the applicability of research before publication and establish structured research repositories - digital platforms where academic findings are indexed and tagged based on UFM criteria - would significantly streamline the knowledge transfer process.

Structured research usability assessments should be mandated for publicly funded projects, ensuring that academic outputs are formatted in a way that facilitates direct application in business. To strengthen industry-academia collaboration, governments could support the creation of AI-enhanced matchmaking platforms, allowing businesses to seamlessly connect with relevant academic research based on UFM indicators.

7. Value

Unlike existing knowledge transfer models, UFM introduces a standardized, transparent approach to assessing research utility, addressing the disconnect between academic knowledge and business application. By integrating structured indicators, this model enhances research accessibility and supports evidence-based decision-making in entrepreneurship. This proposal contributes a simplified utility factors framework, improving economic and financial research implementation. Building on knowledge transfer frameworks like absorptive capacity theory (Cohen, Levinthal, 1990), UFM extends these by providing a structured tool for entrepreneurial decision-making. Integrating KSTE, it shows how academic research fuels entrepreneurship through commercialization and spillover effects, fostering economic growth. Unlike traditional models focused on technological innovation, it applies to economics and financial research, ensuring theoretical insights become actionable strategies. This contribution is significant in three ways: (1) creating a user-friendly framework to simplify complex research into utility factors, aiding policymakers and practitioners; (2) enhancing transparency to boost stakeholder confidence; and (3) facilitating knowledge translation—bridging academia and practice.

Additionally, UFM can train AI algorithms to identify utility factors in past research and streamline future knowledge translation, particularly for ex-post analysis.

By knowledge translating and developing tools and resources that facilitate the application of research findings, it bridges the gap between theory and practice. The introduction of UFM provides a systematic framework for enhancing research applicability, ensuring that economic and financial insights are not only accessible but also actionable. By integrating structured evaluation criteria, UFM enables businesses, policymakers, and researchers to better leverage academic knowledge for strategic decision-making. Future research should focus on empirical validation of UFM in various economic contexts, assessing its adaptability across different industries and policy environments. Further exploration of knowledge spillovers in entrepreneurial ecosystems could enhance the understanding of how structured transfer mechanisms, such as UFM, optimize the diffusion of academic insights for business and innovation. This aligns with the findings of Nguyen et al. (2019), who highlight the significance of design science research in producing innovative artifacts that contribute to knowledge accumulation. Improved decision-making by providing simplified utility factors, aligns with the findings of Drucker & Noel (1986), who emphasize the importance of innovation in enhancing organizational practices. Focus on transparency aligns with the principles of open innovation, as discussed by Mazzocchi (2004), who emphasizes the importance of collaboration and knowledge sharing in driving innovation. This approach allows for iterative design and refinement based on stakeholder feedback, ensuring that the final product is both practical and effective, thanks to produce a user-friendly framework for utility factors (Winter, Aier, 2015; Hevner et al., 2018; Sein et al., 2011).

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CONDITIONS AND CONSEQUENCES OF QUALITY DEVELOPMENT – FROM QUALITY 4.0 TO 5.0

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Purpose: To present the essence, advantages and threats of Quality 4.0 and Quality 5.0 and to indicate further development directions of quality management concepts.

Design/methodology/approach: The research methods used are a thematic review of literature on research on Quality 4.0 and 5.0 and surveys conducted among companies with certified quality management systems in the region of southeastern Poland.

Findings: The challenges and drivers of Quality 4.0 development are closely related to Industry 4.0 and are based on IT revolutionizing the business world. The implementation of Quality 4.0 solutions leads to the integrated and intelligent automation of quality standards. The research results show a growing interest in the implementation of Quality 4.0 and TQM 4.0 solutions. The increased focus on social satisfaction through an environmentally sustainable approach has been reflected in Quality 5.0 related to Industry 5.0 and Society 5.0.

Research limitations/implications: The main limitations of the conclusions presented in this article and the reflections described by the authors and other researchers include: the study does not offer long-term data on the outcomes of Quality 4.0 and 5.0 implementations, making it difficult to assess their sustained impact; the concepts of Quality 4.0 and 5.0 are still evolving, and the article does not provide universally accepted interpretation. The authors acknowledge a need to develop research on Quality 5.0 in the following directions: investigate the role of organizational culture, leadership styles, and employee training in successfully adopting Quality 4.0 and 5.0; explore how Quality 4.0 and 5.0 can be tailored to specific sectors (e.g., healthcare, education, manufacturing) to address unique challenges and opportunities; examine the balance between automation and human involvement in Quality 5.0, particularly in industries where human judgment and creativity are critical.

Originality/value: The article identifies the challenges related to contemporary approaches to pro-quality management of organizations and systematizes the concept of quality in the conditions of Industry 4.0 and 5.0, indicating its key aspects. It is addressed to researchers of quality management issues.

Keywords: Quality Management; Industry 4.0; Society 5.0; Quality 4.0; Quality 5.0.

Category of the paper: General review; conceptual paper.

1. Introduction

The approach to quality has changed over the centuries and has been the subject of interest of philosophers, economists, sociologists and psychologists. Quality is omnipresent in all processes accompanying the activity of economic entities. It is defined as a state to strive for, a dynamic goal, the basis of existence and competitiveness of companies, a determinant of success, a tool for improving products, services, data, knowledge, information, skills, communication, management, relationships and life. It shapes the trust and satisfaction of customers and their loyalty and contentment. Quality is a measure of the maturity of the actions taken. The quality approaches shaped by Americans, Japanese, and Europeans, including Poles, create a base that enables quality development in response to the emerging needs of entities operating in conditions of change, uncertainty and risk (Hamrol, 2023; Souza et al., 2020). Quality development cannot occur without reference to already proven solutions. However, the points of gravity in the approach to quality problems may change.

More than the “classic” understanding of quality is required today. The conditions in which Deming, Juran, Feigenbaum, Crosby, and Ishikawa lived and created were not burdened with such significant variability as today. Today, the quality category must be expanded to include references to globalisation and innovation. Digitisation, networking, and social media force a broader view of quality. Work is being undertaken in standardisation, integration of quality systems, Quality 4.0, environment, social responsibility, sustainable development, digitisation and artificial intelligence (Skrzypek, 2021a). Evolutionary changes in the approach to quality generate the basis for integration, supported by economic, social and organisational premises and the development of digital technologies, enabling real-time decision-making based on data of appropriate quantity and quality, available, collected and coming from various sources. The development of new digital technologies creates conditions for integration. It enables work to be done faster, better, with greater efficiency and at lower costs, leading to business process optimisation. Quality in the Industry 4.0 era is estimated to drive improvements in the entire value chain of organisations, enterprises, corporations and countries (All-about-quality 4.0, 2024).

Quality determines the level of maturity of the actions taken and enables the improvement of organisational processes. The solutions of the fourth industrial revolution are closely linked to quality in a feedback loop. It is estimated that 23% of digitalisation initiatives are quality improvements. Jacobs emphasises that "the arrival of the fourth revolution will affect everything we do. It connects people, machines and data in new ways, democratises technologies previously available only to a few and introduces transformational possibilities such as those in analytics, materials science and connectivity. These technologies are important for quality because they transform culture, leadership, cooperation and compliance" (Jacob, 2017a).

Product quality remains a key social and economic factor. Customers expect innovative technological solutions, high durability, safety, and ecological responsibility of the product, which puts quality at the forefront of the factors determining the organisation's success. Personalisation and sustainable development are essential here. Products are expected to meet customer expectations and be created with the environment in mind.

There are many reasons to justify the development towards Quality 4.0 and 5.0, and we live in the conditions of Society 4.0, which is currently transforming into Society 5.0.

Quality 4.0 is becoming a priority in organisations, fulfilling the promise of a future filled with seamless connectivity, evolving technological innovations, and the associated reduction of process variability. This affects organisations as new insights emerge and industry efficiency increases (Jacob, 2017b).

The article aims to present the essence, advantages and threats of Quality 4.0 and Quality 5.0 and to indicate further development directions of quality management concepts. The research methods used are a thematic review of literature on research on Quality 4.0 and 5.0 and surveys conducted among companies with certified quality management systems in the region of southeastern Poland.

2. The essence of Quality 4.0

Armani et al. (2021) emphasise that Quality 4.0 aims to strengthen existing approaches to quality, expand the scale of application of new technologies, and find ways to improve processes. It means digitalising quality management to integrate technological structures, processes and people.

Quality 4.0 is a concept that refers to promoting the implementation of modern management methods that are based on (Wawak, 2022a):

- co-creation of value through the integration of departments, processes and entire enterprises,
- a systemic approach to management, ensuring trust, transparency and cooperation,
- physical integration of organisational infrastructure with the network and databases, collecting and analysing live data on the functioning of the infrastructure,
- fast, adaptive learning and introducing changes before problems occur,
- using machine learning and artificial intelligence for monitoring, analysis and decision-making.

As a result of research conducted by Armani et al. (2021), the following stages of the evolution of Quality 4.0 were identified:

- Absent quality - lack of knowledge in the field of quality management, lack of activities aimed at quality planning.
- Elementary quality - basic knowledge of the traditional approach to quality, lack of knowledge relating to new practices, technologies, systems and tools.
- Traditional quality - basic knowledge of Quality 4.0 and Industry 4.0, no investment planning in this direction.
- Advanced quality - the organisation has average knowledge of Quality 4.0, does not practice it, but plans to implement technologies, tools and processes that will enable the growth of its potential in this direction.

Quality 4.0 - the organisation has advanced knowledge of Quality 4.0 and uses techniques, tools and processes that enable quality management to be linked with Industry 4.0.

Table 1 shows the evolution of quality towards its fourth generation.

Table 1.
Evolution of quality towards Quality 4.0

Phase	Quality control	Quality assurance	TQM	Quality 4.0
Range	Product	Processes	Organisation, people	TQM, systems, stakeholders
The importance of quality	Checking	Projects	Strengthening	Innovations
Functions	Technical characteristics, statistical control of processes and deviations, corrections	Built-in process quality. Process and certification efficiency. Prevention	Organisational objectives related to certification. Quality as a strategic imperative. Continuous improvement	Suppliers, customers and society are integrated. Focus on data and digital tools providing new and up-to-date information.

Source: Sader et al., 2019.

2. Definitions of Quality 4.0

Gunasekaren et al. (2019) indicate that the first publications on Quality 4.0 appeared after introducing the term Industry 4.0. Watson (1998) predicted the concepts that comprise "Quality 4.0" more than 20 years ago. He drew attention to the availability of telecommunications technologies, the Internet, personal computers, networks, and machines with built-in intelligence. He believed these solutions could improve individual quality functions concerning data, processes, and products and improve quality analyses in an automated manner. The directions for the development of quality management research are expanding. A review of the database of journals analysed in terms of interest in Industry 4.0 and Quality 4.0 showed

the research is at an early stage (Wawak, 2022a). Quality 4.0 has not yet been defined in one widely accepted way. Researchers are trying to describe it by indicating its characteristic features. They point out that it is a concept that refers to the implementation of modern quality management methods, which are based on, among others (Skrzypek E., Skrzypek A., 2023; Wawak, 2022a), the co-creation of value through the integration of departments, processes and entire enterprises, system departure to management, cybernetics, ensuring trust, transparency and cooperation, integration of the organisation's physical infrastructure with the network and databases, collecting and analysing live data on the functioning of the infrastructure, fast, adaptive learning and introducing changes before problems appear (prediction), using machine learning and artificial intelligence for monitoring, analysis and decision-making.

Aldag and Eker (2018) defined Quality 4.0 as combining traditional quality management practices and techniques with new technologies. Such integration has resulted in an advanced collaborative environment where management activities are based on better connectivity in the value chain from supplier to end customer.

Schönreiter (2017) defined Quality 4.0 as integrating and synchronising data-related technologies to production processes and activities with quality management in real time. Quality 4.0 has to be connected with real-time analysis systems that can monitor, analyse, and control the entire value chain to take all necessary countermeasures to prevent production downtime or product rejection.

Hamrol (2023) believes that Industry 4.0, Technology 4.0, Products 4.0, and Society 4.0 create the construct of Reality 4.0, indicating that the processes and phenomena of the fourth industrial revolution somewhat inspire every person's life. Reality 4.0 includes Economy 4.0, Education 4.0, Medicine 4.0, Quality 4.0, etc.

Jacob (2017b) defined Quality 4.0 as leveraging traditional quality management techniques acquired by modern technologies to achieve a new level of excellence at the functional and operational levels. He argues that Quality 4.0 technologies lead to effective and efficient quality management, which increases market share, stimulates innovation, improves the ability to cope with value chain challenges and improves brand recognition (Jacob, 2017a). Business leaders should strive to achieve Quality 4.0. Otherwise, their company will be marginalised and be on their industries' sidelines (Jacob, 2017b). Allcock (2018) emphasised the difference between Quality 4.0 and traditional quality as a shift from manual measurements, recording results on quality charts and re-tuning the production process to fully automated operations, where sensors measure, applications analyse, and control the auto-tuning process (regulation, tuning). Chiarini and Kumar (2021) indicate that Quality 4.0 is associated with a shift towards total customer satisfaction and experience, innovation and sustainability; it refers not only to functions but also means exceeding customer expectations. It includes the overall customer experience, user convenience, after-sales service and environmental impact. Koc (2007) indicates that Quality 4.0 means that products provide positive customer experiences and are consistent with ethical and sustainable practices. An integral part of the perception of quality is information

transparency, which enables access to the Internet and the development of e-commerce. He emphasises the role of prosumers. Quality 4.0 requires the development of quality standards in the form of ISO 9001 standards, Six Sigma and Lean Manufacturing practices, which are proven tools for quality improvement and enable the elimination of waste. Skrzypek and Skrzypek (2023) indicate that Quality 4.0 requires developed organisational knowledge and access to the latest data, information, and technological solutions operating in this area. Training, new competencies, and care for up-to-date knowledge are necessary. Applying acquired knowledge in action is a condition for improving the quality of products and services and implementing projects that lead to the organisation's improvement, maturity, and competitiveness in operating in conditions of change, risk, and uncertainty.

The relationship between knowledge and the optimisation of the communication process, as well as the development of quality, are also highlighted by Gomes, Oliveira, and Chaves (2016). It is important to note that Zonnenshain and Kennett (2020) indicated that in the 21st century, quality serves as the foundation for the integration of various fields and characterized it as a discipline grounded in source data. Employing modelling and simulation for evidence-based quality engineering, utilising non-conformity monitoring alongside quality prediction, and embracing integrated quality management enable the merging innovation quality with innovation management. Furthermore, one cannot overlook the impact of advancing automation and artificial intelligence on predictive data analysis, the integration of reliability engineering with quality engineering, and the enhancement of information quality.

Taking into account the presented views, the authors believe that Quality 4.0 integrates digital technologies such as AI, IoT, and real-time analytics with traditional quality management to enhance decision-making, customer experience, and operational efficiency.

3. Quality 4.0 and Industry 4.0

Quality 4.0 refers to Industry 4.0 (Sony et al., 2020; Wawak, 2022b), which combines technical, information, communication and material models with traditional management models related to quality and closely related categories of excellence. At the same time, assigning decisive importance to technology in Industry 4.0 may be a source of problems in the quality area. The tools, techniques, and methods used so far, as well as the principles of quality management, will still be applicable in the conditions of Industry 4.0 in quality management. Still, solutions are needed to enable more effective collection, storage, processing and analysis of large data sets to make accurate real-time decisions (Jarvis, 2018). This is possible, for example, by using sensors, laptops, artificial intelligence algorithms, the Internet of Things or cloud computing. These changes must be introduced while maintaining the principles of quality management, which put people, their involvement, creativity, innovation and openness

to learning at the centre of attention (Hamilton, 2020; Hong et al., 2021). The components of Quality 4.0 include:

- Data and analytics - data plays a key role in making people informed and accurate decisions, while analytics enables the disclosure of information about raw data.
- Links between business information and operational technology.
- Scalability - processes and best practices must be scalable to ensure quality and uniformity.
- Application development - the role of interactive devices in augmented and virtual reality is rapidly growing (Abou-Zahra et al., 2018).
- Active leadership that has a significant role in promoting and implementing Quality 4.0 initiatives.
- Compliance - modern tools enable the assessment of the organisation's compliance systems and strategies.
- Management systems and system connectivity are essential operational elements of Quality 4.0. Quality management systems and other management systems integrate quality processes and provide data throughout the product life cycle, which can improve the organisation's ability to manage errors and delays effectively.

Digital transformation requires appropriate technologies that are also used in the area of quality management (Jacob, 2017a; Liboni et al., 2019; Reagan, Singh, 2020):

- AI technology: chatbots, robotics, computer vision, personal assistants.
- ML (Machine Learning) based technologies for fraud detection, object categorisation and prediction.
- Blockchain-based approaches to increase transparency and trustworthiness of information and asset transactions.
- Big Data and tools for handling and evaluating large amounts of data- using data to combine different data sets, categorise them, find helpful information and reduce large amounts of observational data to the most important factors.
- Deep Learning, including complex pattern recognition, sound and art creation, time series prediction and image adaptation.
- supporting technologies, e.g. Cloud Computing, Augmented Reality, Virtual Reality, sensors, Internet of Things, and Data Streaming.

People's creativity is the condition for developing the full potential in the automation of production processes. Automated production using conventional industrial robots is related to tedious programming. At the same time, robots cooperate directly and flexibly with employees; this causes production to gain new dynamics and releases new potential because robots take over standard processes while humans are involved in other activities that create added value. An employee using a robot, a so-called Cobot, as a multifunctional tool, e.g. a packaging machine, a palletiser, etc., feels significant relief and can focus on other, more important types

of work. A robot cannot replace human work but can supplement it by performing difficult, routine and even dangerous tasks. Artificial intelligence is also important because it performs tasks within assigned structures and develops its solutions through independent analyses. This, in turn, saves time for employees, who can continue to work more efficiently with specific results (Krill, 2024; Mills, 2020; Nahavandi, 2019; Omar, Nehdi, 2017).

Taking into account the developing research in the field of Quality 4.0 and their results presented in publications, selected characteristics of Quality 4.0 as an aspect of Industry 4.0 can be indicated:

- A priority in organisations that fulfils the promise of a future filled with seamless connectivity, evolving and innovative technologies and the associated reduction of process variability.
- A motive and test of efficiency and effectiveness of action.
- A factor shaping organisational maturity.
- A tool for improving management, products, services, knowledge, information, competencies, relationships, life.
- A determinant of success in conditions of variability and risk, uncertainty, lack of continuity of operations, a dynamic goal in conditions of environmental variability.
- An instrument shaping interpersonal relations.
- A signal in the process of shaping intellectual capital.
- A tool for integrating engineering with the concept of value and human satisfaction in the process of striving for perfection of all kinds.
- A set of tools for building trust.
- A concept that defines technologies, practices and processes aimed at quality management, which enable manufacturers to develop and maintain appropriate standards throughout the supply chain from research and development through procurement, production, logistics, sales, after-sales services and other corporate functions to administration and management.
- Complementing the concept of Industry 4.0, including machine learning, predictive analytics, Internet of Things, big data, and cloud computing, which, combined with traditional quality management systems such as QMS software, enable continuous improvement and improvement of overall business performance.

Skrzypek (2019, 2020, 2021b, 2023), based on the conducted research, indicated that Quality 4.0 is defined as a multi-aspect approach to quality, a platform enabling the use of digital tools in the process of optimising business processes, an approach creating broad opportunities for the development of quality management practices based on ISO 9000 standards, a tool for improving business efficiency, technology and a new way of quality management, a dynamic concept, an instrument for improving comprehensively understood efficiency, productivity and organisational maturity, solutions improving processes, solutions

improving processes, tools for intelligent quality management, a concept justifying standardisation 4.0, a platform for real-time process control and a chance for success.

The approach to Quality 4.0 is combined with the concept of promoting the implementation of modern management methods, which refer to prediction, wider use of machine learning and artificial intelligence solutions, efficient data collection and analysis, creating conditions for the integration of the organisation's physical infrastructure with the network and databases, co-creation of value and a systemic approach to ensuring transparency, trust and cooperation (Skrzypek, E., 2021a, 2021b; Souza et al., 2022). The keys to the development of Quality 4.0 are strong leadership for quality, quality measurement, training in the area of quality, developed quality culture, ongoing data acquisition and processing, analysis of large data sets, real-time decision-making, strong integration, developed competencies of the future, including digital ones, development of multidisciplinary teams, support and development of innovation and the use of the "Open-Quality" concept, which allows for the connection of quality experts with data analysts, which should support the adoption of solutions brought by the fourth industrial revolution.

There is a need to invest in Quality 4.0, which requires investment in technologies. Digital technologies are revolutionising the business world, and innovation is the key to the success of every organisation. So far, attention to quality issues has been focused on products and services, including the quality of products (What is Quality 4.0, 2021). In the conditions of Quality 4.0, more attention must be paid to the quality and security of data-related services. In addition, a significant part of the tasks performed by quality specialists are taken over by IT systems that can analyse data, interpret it, and propose solutions. At the same time, not all problems in quality management can be computerised and automated; it is necessary to develop the so-called competencies of the future (Skrzypek, 2023).

Quality 4.0 aims to strengthen existing approaches to quality, expand the scale of application of new technologies, and find ways to improve processes, which means digitalisation of quality management to integrate technological structures, processes and people (Arsovski, 2019). Assessment of the need for technological progress should consider aspects of feasibility and profitability, and it is also necessary to answer the question: Why are we developing technology? Here, business, science, government and society should clash.

Management must be subordinated to quality, which has become the central point of modern management of production and service organisations.

Quality 4.0 refers to the digitalisation of the total quality approach (TQM), in which effective ways of influencing the quality of technology, processes and people are sought (Chiarini, 2020). According to Chiarini (2020), this phenomenon combines intelligence and automation to increase efficiency and create conditions for real-time decision-making involving stakeholders to ensure greater transparency. The digitalisation of management methods also concerns quality management methods because the amount of available data is increasing, IT systems are being integrated, the Internet of Things and Services are being used on a wider

scale, and it is expected that the time needed to make decisions will continue to shorten (Sony et al., 2020). TQM involves coordinating decisions to achieve optimal quality, i.e., the quality expected by the customer and the organisation.

Quality 4.0 reduces defects, enables personalization, improves efficiency, and fosters data-driven transparency. When pointing out the effects of Quality 4.0, it should be emphasised that:

- Digital transformation leads towards integrated and intelligent automation of quality standards, which should translate into profitability and success of the organisation as well as increased efficiency and competitiveness (Wawak, 2022a).
- Quality 4.0 is reflected in research and development, which should be reflected in the quality of projects because comprehensive integration in Industry 4.0 will enable designers to access data and analyse it, which should translate into increased adaptability through faster response to changes in demand and shorter information processing time (Seon et al., 2018).
- Digitalisation and automation improve the quality of processes, automated systems facilitate machine learning, and there will be quick access to data from production processes and customers, which will enable better mapping of customer needs and production of products that better meet their needs and expectations (Liboni et al., 2019).
- Digitalisation of quality management enables real-time data telemetry, and advanced machine learning algorithms are emerging (Jarvis, 2018).

Quality and effective quality management in all management areas are good platforms for integrating management systems because they facilitate access to data, more efficient management, and real-time decision-making. In the conditions of the fourth industrial revolution, this is a desirable solution. Methods, techniques, and quality management tools must be adapted to the requirements of the digital revolution and integrated with IT systems.

The benefits of Quality 4.0 resulting from the research include (Liboni, 2019; Seon et al., 2018): improving process management in the organisation, gaining long-term competitive advantage resulting from quality, effective risk and opportunity management, optimising the quality cost structure, reliable quality assurance of all processes, faster and more complete identification of customer or other stakeholder requirements.

In addition, the following are indicated (Wawak, 2022b): improving the prevention of quality problems already in the design and development phase, broader involvement of employees in decision-making processes at various management levels, shortening the time of current order fulfilment, and increasing the flexibility of response to product and process deviations from specifications. Researchers also point to the possibility of achieving compliance at the 6 sigma level, the possibility of mass personalisation of products. Thanks to Quality 4.0, leaders receive data needed for monitoring, efficiency, quality, and estimating the real costs of good and bad quality.

The following barriers to the implementation of Quality 4.0 are identified (Wawak, 2022b): too high investment and time requirements, lack of a long-term quality management strategy in the organisation and the need to acquire completely new knowledge by many employees of the organisation, often passive approach and reluctance of top management or the owner, current lack of financial resources and difficult communication and cooperation between quality management staff and IT specialists.

In 2020, at the Maria Curie-Skłodowska University in Lublin, in the Department of Intellectual Capital and Quality, research was conducted on Industry 4.0 and Quality 4.0. The online survey was addressed to 300 enterprises with a certified QMS; the enterprises are located in Poland. The statistical analyses were based on the responses from 100 surveys. A tag cloud indicated the respondents' definition of Quality 4.0. The most frequently mentioned definitions were: comprehensive definition of quality (43.1%), technology and a new way of quality management (42.2%), a new way of quality management (42.2 %), a tool for improving the management of an organisation supported by IT technologies, an opportunity to increase productivity (30.4%) (Skrzypek, E., 2021b).

The links between quality and important problems from the point of view of the functioning of quality-oriented enterprises were also indicated. These studies show that Quality 4.0 is associated with (Skrzypek, E., 2021b):

- Reducing costs by avoiding failures and eliminating downtime.
- Supporting business through rapid response, anticipation and taking proactive actions with less employee involvement.
- Its use on production lines, warehouses, retail and remote offices, i.e. in the entire lifecycles of goods and services.
- Correlating current data from various sensors (5G) with historical data, which opens up new business opportunities.
- The Internet of Things and progress in the fourth industrial revolution.

The following directions of research are indicated as related to TQM and Industry 4.0 (Wawak, 2022a):

- Technology-related area: how to manage quality through digitalisation and automation of processes while ensuring security, privacy and data protection.
- Area related to quality: is it possible to assess the maturity (stage of development) in terms of the organisation's adaptation to TQM 4.0.
- The area related to people management: how to prepare quality management specialists to acquire the skills necessary to cope with the challenges related to Industry 4.0 (e.g. the use of big data), how to help employees who have been involved in quality management for a long time to adapt to emerging changes (e.g. quality monitoring), using online platforms in real-time.

TQM 4.0 is focused on creating and designing analogue and digital measurement systems, saving the collected data for analysis, and, based on the obtained results, improving the production process in terms of quality (Sader et al., 2019).

4. Quality 5.0 as a new concept of quality and social satisfaction

The idea of Industry 4.0 is already represented in many industries and companies. However, its human-centric and pro-ecological reorientation and integration with technological achievements are being observed, referred to as Industry 5.0. Therefore, the definition of Quality 5.0, referring to the concept of Industry 5.0, assumes that it is the satisfaction of all stakeholder groups while meeting social needs through a sustainable approach to environmental issues. Organisations' future strategies must focus on all groups of stakeholders, including competitors. All social and environmental problems must be included in the development strategy of enterprises within the fifth generation of quality management, Quality 5.0, towards social satisfaction. Therefore, there is a need to develop new approaches, methods, tools, and a new quality function to support organisations in sustainable business development. Adopting the Quality 5.0 concept is expected to create conditions for the dynamic, sustainable development of companies. Quality 5.0 from 2020 reflects a new era marked by digital transformation, growing automation and awareness of the impact on the environment and society (Deleryd, 2020). This approach is based on Industry 5.0 (Nahavandi, 2019). Defining the concept of Quality 5.0 is increasingly associated with innovation, technology and sustainable practices. It is noticeable that in this context, expectations arise that high-quality products and services will be able to provide users with exceptional experiences, enriched with digital interfaces and artificial intelligence, and at the same time, will be sustainable and will positively impact society. As part of quality 5.0, manufacturers will use advanced technologies, e.g. artificial intelligence or analysis of large data sets, to accurately predict customer needs and personalise the experience, improving the quality of the market offer. In a closed-loop economy, quality is redefined, and principles related to waste reduction, recycling and manufacturing products that do not harm the environment are important. Quality 5.0 considers customer satisfaction, innovation, social impact and sustainable development.

Quality 5.0 is, according to J. Frick and P. Grudowski, the fifth evolution of quality management principles, which reflects the transformational impact of new technologies and holistic quality concepts on industrial processes. It emphasises the quality of the product and service and a holistic view encompassing sustainable development, customer satisfaction, employee involvement and social responsibility. They formulated the principles of Quality 5.0, indicating its components (Frick, Grudowski, 2023):

- Design: Design software solutions enable the creation of virtual product prototypes and appropriate testing before a physical prototype is created. This leads to more precise quality control during the design phase.
- Production: Monitoring production and identifying and correcting errors in real time are enabled by advanced technologies, such as the Internet of Things, automation, robotics, and artificial intelligence. This leads to minimising waste, reducing machine downtime and creating the basis for the final product to meet the highest quality standards.
- Inspection: Technology solutions enable computer vision systems to use artificial intelligence in automatic inspections, which helps identify defects with greater accuracy. Machine learning algorithms constantly learn, allowing for increased quality control accuracy and reliability.
- Data analysis: data analysis and machine learning are used to analyse large data sets generated during production. As a result, patterns and trends related to quality issues can be identified, allowing for further quality improvement through proactive quality control.

The concept of Quality 5.0 is consistent with the concept of Society 5.0. The Japanese government's 5th Science and Technology Basic Plan 2020 proposed Society 5.0. There is a need to incorporate new CSR and environmental care solutions into the principles of quality management. Japan has developed a plan to move from Industry 4.0 to Society 5.0. The Japanese government has adopted a plan in which all aspects of society, including industrial work, are shaped by the latest techniques and technologies. Economic growth will occur through artificial intelligence, further robotisation of society, automation of industry and faster communication. Revitalising management models using new measures of social satisfaction is the first step towards achieving future profitability, a sustainable future and lasting organisational success. Referring to the conditions for developing Quality 5.0, it should be pointed out that new solutions, concepts, methods, techniques and tools will be necessary to support Quality Management 4.0 and 5.0 and enable real-time decision-making in quality (Deleryd, 2020). Scientific research must be conducted to establish the theoretical foundations for Quality 4.0 and 5.0 and to provide guidelines for their implementation within the realm of Quality Management 5.0 in enterprises. In the context of Industry 5.0, understood as a technological transformation, emphasis is placed on collaboration between human beings and advanced technologies to achieve high and sustainable production quality (Liboni, 2019). Quality 5.0 creates a platform for integrating quality control with the production process, focusing on proactive measures to prevent defects and inefficiencies. There are two approaches to product quality control: one is the direct testing of product quality, while the other is testing process quality. Quality 4.0 engages in both approaches, addressing challenges identified by manufacturers. Quality 5.0, in the area of control, represents a proactive approach to replacing the traditional control model, which concerns itself with identifying and removing defects after

production. This shift includes continuous monitoring, predictive analytics, and real-time corrections to prevent defects before they occur (Nahavandi, 2019).

However, the following problems associated with Quality 5.0 should be addressed (Frick, Grudowski, 2023):

- Shaping new roles of quality managers in integrating economic, environmental and social aspects for sustainable development.
- The growing role and importance of management teams working with co-producers, collaborators and business competitors, exploring the role and scope of decision-making through artificial intelligence and machine learning.
- Measurement adaptation: moving from previously used customer satisfaction measures to society's satisfaction based on existing and new ones, including social, environmental and economic factors in the fifth generation of quality.
- Searching for tools enabling efficient management of the transition from the fourth to the fifth generation of quality implies a change in the main values of external stakeholders.
- Solving the problem of how a company's internal core values can be aligned with the external core values desired by society.

Summary

The approach to quality has changed over the centuries. In the conditions of the fourth industrial revolution, Quality 4.0 appeared, and its components included data and analytics, connections between business information and operational technology, scalability, application development, leadership, compliance, and management systems. It is a concept defining technologies, practices and processes aimed at quality management. The challenges and keys to developing Quality 4.0 are strongly related to Industry 4.0 and are based on information technologies that revolutionise the business world. Implementing Quality 4.0 solutions leads to the integrated and intelligent automation of quality standards. The research results prove the growing interest in implementing Quality 4.0 and TQM 4.0 solutions. Paying more attention to social satisfaction through an environmentally sustainable approach was reflected in Quality 5.0 associated with Industry 5.0 and Society 5.0.

The main limitations of the conclusions presented in this article and the reflections described by the authors and other researchers include:

- The article primarily relies on literature reviews and theoretical discussions, providing limited empirical data or case studies to substantiate claims regarding the effectiveness of Quality 4.0 and 5.0 implementations.

- The study does not offer long-term data on the outcomes of Quality 4.0 and 5.0 implementations, making it difficult to assess their sustained impact.
- The concepts of Quality 4.0 and 5.0 are still evolving, and the article does not provide universally accepted definitions, which may lead to interpretation issues.

The authors acknowledge a need to develop research on Quality 5.0 in the following directions:

- Investigate the role of organizational culture, leadership styles, and employee training in successfully adopting Quality 4.0 and 5.0.
- Track the implementation of Quality 4.0 and 5.0 over time to assess long-term effects on organizational performance, sustainability, and stakeholder satisfaction.
- Explore how Quality 4.0 and 5.0 can be tailored to specific sectors (e.g., healthcare, education, manufacturing) to address unique challenges and opportunities. - Develop and test metrics for evaluating the environmental and social impact of Quality 5.0, aligning with its focus on sustainability and societal satisfaction.
- Examine the balance between automation and human involvement in Quality 5.0, particularly in industries where human judgment and creativity are critical.
- Investigate the ethical implications and data privacy challenges associated with the use of advanced technologies (e.g., AI, IoT) in Quality 4.0 and 5.0.

By addressing these limitations and exploring these future research directions, scholars and practitioners can deepen their understanding of Quality 4.0 and 5.0, paving the way for more effective and sustainable quality management practices.

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AWARENESS OF KNOWLEDGE AND INNOVATION OF EHEALTH: SIMILARITIES AND DIFFERENCES IN THE ASSESSMENT OF EHEALTH PORTALS AND MHEALTH APPLICATIONS IN STUDENTS' PERSPECTIVE

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Purpose: The aim of the article is to identify students' views on the possibilities of using modern information technology tools in prevention and health protection at the University of Economics in Katowice, divided into distinguished fields of study.

Design/methodology/approach: The main research tool was an electronically distributed survey questionnaire (Computer-Assisted Web Interview). The research was conducted in mid-2023. The obtained results were reduced to comparability by counting percentages in individual answers to questions. To analyze the differences between fields of study, urban and Euclidean distances were calculated. Additionally, hypothesis H₁ was put forward about a statistically significant differentiation of the obtained answers. The measure was the right-sided F-Snedecor test.

Findings: The presented results are part of the research on knowledge and awareness and the use of modern IT tools to improve the living conditions of society. Obtained results identify students' views on the use of portals and mobile applications (mHealth) in the field of eHealth, while the hypothesis about significant differentiation was verified only in 9% of cases.

Research limitations/implications: The limitation of this study was that it was based only on a single university and young people from the academic environment. Nevertheless, the conclusions presented may help shape the policy of building and using portals and Internet applications in prevention and health protection by students – potential, future IT specialists, and companies involved in their construction and modification at present.

Originality/value: The uniqueness of this study lies in its focus on the analysis of the views of a specific group of end users on the possibilities of using IT tools across the fields of study, at the distinguished university.

Keywords: prevention and health protection, information technology in health protection, awareness of the possibilities of using IT in health protection, differences in opinions about eHealth by field of study.

Category of the paper: Research paper.

1. Introduction

The issue of broadly understood health protection, including the promotion of a healthy lifestyle and planning its protection after the COVID-19 pandemic, has become particularly important in the social, economic, and – as it turned out – also technological policies of the governments of individual countries (Omari et al., 2021). Particularly dynamic growth, due to the imposed restrictions on movement and interpersonal contacts, occurred in the use of information technologies for this purpose. Health threats caused by the pandemic resulted in an avalanche of interest in eHealth portals and mobile applications (mHealth). Even if these needs have decreased somewhat after the end of the pandemic, due to the lack of the need to register vaccinations or remote consultations, it seems that the remaining awareness of the convenience of using most eHealth functionalities has remained. We undertook research on this topic due to the importance of the issues they concern. The scope presented in this article is fully consistent with previous comparative studies conducted for the University of Economics in Katowice and the University of Warsaw, concerning not only comparisons of general opinions expressed by students of these universities but also comparisons in regional and gender cross-sections. The current article is a detailing of previous studies (Chmielarz, Sołtysik-Piorunkiewicz, 2024) and focuses on the one hand on the identification of opinions on eHealth portals and mobile applications (eHealth) and the comparison of these opinions in the cross-section of two courses of study at the University of Economics in Katowice (informatics and management of the total of respondents from other courses).

Analysis of the impact of IT on prevention and health care is widely present in the literature (see section 2), but it mainly concerns problems related to health threats, methods of preventing these threats, methods of treatment, and, perhaps even above all, methods of communication with doctors and health care facilities (Sołtysik-Piorunkiewicz, 2018). While in the former topics, the role of IT is primarily reduced to providing competent information on individual diseases, methods of their treatment, drugs, and paramedicines; in the second field, IT offers complete procedures for searching for public and private health facilities, with a full range of possibilities for registering with the right doctor at any time, issuing prescriptions, providing advice, etc. The application of artificial intelligence (AI) or remote control of surgical operations, decision-making support in rare but recognizable clinical cases, etc. are also being analyzed more and more widely (Cameron, Ramaprasad, Syn, 2017). However, cases of examining the awareness of future patients are rare, especially young ones, i.e. those who reach for online communication rarely in their cases, more often for their loved ones or friends (Octavius, Antonio, 2021). Even rarer – for such environments that may constitute not only a potential customer base but also, from a professional point of view, become designers and/or makers of tools for on-site or remote service of this, as we have shown, social and economic field. The lack of their assessments and opinions, with recommendations, does not allow for

a reliable pre-design or pre-implementation analysis – preceding the construction and implementation of IT tools into reality. The effects of the lack of recognition of the current state are visible in the knowledge and social awareness of eHealth portals and mobile applications, sometimes too complicated for the average person. This constitutes a research gap that can be filled, together with the previous ones, by the presented studies.

Therefore, the article aims to identify and compare the views of students of informatics and management at a selected university on the possibilities of using modern information technology tools in prevention and health care. As mentioned earlier, on the one hand, they are clients of these tools, on the other – soon – they may design such systems (e.g. management students) or create them (e.g. IT students). The scope presented in this article is consistent with previous comparative studies conducted for the University of Economics in Katowice and the University of Warsaw, concerning not only comparisons of general opinions expressed by students of these universities but also comparisons in regional and gender cross-sections. An attempt was also made to make international comparisons between Poland and Turkey.

To achieve this aim, the following structure of the article was adopted. The first section introduces the subject matter of the issue, presents the research problem generally presents the state of previous research, and identifies the research gap and its goals derived from it on this basis. The next section synthetically presents the research conducted on the subject of IT in health care and, against this background, the originality of the conducted research. Then, the research procedure, research sample, and research methods are presented. The fourth section contains an in-depth analysis of the obtained results. A discussion of these results is presented in the fifth section. The last section contains conclusions summarizing the research, describing its limitations and resulting directions of future research.

2. Literature review

The World Health Organization (WHO) adopted a definition of health in its constitution, which states that: health is not only the absence of disease or disability but full physical, mental, and social well-being (Światowy Dzień Zdrowia - 7 kwietnia 2023 r., no date). The definition shows that it is also a social dimension that makes people able to maintain relationships with others. All this affects the multi-faceted perception of the issue of human health (Maszczak, 2005).

Dynamic social, economic, and technological changes make it necessary to "manage health", meaning providing the population with easily accessible, effective, and appropriately high-quality health care, but also prevention, promotion of a healthy lifestyle, sports, etc. This comprehensive and complex phenomenon is influenced by various factors, including profound technological changes that have allowed, among other things, to mitigate the effects

of the COVID-19 pandemic (Giansanti, 2021). The diversity of the health management phenomenon simultaneously occurs in separate areas of activity undertaken in broadly understood health care: disease prevention, pro-health behaviors, and health care planning.

Disease prevention consists of the possibility of avoiding or stopping the disease through skillful action preceding the disease state: the use of stimulants (e.g. smoking, excessive alcohol consumption, drug use, overweight and obesity, lack of physical activity, or stress). They are the cause of many diseases such as hypertension, atherosclerosis, heart attacks (Chomik, 2019), and cancer (Tokarczyk, Kloc, 2020). Health education can help reduce the impact of these phenomena, which is also widely possible via the Internet using social networking sites. The Internet also widely promotes physical activity, healthy eating, or regular monitoring of one's health through preventive examinations. Reaching the elderly is not always possible via the Internet by choosing the right doctor who, in addition to preventive examinations, will also feel the need to educate them about proper health behaviors. Screening tests are also important to detect possible irregularities and early symptoms of the disease (Aniśko et al., 2020). In this way, a quick response can be taken by visiting the appropriate specialist. Institutional restrictions are also important – a ban on buying alcohol at certain times, or a ban on the consumption of energy drinks by young people. Health-promoting behaviors are conscious choices and actions taken by individuals to support health, prevent disease, and improve their general physical and mental condition (Gruszczyńska, Bąk-Sosnowska, Plinta, 2015). They concern many areas of life, in which, after implementing appropriate actions, they will result in improving health or preventing its deterioration. The greatest impact of these phenomena is: an appropriate diet (healthy eating pyramid) (Olszak, 2018), proper working conditions, regular examinations, personal hygiene, giving up habits, etc.

Healthcare planning consists of creating a strategy for organizing and managing health or treatment in order to provide the patient with the best possible care. The most important thing here is the choice of a health facility and doctor, regular check-ups on health through preventive examinations and consulting them with your doctor, in the case of chronic diseases – treatment in accordance with the doctor, i.e. regular taking of medications and monitoring health status by monitoring test results. Unfortunately, many patients forget about the regularity of these activities, hence the emergence of more and more portals and mobile applications on the market that remind patients of the mandatory taking of medications or the next recommended dates of visits for tests. You can also consider using an appropriate device, such as a smartphone or smartwatch, which will regularly measure specific parameters of our health in everyday life to best control the disease (Bogusławski, Czech, 2019). The above actions allow you to partially prevent such challenges as reducing the cases of people affected by chronic diseases. Data from WHO show the scale of the problem presented above. WHO analysis indicates that 74% of all deaths in the world are caused by chronic diseases of the circulatory system and respiratory system, diabetes, strokes, or cancer (Noncommunicable diseases, 2023). Therefore, such a significant challenge in the current times is to pay special attention to stopping the

development of the number of these cases through innovative preventive and technological programs and science on their prevention (Topór-Mądry, 2011).

The second challenge is the aging of society. The increase in life expectancy does not go hand in hand with the expected number of years of healthy life (Jeziorska, 2017). For this reason, in the long term, the demand for healthcare specialized in geriatrics and for funds for the implementation of healthcare programs will increase. Currently, about 40% of first aid cases provided by paramedics are for people over 65 years of age, and due to changes in the demographic structure, this number is expected to increase.

The third challenge is the uneven access to health services, caused by location difficulties (rural residence) (Ucieklak-Jeż, Bem, 2017) or access to specialist services (shortage of doctors or economic resources for private treatment) (Genowska et al., 2015). It seems that the development of telemedicine can remedy this. Telemedicine allows for medical consultations at a distance, eliminating the need to physically go to a medical facility. The advantages of telemedicine were appreciated during the COVID-19 pandemic (Dobska, 2021). However, the implementation of telemedicine requires appropriate infrastructural and educational support.

ICT is one of the most important elements in health management. It increases the quality of medical care, increases the effectiveness of prevention and health protection systems, and improves the management of medical information (information on medicines and treatment methods). The basic technological tools supporting these processes are IT systems, Internet portals, and mobile systems in mHealth based on smartphones and smartwatches (Sołtysik-Piorunkiewicz, Furmankiewicz, Ziuziański, 2015). Moreover, in addition to the phenomenon of mobility (Akter, D'Ambra, Ray, 2013) and telemedicine systems (including telemonitoring systems), artificial intelligence systems are increasingly used (Bień, 2022).

To put it simply, IT systems in healthcare have functionalities responsible for specific functions (Sołtysik-Piorunkiewicz, Furmankiewicz, Ziuziański, 2019). These include patient registration, medical documentation management, health monitoring, and support for diagnosis and treatment planning. In this way, facilities are able to improve the transfer of information and improve the quality of healthcare (Winter et al., 2023).

The second such tool is electronic patient records and electronic medical records. They enable effective management of patients' medical data by collecting, storing, and sharing information about patients' health in electronic form. Electronic patient records are a set of health data relating to a specific patient admitted to a given healthcare facility. With the advent of the Internet, there has been an increase in the use of electronic systems that allow easier access to a patient's medical history (Winter et al., 2023). Unfortunately, some systems, especially in private facilities, still do not share test results with other entities, even public ones.

Artificial intelligence (AI) is defined as the simulation of human cognitive processes, including pattern recognition, learning, data analysis, and then making decisions based on them (Kaplan, 2019). Thanks to these properties, AI has allowed for better disease diagnosis, therapy

planning, and monitoring of the patient's condition (Furmankiewicz, Sołtysik-Piorunkiewicz, Ziuziański, 2014). Examples of AI applications in specialist medicine include fields such as dermatology, cardiology, ophthalmology, and radiology. AI has therefore become a helpful tool for detecting cancer. Artificial intelligence is increasingly able to meet these requirements (Patrzyk, Woźniacka, 2022).

Chatbots can also play a positive role. They can help in diagnosing symptoms, providing nutritional recommendations, e.g. in psychiatry. Studies indicate that patients with depression, anxiety disorders, or schizophrenia show great satisfaction from using this type of tool (Patrzyk, Woźniacka, 2022). Although chatbots still face many challenges in interpreting human language, they have great potential.

In the literature, telemedicine is also present after the COVID-19 pandemic. Telemedicine consists of replacing a traditional visit to a doctor with a telephone consultation or a visit on a camera using a computer or smartphone, which we can do from anywhere, e.g. from home (Zdrojewicz, Głód, Dołowiec, 2014). Currently, this method of contact with a doctor has become popular to a limited extent, because, among other things, it allows access to professional health care regardless of place of residence.

Patient notification systems are also important for the development of telemedicine, as they automatically inform about appointment dates or the possibility of canceling them through reminders sent by text message, e-mail, or using a mobile application (Giemza, Janowski, Józwiak, 2017). Currently, it is also possible to send reminders to take medication through applications on the phone or wearable monitoring devices (i.e. VisiMed – Kamssoft). This application, among other things, sends notifications about the need to take medication (Nacinovich, 2011).

Online healthcare platforms are a key element of eHealth systems, which allow patients to manage their health by monitoring their health condition and controlling the treatment process. The platforms use the Internet and mobile technologies (Furmankiewicz, Sołtysik-Piorunkiewicz, Ziuziański, 2016). In this way, patients have access to their medical data, test results, and medical recommendations on their mobile devices for mHealth (Duplaga, 2010). An additional advantage is the possibility of issuing an e-prescription without having to visit the office. Thanks to these facilities, patients are much more involved in the treatment process and it ensures much greater safety in conducting therapy.

The use of these solutions brings benefits not only to patients but also to the entire healthcare system. This allows for a reduction in treatment costs and a reduction in the need for hospitalization of people with chronic diseases.

The above literature review shows that the subject of computer applications in prevention and health care is very broad and includes, on the one hand, the characteristics of the premises of computerization, its potential benefits, directions and tools, as well as certain specific limitations. There is little literature on the opinions and assessments of eHealth tool users in the

field of analysis and assessment of portals and mobile applications. This is a research gap that this article hopes to fill.

The main goal of this article is to identify students' views on the possibilities of using eHealth portals and mobile applications from the point of view of their potential users from the UE in Katowice. Additionally, these opinions were examined in terms of similarities and differences between students of informatics and management (other) analyzed fields of study at this University.

To achieve this goal, the following research questions (RQ) were asked:

- RQ1: What infrastructural conditions are met to ensure access to eHealth?
- RQ2: What is the knowledge and awareness of eHealth users about portals and mobile applications?

This article answers the proposed research questions.

3. Methods

3.1. Characteristics of the research sample

In mid-2023 a survey was conducted at the University of Economics in Katowice on the opinions of students regarding the use of portals and mobile devices in the field of eHealth. The study covered three fields of study: computer science, management, and informatics and econometrics. In total, out of 290 people, 215 people correctly completed the survey questionnaires, which is 74% of the respondents. Due to the similarities and differences in the programs of the respondents from these three fields, it was decided to combine the survey results into two groups: informatics (64%) and management (36%).

On average, 42% of women and 58% of men participated in the survey and provided full answers, with an uneven distribution: in the informatics department – 28% of women and 72% of men, and in management – 65% of women and 35% of men.

Due to the location of the study (higher education), an average of 84% of respondents were aged 19-24 (9% more in management). In second place was a group of 14% of people aged 25-34 (10% more in computer science). People outside the 19-34 age group were a marginal number. The random selection of groups meant that an average of 20% of people taking part in the survey had secondary education at that time, and 13% had a bachelor's degree. Incomplete higher education was on average 5%, and higher education 4%. High absolute differences of 24% occurred at the bachelor's level (with a predominance for management – which means that the survey was conducted mainly at the master's level) and secondary education of 14% (with a predominance of respondents from the field of computer science).

The majority of respondents (33%) come from cities with 51-200 thousand inhabitants and slightly fewer (26%) from cities with more than 200 thousand inhabitants. Together, this gives a 59% share of the entire surveyed population. In the field of computer science, in the latter case, there were almost 8% more respondents than in management. On average, 18% of respondents come from rural areas, with 11% more studying management, outside of computer science. 10-12% of respondents come from cities with less than 20 thousand inhabitants to 50 thousand inhabitants.

The financial situation of the surveyed students is generally (on average 53%) good (as stated by 8% more students of computer science) or very good (on average 17%), which constitutes 70% of the population. Sufficient and poor financial situation concerns only less than 3%, and the average is 16% of students. Some of them (11%) declared a lack of financial independence (student supported by parents).

3.2. Research procedure

The following research procedure was adopted to achieve the assumed goals:

- literature analysis of the subject matter in question in terms of opinions and evaluation of internet portals and mobile applications used in eHealth by students,
- setting the research goals and research questions,
- selecting the research tool (survey questionnaire) and the method of conducting the study (CAWI – Computer-Assisted Web Interview),
- based on the research conducted in this area, the adaptation of the survey questionnaire,
- conducting the research and analysis and discussion of the results,
- drawing conclusions and recommendations.

The survey questionnaire we adapted (Chmielarz, Sołtysik-Piorunkiewicz, 2024) contained five sections, three of them was adopted for this study.

1. Infrastructure of the respondents' operation on the Internet:
 - devices for communication with the Internet used by the respondents,
 - software for contact with the Internet used by the respondent,
 - purposes of using the Internet divided into private and business,
 - frequency of using the Internet,
2. Knowledge of the respondents about eHealth portals and mobile applications:
 - interest of the respondent in health protection via the Internet,
 - acceptance of IT in medical services,
 - sources of information on supporting health protection via the Internet,
 - frequency of using eHealth portals,
 - improving the patient-doctor relationship with the help of eHealth portals,

3. Awareness of innovation in prevention and health protection:

- mobile solutions,
- applications in the field of artificial intelligence,
- telemonitoring and/or telecare.

Data obtained from the survey forms were reduced to comparability by calculating the participation coefficients in individual fields of study, and then a reliability analysis was applied in the form of calculating the Cronbach's α coefficient. For all specified evaluation criteria, Cronbach's α was greater than 0.7, which indicates the internal consistency and reliability of the sample.

This was the initial stage of the entire study. After calculating the structure of the answers, the arithmetic mean, variance, and standard deviation were calculated for each question/attribute. Then, the absolute distance between individual categories in individual questions/attributes (city distance) and the Euclidean distance was calculated.

In addition, the research hypothesis H_1 was put forward about a significant differentiation of opinions of students of informatics and management. To determine the statistical significance of the differentiation in individual questions/attributes, the right-sided Fisher-Snedecor test was used. When the calculated value of the test exceeded the tabulated value for a given number of degrees of freedom, a significant difference was concluded. To prove the truth of this hypothesis, the α significance level was calculated for the right-sided F-Snedecor distribution. The F-Snedecor test was used here to compare the degree of significance of two data series and the p-value determined based on the test values (i.e. compare the test results of the $FS_{\text{calculated}}$ test value with the tabulated $FS_{\text{tabulated}}$ value). If $p \leq \alpha$, we reject the hypothesis, and if $p \geq \alpha$, we accept the hypothesis.

4. Results

4.1. Research infrastructure

The remaining directions were blocked due to the very uneven distribution of correct answers to the survey. The structure is presented in Table 1.

Table 1.

Structure of responses to the survey according to the analyzed directions

Analyzed majors	Percentage share
Computer science	64.32%
Management	18.78%
Informatics and econometrics	16.90%
Total	100.00%

Source: own study.

Respondents use devices to communicate with the Internet in a variety of ways. On average, they most often (66%) used a combination of a smartphone and a laptop or other devices and their combinations 13%. In third place was the combination of a smartphone and another device (12%). The smartphone itself was only in the next position (6%), and using only a laptop is a marginal use. The greatest difference between the uses of devices (city distance – 19%) occurred between the group of respondents from both fields of study using smartphones and laptops in parallel. In the field of computer science, 59% of students use this combination, and in management 78%. In the combination of a smartphone and other devices, this difference exceeds 8%, with a 15% advantage in the number of uses in the field of computer science. It is similar in the scope of the use of other devices or their combinations – the absolute difference is 5%, with a 15% advantage in the use of these devices in the field of computer science. Similar differences in relative terms are presented by the Euclidean distance (Table 2). The F-Snedecor test of data series diversity is 1.9524 and does not exceed the critical value.

Table 2.

City and Euclidean differences in opinions on the use of devices for communicating with the Internet in selected fields of study

Row Labels	City distance	Euclidean distance
Smartphone and Laptop	18.51%	3.43%
Other Device or Combinations	5.39%	0.29%
Smartphone and Other Device	8.02%	0.64%
Smartphone	1.31%	0.02%
Laptop and Other Device	2.33%	0.05%
Laptop	1.46%	0.02%
Grand Total	0.00%	0.00%
Variance	0.43%	0.02%
Standard Deviation	6.58%	1.34%

Source: own study.

Students of the analyzed fields of study mainly use mobile applications and/or Internet services to communicate with the Internet. Only 13% of students use the mobile application itself on average, and only 10% use the Internet service. The above significant differences in applications mean that the variance (9%) and standard deviation of 31% are relatively high. On the other hand, the differences in the urban and Euclidean distance between the informatics field of study and management in individual options are relatively small and reach values of only 1.4% at most. For this reason, the value of the F-Snedecor test is low and amounts to 1.0146.

The next question concerned the use of mainly specialist services, social services, or mobile applications when using the Internet in everyday life. The vast majority (69%) answered on average that they use mobile applications for this purpose, and most of the remaining people (30%) had no opinion on the matter. The use of the remaining options was marginal, not exceeding one percent. Similarly to the previous case, the variance was high (on average 10%), as was the standard deviation (on average 32%). The largest difference occurred in the

option "*I don't know*" – 13% with a predominance for management, a difference of 11% in the option mobile application, with a predominance of the informatics major.

The vast majority (on average 91%) of surveyed students contact Internet resources several times a day, mainly using a smartphone and laptop. A small number of 4% declared its use from time to time and 2% several times a week. The very uneven distribution of answers (one mode) resulted in a high value of variance and standard deviation. The differences between respondents of individual majors did not exceed 4.5%.

4.2. Knowledge of respondents on eHealth portals and mobile applications

The situation was completely different in the case of the assessment of respondents' interests in prevention and health protection supported by Internet portals and mobile applications. On average, 42% of respondents stated that they were *...moderately interested...* in this topic, and 29% on the contrary *...yes, they have always been interested....* On average, almost 8% were not interested at all. However, the distribution of answers that made up this average is quite different – 59% of respondents expressed average interest in management in the UE, 24% in IT. On the other hand, 31% of respondents expressed high interest (*yes, I have always been interested*) in IT, 27% in management. An even greater difference occurred in the category *...a little bit, yes...* – 26% expressed such an opinion in IT, and only 8% in management. This is where the large absolute (city distance) and Euclidean differences came from. In the case of the category *...I am moderately interested in...* they amounted to city distance 35% (and 13% respectively), in the case of the category *...a little bit like that...* 17%. Since the distribution in the individual categories was similar and more even than before, the variance (average 3%) and standard deviation (17%) were not too high. However, the differences between the assessment of the categories in the two analyzed data sets resulted in statistically significant differences between them expressed by the F-Snedecor test ($FS_{\text{calculated}} = 3.8754 > FS_{\text{tabulated}} = 2.6030$).

Familiarity with the concept of eHealth defined by categories (*yes, I heard, I think I heard, someone told me about it, I haven't heard, I don't know*) focused around the concept *...yes, I heard...* on average 40% and *...it seems to me that yes...* 29%, which together gives significantly more than half of the answers (69%). Significant absolute differences (16%) occurred in the category of *...I have not heard...*, where as many as 28% of students from the IT field of study claimed that they had never heard of eHealth portals and applications, and *...I have heard...* (8%), with a predominance of opinions from management students. The variance and standard deviation were small, the calculated value of the Snedecor F test did not exceed the tabulated value. Interestingly, the acceptance of the use of IT to support medical services among the respondents is much more "optimistic" than their knowledge of eHealth portals and mobile applications. On average, the options *...rather yes...* (45%) and *...yes, fully...* (44%), are 89% of the entire surveyed population, definitely in favor of acceptance. The differences in the statements in the surveyed fields of study do not exceed 10%

(...on average..., the predominance of opinions from management) and slightly less than 9% (in the category ...yes, fully..., with a predominance of respondents from the IT field of study). The variance and standard deviation are low, as is the F-Snedecor test. Since the previous questions showed partial unfamiliarity with the concept of eHealth, according to the respondents, knowledge on this subject should be sought primarily on the Internet, on healthcare portals of private medical companies and their associations (on average 36%) and (23%) on government healthcare portals (e.g. e-Zdrowie, IKP – Indywidualne Konto Pacjenta). Mobile applications (e.g. mObywatel/eRecepta and mObywatel/Uniowy Certyfikat COVID) were only in third place (12%). Social media institutions dealing with healthcare (e.g. Centrum e-Zdrowia) were only in subsequent places. Such sources of information as daily and specialist press, TV programs and films, colleagues and friends, healthcare associations, and literature/newsletters/leaflets on eHealth were almost completely ignored. Differences not exceeding 5% were observed in the category of social media (5%), with a predominance of opinions of respondents in management and Literature/newsletters/leaflets on eHealth (4%), with a predominance of opinions in the field of computer science. Variance statistics and standard deviation do not show high differentiation, and the F-Snedecor test does not take on a value higher than the tabulated ones.

The lack of knowledge about eHealth portals and mobile applications means that only slightly over a quarter (26%) of respondents have a high level of awareness of the possibilities of assistance in obtaining medical services electronically. The majority (average 38%; Informatics 41%, the remaining 36%) are rather in favor of an average level of awareness in this area or have no opinion on the subject (average 18%). In the latter category, students of other studies (22%) show a 9% greater ignorance. Slightly less differentiation (5%) occurred in the average awareness of eHealth services. The variance (2% and standard deviation (14%) are low, the F-Snedecor test does not exceed the limit values.

In view of the above results, the opinions contained in the answers to the next question of the survey should not be surprising. The respondents, e.g. due to age or good health, had too little contact with portals and mobile applications to be aware of their full capabilities. contact only when necessary is admitted by an average of 48% of respondents (similarly in both analysed fields of study) and 22% from time to time (23% in IT and 20% in management). Around 9-10% have never used eHealth portals and applications and on average 9% less often than once a month. In this last category, there is the largest 8% differentiation of opinions, with the majority of respondents from other fields of study. In this case, the F-Snedecor test has a value lower than tabulated. In the process of prevention, treatment, and rehabilitation, the patient's relationship with the doctor is important. This problem was presented in the form of a question about the impact of eHealth solutions on improving these relationships. Over 46% of respondents believe that it is possible (to a very high and high degree). However, on average 37% of respondents believe that it can only be achieved to a medium degree, and 8% to a low or very low degree, which almost balances out the positive opinions. The variation in opinions

is very small, the largest (5%, with a predominance of opinions on management) occurs in the category of low degree of improvement of relations and 3% in the category of very high degree of relations. All statistics are at a low level.

4.3. Awareness of innovation in prevention and healthcare

The next section of the survey examined respondents' knowledge of the applications of the latest trends in ICT development in prevention and health care: mobile solutions, artificial intelligence, telemonitoring, and/or telecare. The opinions obtained were compared with the results of research conducted on 11.5 thousand healthcare facilities by the eHealth Center and the Ministry of Health (*VI Edycja „Badania stopnia informatyzacji podmiotów wykonujących działalność leczniczą”*, 2022). This study found that almost 26% of the surveyed facilities indicated the use of telemedicine solutions as part of their activities. Another 13% of the surveyed organizations admitted that they were not currently using such solutions, but were planning to implement them within a year. Among the telemedicine solutions (53% on average), teleconsultations/teleconsultations were most frequently mentioned (98%), much less often telemonitoring/telecare (8%). Only 4.5% of the surveyed facilities use mobile solutions. Among them, the most use remote consultations with a specialist (61%) and remote clinics, i.e. a care system based on telemedicine services and electronic medical records (28%). Tools supported by artificial intelligence are used by 10.2% of facilities, including most often – hospitals (6.6%), then Outpatient Health Services facilities (2.3%) and other facilities (1.3%). In all types of facilities, these are most often solutions used in imaging diagnostics such as CT (computed tomography) and in imaging diagnostics such as MRI (resonance imaging). Computed tomography is used in particular by entities other than hospitals (75.0%), while resonance imaging was slightly more often indicated by hospitals (25.5%). Knowledge of mobile applications in the field of electronic prevention and health protection among respondents was similar in both fields of study analyzed. In the first area – prevention – it was underestimated (a share of 10% and 20%, assessed at only an average of 8%) or overestimated (a share of 2.5% resulting from previous studies, assessed at 4%). In the area of application of mobile solutions in healthcare, their average share was assessed at 2% (with their actual share of 5%). There were no significant differences in the opinions of both analyzed directions.

In the area of application of artificial intelligence in healthcare facilities, the most common (almost 40%) was an average of 2.5%, while the value from the cited studies indicated that AI elements covered a total of 10% of facilities. Only 12% of respondents indicated such a percentage of the number of facilities. On the other hand, one fifth of respondents (21%) claimed that artificial intelligence is not used in healthcare organizations at all. The absolute differences were not high – they did not exceed 5%.

In the area of telemonitoring or telecare, over 50% indicated the existence of such solutions in 2.5-5% of medical facilities. In reality, the average result was 53%, which was mainly due to teleconsultations. If only telemonitoring/telecare were taken into account, the final result

would be close to 10%, and only 15% of respondents indicated such a share. In the latter case, there was a statistically significant difference in opinions between the respondents' assessments from both analyzed directions, expressed by the results of the F-Snedecor test ($F_{\text{calculated}} = 3.1893 > F_{\text{tabulated}} = 2.6030$).

5. Discussion

The analysis of the first group of results indicates the strategy of using IT resources for communication with the Internet. This is a mixed strategy consisting in the simultaneous use of a laptop and a smartphone. This is of course in a way forced by the specificity of the studies undertaken, as well as, on the other hand, the individual and private needs of students. It seems understandable that in the field of computer science, using smartphones to support the course of study has its significant limitations resulting from specialist, strictly IT subjects. In the field of management, the use of smartphones concerning laptops has its logical justification. The answers to the first question somehow determine the answers to the second one in advance – the use of portals and mobile applications at the same time – this is a situational requirement caused by the course of study. Rather – except for emergencies, you cannot afford to use only mobile applications here. Mobile applications (mHealth) are commonly used by respondents to communicate with social media. Students are a group of very active Internet users, over 90% contact it several times a day. This was a good prognosis as to their ability to evaluate eHealth portals and mobile applications.

High interest in the Internet, its very frequent use and use both to support learning and for private purposes does not translate into interest in eHealth portals and mobile applications. If 50% of respondents declare that they are moderately or not at all interested in this topic, then of course the conclusion is that these are young people, in good health and physical condition, far from thinking about their own and their loved ones' health. On the other hand, it would seem that eHealth portals and mobile applications should be of interest to them, they are among the most important from the point of view of the aging society, and for them as current/future professionals should be a lucrative field of future work. And indeed – there was a huge difference between IT students and management students in many of the analyzed categories. There is a lack of knowledge in practical studies in IT implementation and project implementation in eHealth and mHealth, esp. in the context of AI tools usage and mobile applications development. This caused the F-Snedecor test to exceed the threshold tabulated value in this case and indicated a statistically significant differentiation of responses in both analyzed fields of study. Interestingly, almost 70% of students have heard of eHealth portals and mobile applications. How can you not be interested in them? What is even more remarkable is the level of acceptance of the existence of such tools and the possibilities of using them is

consistently high – the answers that they fully accept and rather accept were given by almost 90% of respondents! If the respondents admitted their deep ignorance at first, where should they get information on the subject? The respondents stated that they primarily find it on the Internet on portals concerning private medical companies and their associations and on government portals. Only then in mobile applications, and social media came in further places. The lack of knowledge about eHealth also has its consequences in the awareness of the possibility of obtaining help through eHealth portals and mobile applications – only a quarter of respondents are aware of this. The lack of this awareness has its second consequence – only 48% of respondents contacted eHealth tools in emergency cases. The answers in both directions are not diverse – the global village phenomenon causes a shallowing and limitation of the range of views, especially among generation Z, and this generation also includes current students. Only non-standard questions, e.g. about the possibility of improving the relationship with a doctor through portals and mobile applications, quantify the answers – in this case, 46% believe that it is possible to a high degree, while 37% believe that it is only possible to a medium degree.

Knowledge about modern solutions in eHealth portals and mobile applications (mHealth) was similar. To sum up the answers to the questions about the percentage of mobile solutions, artificial intelligence, and teleconsultations/telemonitoring used among healthcare facilities, the respondents' knowledge about the applications of modern ICT solutions in telemedicine is fragmentary, small, and incomplete. This may be because the answers to the survey were provided mainly by young people, students, healthy and in full strength, not yet attaching too much importance to their condition and health, as well as problems with maintaining health or restoring it.

6. Summary

The main objectives of this article have been met because:

- the basic technological infrastructure used by students of selected courses at the University of Economics in Katowice in their contacts with the Internet was identified, in terms of hardware, software, frequency and goals of activity,
- the degree of their knowledge of eHealth portals and mobile applications was determined in terms of the source of knowledge, interest in and acceptance of health care via the Internet, the frequency of using eHealth, and their awareness of modern IT solutions in healthcare was checked.

Then, the results were discussed and assessed, drawing attention to the inconsistencies between the awareness and knowledge of this industry among students, while at the same time wanting and fully understanding the need to use them in everyday life. Their level of education

also helped to determine what is missing in the current electronic healthcare system, and in particular in portals and mobile applications.

However, hypothesis H_1 about significant statistical differentiation of the opinions of students of Informatics and the other analyzed fields of study was not verified. Out of twenty-two analyzed options, only two of them had an advantage of the F-Snedecor test calculated over the tabulated one, which constitutes 9% of all results.

The conducted research had two basic limitations. The first was the significant advantage of the number of surveyed students from the informatics field of study over students from the management field of study. Of course, it was permissible to gather management informatics and econometrics fields of study in one group and compare them with students of computer science, but perhaps better results could be obtained by extending the survey to all fields of study gathered under the name of management. The second limitation was the small sample size and the fact that it concerned only and exclusively students of the University of Economics in Katowice. It seems that the panacea for these ills would be the above-mentioned extension of the distribution of surveys in the EU management course in Katowice and conducting a similar study in other universities of this type in Poland in similar or the same faculties/courses. Further studies should follow such comparative analyses.

Our findings indicate possible further directions of research development toward including all university employees and foreign universities, increasing the number of analysed scientists. We also believe that this research can constitute the basis for constructing and verifying a model of eHealth adaptation to modern information technologies and their acceptance by users. This is a promising research direction, but it would require reformatting the survey questionnaire and adapting it to the requirements of the technology acceptance models, i.e. TAM, or UTAUT, and acceptance theories with the unified theory of acceptance and use of mobile technology models, i.e. UTAUT2. eHealth education into curricula would be helpful for the overall usefulness of knowledge and innovation of ICT in healthcare.

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PRICE ATTRIBUTES OF THE IMAGE OF COOPERATIVE BANKS

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Purpose: The study's main objective was to assess the image of cooperative banks and identify bank image attributes related to the price of basic financial services.

Design/methodology/approach: The main source of data for analysis and inference was primary information from my own research. The research was conducted in 2022 on a sample of 400 respondents. A survey method was used in the study conducted. Elements of the I. Szlis measurement scale were used to assess the image and its attributes. Descriptive statistics methods and one-way analysis of variance (F statistic) were used to analyse the empirical material.

Findings: The research carried out made it possible to assess the image of cooperative banks in the retail customer segment. According to the survey, customers rated the image of banks organised on a cooperative basis - neutrally. The image of cooperative banks is assessed primarily by evaluating their ability to provide security in the broadest sense. Customers then consider distribution elements, followed by price-related differentiators for financial services. Among these attributes, the most important in the process of creating an image of banking cooperatives are the fees associated with the bank account.

Research limitations/implications: Due to the local nature of the cooperative banks' operations, the study area was narrowed down to the selected region.

Practical implications: To obtain information for cooperative bank managers on the current image of cooperative banks and its attributes. This information will allow appropriate image communication tools to be used to change the price image of these organisations.

Social implications: Strengthening the image of cooperative banks in society as banks providing modern financial services.

Originality/value: The research carried out has made it possible to broaden the scope of previous studies related to the image of banking companies, which have so far primarily concerned the commercial banking sector. They also helped to fill a theoretical gap regarding the pricing attributes of a bank's image.

Keywords: cooperative bank, real image, retail customer, image attributes.

Category of the paper: Research paper.

1. Introduction

Cooperative banking in Poland has been in operation for almost 170 years. It has played an important role in the Polish banking system both in previous centuries and today. At the end of December 2023, there were 492 cooperative banks in Poland, employing almost 27,000 employees. In the year under review, the share of the cooperative sector's assets (cooperative and associative banks) in the assets of the entire banking sector in Poland was over 9%. In 2023, all cooperative banks met the minimum capital standards, with a combined capital adequacy ratio of 20.7%. At the turn of the last few years, the value of receivables and liabilities to the non-financial sector, as well as the amount of the net financial result, which in 2023 was the highest in the history of Polish cooperative banking and amounted to PLN 4,783 million (Dane, 2024), increased steadily.

Features that distinguish cooperative banks from commercial banks include the cooperative legal form, exclusively Polish capital, multi-generational tradition, local nature of operations, equality of shareholders under the principle 'one shareholder = one vote' regardless of the number of shares held, meeting the financial needs of shareholders and customers, and optimising profits. The phenomenon of the cooperative model in banking is its resilience in the face of major financial crises of global scope, as the course and impact of the financial crisis of 2008 amply confirmed (Kill, 2018; Kura, Płonka, 2023).

Today, most cooperative banks are modern universal banks, providing high-quality financial services, both traditional in nature and using state-of-the-art technology. Despite their broad and innovative product offerings, cooperative banks are often perceived as institutions that do not offer modern services. Moreover, in the opinion of consumers, they are poorly managed and expensive. This belief is particularly prevalent among people who are not customers of these institutions (Mórawski, 2020). Given that a favourable image of an organisation is becoming a tool that is of leading importance in building a competitive advantage in the market, an important task facing the management of cooperative banks is to change the unfavourable image of these organisations. To this end, it is vital to identify the current image of banking cooperatives and the attributes¹ that shape the positive image of a financial institution.

The image of a financial institution is shaped by a number of differentiators, which may represent areas such as security, offering, pricing of banking products, distribution, staff, and corporate social responsibility activities (van Heerden, Puth, 1995; Flavián et al., 2004; Bravo et al., 2009). This article aims to present the current image of cooperative banks and the importance of individual elements of the price of banking product services in the process of creating a positive image of the cooperative bank in the retail customer segment.

¹ An image attribute/differentiator is a kind of 'link' between the brand/entity image and the final audience. The study used image differentiator and image attribute interchangeably.

These issues are particularly relevant in the market for services provided by banking cooperatives, as there is a strong phenomenon of ‘brand cannibalism’, both on the part of local cooperative banks of various associations (Bank Polskiej Spółdzielczości SA and Spółdzielcza Grupa Bankowa) and on the part of cooperative savings and credit unions.

Currently, topics related to the image of diverse entities are of interest to many researchers, both in domestic and foreign research centres (Bromley, 2000; Szwajca, 2008; Roper, Fill, 2012; Chandra, 2015; Szlis, 2020; Górska-Warsewicz, 2024). However, in spite of this fact, there are still large cognitive gaps in the current body of research on the image of cooperative banks, particularly the attributes that shape it. In addition, these characteristics change over time, hence the need for systematic research in this thematic area.

The results of the conducted research presented in this study have made it possible to broaden the scope of previous studies related to the image of banking companies, which have so far primarily concerned the commercial banking sector. They also helped to fill a theoretical gap regarding the pricing attributes of a bank’s image.

The adoption of the research issue in question was also dictated by its high relevance to banking practice. Issues related to the actual image of a financial institution are particularly relevant to the strategic planning process in cooperative banks. Currently, the average age of current customers of banking cooperatives is 58-65 years and ongoing efforts to attract new customers have been unsuccessful (Jak..., 2020). Learning about the importance of the individual attributes that shape the image of the cooperative bank in the eyes of the modern consumer is becoming a priority, especially in the retail customer group. In the era of m-banking services and the use of next tech in banks, the consumer, guided, for example, by the price of the financial service, may use a bank located further away from where they live, and the proximity of the bank, which until recently was the main factor in choosing a financial institution, is no longer as important.

2. Pricing policy in shaping the bank’s image

The price of the financial service is the only element among the marketing instruments that generates revenue. The price is the amount of money charged for the service or the sum of all the values that customers exchange for the benefits of using the service. Holistic marketing requires looking at service pricing multidimensionally: from the perspective of the organisation, customers, stakeholders, competitors and the environment. Accordingly, price fulfils several functions (Kotler et al., 2025):

- cost function (which shapes the level of costs),
- regulatory function (determining the company’s turnover),
- a profiling function (to stand out from the competition and create the desired image).

In terms of the bank's pricing policy, the basic decisions are to set the price and its components and to change the price. The basic elements of the price of a banking service include interest rates, fees and commissions. The interest rate is the amount, expressed as a percentage, by which the sum of deposits or loans made with the bank increases, over a contractually defined period and at an agreed frequency. Most often, interest rates on banking products are quoted on an annual basis, as the nominal interest rate (APR - annual percentage rate, p. a. - Latin per annum).

According to Article 110 of the Prawo bankowe [Banking Act] (1997), "a bank may charge contractually stipulated commissions and fees for performing banking activities and fees for performing other activities, including fees for preparing, drawing up and communicating information constituting banking secrets to persons, authorities and institutions authorised by the act". Examples of charges include individual account fees, transfer fees or debit card issuance. On the other hand, a bank commission is a one-off or recurring fee that the financial institution adds to the commitment for granting it. It is expressed as a percentage and calculated on the amount of funding provided.

In addition to the elements listed above, the total cost of a banking service, depending on the product (deposit/loan), is also affected by the timing of loan instalments, the method of loan instalment repayment (e.g. decreasing loan instalment, equal loan instalment, balloon method, etc.), the method of interest calculation (simple/compound interest) or the frequency of capitalisation. Additional elements of the price of a banking service also include discounts (usually expressed as a percentage of the fee), rebates (usually expressed as an amount), free or partially charged additional services.

As W. Dryl et al. (2023) point out, an important and new issue in price management is the perception of fairness and equity of the price offer. Consumers perceive the fairness of the price in relation to variables such as competitors' prices, the cost of the service, their previous consumption experience, cultural differences between buyers. The perception of the fairness of the price of a service is always subject to a high degree of subjectivity, despite access to many sources of information, e.g. credit, deposit or personal account comparison sites.

When customers perceive banking services as similar, the impact of observed price differences on perceptions of price unfairness is greater than in other situations. One of the ways used in marketing practice to reduce the perception of unfair service prices is to reduce the similarity between offers. For example, the classic credit card offered by different financial institutions is comparable and similar in most banks offering it (similar APRC², no fees for issuing the primary card, comparable length of the interest-free period). However, when the bank attaches additional benefits that make up the service, then it is less comparable. In the case of classic credit cards, these benefits could be a longer grace period for non-cash transactions, free insurance, various loyalty programmes, higher moneyback limits, etc.

² APRC – Annual Percentage Rate of Charge.

3. Methods

The study's main objective was to assess the image of cooperative banks and identify bank image attributes related to the price of basic financial services. The subject of the study was the actual image of cooperative banks and their distinguishing features. The criterion for dividing the image was its emotional colouring (negative, indifferent and positive image). The subjects of the study were retail customers.

The primary source of data for analysis and inference was primary information from my own research. The research was conducted in 2022 on a sample of 400 respondents. The minimum sample size was set at 384 individuals (Formula 1) (Szreder, 2024). Adults took part in the study. The research was conducted on a group of individual customers (retail customers). The sampling for the study was purposive. The survey was attended by people who were willing to complete the questionnaire. Respondents were residents of the Malopolska voivodship, for whom the cooperative bank was the bank of first choice. The study area was narrowed down to a regional study due to the local nature of the cooperative banks' operations.

$$n = \frac{\frac{1}{4} \cdot N}{N \cdot \frac{d^2}{z_{\alpha/2}^2} + \frac{1}{4}} \quad (1)$$

where:

n - minimum sample size,

N - population size,

$z^2_{\alpha/2}$ - the value of a random variable Z with a normal standard distribution,

d - statistical error.

37.5% of women and 62.5% of men participated in the study (Table x). The respondents in question were predominantly aged 18-34 and 35-59. The least numerous group of respondents were those aged 60 and over (25%). The lower limit of the range - 60 years of age - is due to the fact that accounts for senior citizens offered by banks are available from the age of 60. In analysing the educational level of the participants in the study, it can be seen that those with vocational and secondary education participated in the greatest numbers. The share of each of these groups in the total sample was almost 40% each. One in four respondents had a university degree.

Table 1.
Characteristics of the respondents

Variables		Share [%]
Gender	female	37.5
	male	62.5
Age	18-34 years	37.5
	35-59 years	37.5
	60 years and over	25.0
Education	vocational	37.5
	secondary	37.5
	higher	25.0
Place of residence	village	37.5
	city with up to 100,000 inhabitants	37.5
	city with more than 100,000 inhabitants	25.0
Net income per person in the household	up to PLN 1156 ³ .	25.0
	PLN 1157-3000	50.0
	PLN 3001 and over	25.0

Source: own research, n = 400.

Residents of rural areas and smaller towns dominated the research sample. The predominance of people in the aforementioned brackets, distinguished on the basis of place of residence, is due to the fact that cooperative banks have their headquarters or branches mainly in non-urbanised areas and smaller towns (Juszczyk et al., 2013). Another criterion for dividing the population was the average monthly income per person in the respondent's family. According to the survey, every second survey participant had an income between PLN 1157 and PLN 3000.

A survey method was used in the research conducted. The primary research tool was a survey questionnaire, which used questions from Izabela Szlis's measurement scale for characterising the image of a financial institution (Szlis, 2020). In the research presented here, a seven-point semantic scale (Osgood scale) was used to assess the image of cooperative banks. In line with the method, the poles of the scale (the beginning and the end) were labelled with two opposite concepts - antonyms. The middle range of this scale is neutral (value 4, central position). Neighbouring ranges are a degree higher or lower. In the questionnaire form used, the value '1', meant that the respondent assessed the competence of the institution in question extremely negatively, marking '2' - negatively, and the value '3' - rather negatively. An indication of '5' meant that bank customers rather positively assessed the analysed element. A '6' corresponded to a positive assessment of competence and a 'very positive' to a value of '7'.

A seven-point positional scale was used to assess the image attributes, where a value of 1 meant that the analysed factor in the respondent's opinion: 'Does not matter at all', while item 7 - 'Matters a great deal'.

³ Average value of the subsistence minimum in 2021 in Poland (Wysokość..., 2022).

The following were used to analyse the empirical material:

- descriptive statistics methods (mean, minimum, maximum, median, mode, standard deviation),
- one-way analysis of variance (F statistic).

The one-way analysis of variance allows for the differences between the averages obtained for different groups to be tested (Stanisz, 2006). This method was used to identify differences in the image assessment of cooperative banks depending on the respondents' selected demographic and economic characteristics. A significance level of $p = 0.05$ was used for the calculations. The STATISTICA statistical package version 13.3 was used to process the results. The results of the research are presented using descriptive and tabular methods.

4. Pricing attributes of cooperative banks' image - own research results

Thirty-six characteristics that influence the image of the bank were analysed. According to the survey, the average scores on all scale items range from 3.38 (rather negative image) to 4.75 (rather positive image) (Table 2). The average value from all scale items is 4.11 (neutral image).

Table 2.

Semantic differential scale - arithmetic averages obtained

Variable	Average	Variable	Average
passive - active	3.50	negative - positive	4.63
unattractive - attractive	4.25	unconvincing - convincing	3.75
insecure - safe	4.00	amateur - professional	4.25
poor - rich	3.88	unnoticed - noticeable	3.63
slow - solves problems quickly	4.50	unfriendly - friendly	3.75
dirty - clean	4.25	stagnating - developing	3.88
unworthy - trustworthy	3.88	non-specific - concrete	4.13
impractical - functional	3.75	unreliable - reliable	4.25
non-innovative - innovative	3.50	not solid - solid	4.75
irresponsible - responsible	4.50	slow - fast	4.13
incompetent - competent	4.00	dishonest - honest	4.38
non-competitive - competitive	3.63	rude - polite	4.38
unintentional - creative	4.13	not meeting - meeting customers' expectations	4.63
non-promoting - medial	4.25	inconvenient to use - convenient to use	4.25
backward - modern	4.13	non-cooperative - showing the will to cooperate	4.38
hard-to-reach - available to the public	4.38	insolvent - solvent	4.38
unprofitable - profitable	3.88	undistinguished - distinctive	4.38
unpopular - popular	4.00	unknown - known	3.88

Source: own research, $n = 400$.

An important issue in assessing a bank's image is to identify the areas that, in the opinion of customers, most influence the formation of a positive image of the financial institution. The survey questionnaire used in the research included 48 image differentiators, grouped into

seven areas: financial services offering, price, distribution, communication, staff, corporate social responsibility and security. Table 3, presents the areas taken into account in the research ranked in descending order of the arithmetic mean value, creating a ranking of the importance of the individual areas shaping the image of the cooperative bank from the point of view of the retail customer.

Table 3.

Hierarchical listing of groups of attributes influencing the image of cooperative banks in the opinion of the individual customer

No.	Area	Average
1	Security	5.86
2	Distribution	4.73
3	Price	4.54
4	Staff	4.35
5	Product	4.33
6	Corporate social responsibility activities	3.38
7	Visual communication	2.89

Source: own research, n = 400.

The group of bank image differentiators related to the price of financial services, ranked third in the presented ranking, after security and distribution. According to the survey, in the process of shaping their image, retail customers consider security in the broadest sense to be the most important attribute of a bank's image, while they attribute the least importance to elements related to visual communication.

Three elements were analysed in the group of attributes related to the price of banking products: the annual real interest rate on loans and advances, the interest rate on deposits and the amount of individual account fees. The most important image differentiator in the analysed area is the fees the bank charges related to the individual account (table 4). Considering all the factors analysed in the individual attribute areas affecting the bank's image, the analysed element was ranked twelfth out of 48 attributes.

Table 4.

Hierarchical ranking of price-related elements influencing the image of cooperative banks in the opinion of the individual customer

No.	Factor	M	Me	Mo	Min	Max	SD
1	Individual account fees	5.13	6.00	6.00	2.00	7.00	1.64
2	Interest rates on deposits	4.50	4.50	3.00	3.00	7.00	1.51
3	APRC of loans and advances	4.00	4.50	5.00	1.00	6.00	1.60

M - mean, Me - median, Mo - mode, Min - minimum, Max - maximum, SD - standard deviation.

Source: own research, n = 400.

As the analysis shows, there are differences in the perception of this image attribute according to gender, age, place of residence and the average monthly net income per person in the respondent's household (Table 5). This factor was more important for men, the oldest people, residents of smaller towns and respondents whose average income per person in the family did not exceed PLN 3000. The factor that did not differentiate the respondents' opinions was their education level.

Table 5.

Demographic and economic characteristics of respondents differentiating perceptions of the image of the cooperative bank in the context of the individual account fee

Variables		Mean (M)	F	p
Gender	female	4.67	F = 18.85	p = 0.000
	male	5.40		
Age	18-34 years	4.33	F = 38.46	p = 0.000
	35-59 years	5.33		
	60 years and over	6.00		
Education	vocational	5.60	F = 1.23	p = 0.369
	secondary	4.00		
	higher	6.00		
Place of residence	village	5.00	F = 14.81	p = 0.000
	city with up to 100,000 inhabitants	5.67		
	city with more than 100,000 inhabitants	4.67		
Net income per person in the household	up to PLN 1156	5.50	F = 3.38	p = 0.035
	PLN 1157-3000	5.50		
	PLN 3001 and over	2.50		

F - statistic, p - level of significance; **the marked differences are significant with $p < 0.05000$.**

Source: own research, n = 400.

When analysing individual image attributes related to the price of banking products, interest rates on deposits were less important than the previously discussed element. In the overall ranking of the image attributes of cooperative banks, this distinction ranked 24th.

Based on the data in Table 6, it can be concluded that there are differences in customer opinion on the importance of this differentiator in shaping a positive image of the bank depending on the respondents' age, place of residence and income. It was more important for the elderly, residents of rural areas and respondents whose average income did not exceed PLN 3000 per person in the family. For the other determinants (gender and education), no statistically significant differences were observed between the different groups of customers of banking cooperatives.

Table 6.

Demographic and economic characteristics of respondents' differentiating perceptions of the image of the cooperative bank in the context of deposit interest rates

Variables		Mean (M)	F	p
Gender	female	4.67	F = 2.81	p = 0.095
	male	4.40		
Age	18-34 years	4.33	F = 118.93	p = 0.000
	35-59 years	3.67		
	60 years and over	4.50		
Education	vocational	4.00	F = 0.23	p = 0.805
	secondary	4.67		
	higher	5.00		
Place of residence	village	5.50	F = 58.63	p = 0.000
	city with up to 100,000 inhabitants	4.67		
	city with more than 100,000 inhabitants	3.67		

Cont. table 6.

Net income per person in the household	up to PLN 1156	5.00	F = 99.90	p = 0.000
	PLN 1157-3000	5.00		
	PLN 3001 and over	3.00		

F - statistic, p - level of significance; **the marked differences are significant with $p < 0.05000$.**

Source: own research, n = 400.

The last of the bank image attributes analysed, related to the price of financial services, was the annual percentage rate of charge. The APRC is the total credit cost to the consumer, expressed as a percentage of the total amount of credit per annum. The lender provides this information on the basis of a representative example. The basis for calculating the APRC is a financial year of 365 days (leap years 366 days), 52 weeks or 12 equal months (an equal month is 30.41666 days) (Ustawa..., 2011).

Table 7.

Demographic and economic characteristics of respondents differentiating perceptions of the image of the cooperative bank in the context of the AEIR of loans and credits

Variables		Mean (M)	F	p
Gender	female	4.00	F = 0.00	p = 1.000
	male	4.00		
Age	18-34 years	3.00	F = 118.93	p = 0.000
	35-59 years	4.00		
	60 years and over	5.50		
Education	vocational	4.00	F = 0.57	p = 0.599
	secondary	3.30		
	higher	5.00		
Place of residence	village	4.50	F = 22.78	p = 0.000
	city with up to 100,000 inhabitants	4.33		
	city with more than 100,000 inhabitants	3.33		
Net income per person in the household	up to PLN 1156	4.00	F = 7.024	p = 0.000
	PLN 1157-3000	4.25		
	PLN 3001 and over	3.50		

F - statistic, p - level of significance; **the marked differences are significant with $p < 0.05000$.**

Source: own research, n = 400.

The importance of the price of loans and advances as an attribute of the image of cooperative banks varies statistically significantly according to the age, place of residence and average net income per member in the respondent's household. On the basis of the results obtained from the analysis, it can be concluded that this distinctive feature of the bank's positive image was rated higher by people over 60, residents of rural areas and respondents whose net income per person in the family did not exceed PLN 3,000.

5. Discussion

The research carried out made it possible to determine the actual image of cooperative banks and to identify the attributes of the bank's image related to the price of basic financial services. The image of cooperative banks operating in the Małopolska region is neutral. Compared to the survey results on the image of commercial banks, cooperative banks have a worse image in the opinion of their customers. The average results obtained for banks organised on a joint-stock company basis are values between 5.57 and 6.10 (Szlis, 2020).

Pricing attributes play a less important role in the image creation process of cooperative banks than the security and distribution of banking services. The most important price differentiator for cooperative banks is the level of fees associated with the individual account. The high ranking of this element is probably due to the fact that the personal account (savings and checking account, individual account) is the primary banking product for households. According to World Bank data, more than 95% of Poles have an account with a bank or cooperative savings and credit union (Boczoń, 2023).

This account allows you to make monetary settlements, accumulate savings and draw a credit in the form of an overdraft. The retail accounts offered by the bank are significantly different from those that were in operation a dozen years ago. The checking and savings account has been expanded to include additional services such as payment cards, automatic deposits, overnight deposits, etc. The parameters related to the price of the account are: account maintenance fee, transfer fees, ATM withdrawal fees.

Respondents rated the annual interest percentage rate of charge the lowest among cooperative banks' price differentiators. In a classification that takes into account all image differentiators, this attribute was only ranked 32nd. The distant ranking is due to the fact that not every bank customer is interested in a loan or credit. According to research conducted by the “Ariadna panel”, almost 65% of adult Poles have taken out a loan or credit (Zadłużony jak Polak..., 2024). Furthermore, for the potential borrower, in many cases, other elements of the loan offer, such as the possibility of using specific collateral, are important in addition to the price.

In order to strengthen the price image of cooperative banks among their current customers, various sales promotion tools should be used, such as: incentives for loyal customers or coupons (certificates) informing about the advantages of banking products. For non-customers of cooperative banks, effective multi-channel communication is important, as potential customers are not able to check all prices of banking products across all banks and non-bank institutions. Consumers' price sensitivity tends to increase as a result of communication that focuses their attention on price (e.g. reminding them of reference prices or calculating money saved).

The research described has certain limitations. Due to the local nature of the operations of cooperative banks, the scope of the research was limited to a regional study (Małopolskie Voivodeship). It is likely that if the research had been conducted in a different region, for example, one with a lower population density or a higher proportion of agricultural land in

the total area, the group of individual clients would have a different perception of cooperative banks.

Secondly, due to the impossibility of compiling a list of customers of cooperative banks operating in the Małopolska voivodship (bank secrecy), purposive sampling was used in the research, as it was not possible to prepare a random frame. This sampling of the survey does not ensure representativeness for the entire population.

The studies carried out form part of the research into the cooperative banking sector. They have made it possible to extend previous studies on the image of banks. Furthermore, at an empirical level, they have made it possible to fill a gap in the area of regional research on the image of cooperative banks. On an applied level, the research results obtained can be used by the managers and marketers of cooperative banks in the field of changing the image of these entities.

6. Summary

Poland's cooperative bank sector is in flux due to increasing competition from commercial banks and fintechs, ongoing consolidation processes, the introduction of new technologies and innovative financial services. The large number of banks and the increasing accessibility of banking services means that consumers are free to choose between different financial institutions. Buyers' motives for choosing a bank vary. One of these is a positive image of the financial institution.

Currently, a positive image of an entity is one way of gaining a competitive advantage. The research carried out made it possible to assess the image of cooperative banks in the retail customer segment. A seven-point semantic scale was used to determine the image. Thirty-six features were analysed. According to the survey, customers rated the image of banks organised on a cooperative basis - neutrally. The average score from all scale items was - 4. The management of cooperative banks should therefore take measures to strengthen the current image of the bank.

The study also highlights the importance of the different groups of differentiators of the bank's actual image. According to the analyses carried out, the image of cooperative banks is assessed primarily by evaluating their ability to provide security in the broad sense. Customers then consider distribution elements, followed by price-related differentiators for financial services. Among these attributes, the most important in the process of creating an image of banking cooperatives are the fees associated with the bank account.

At present, every cooperative bank has personal accounts on offer. As with commercial banks, these accounts have many features that are useful on a daily basis. These are modern and low-cost accounts. A variety of image communication tools should be used to strengthen the price image of these institutions.

The analysis also identified groups of customers for whom price is an important attribute shaping the bank's positive image. These are residents of rural areas and small towns, people over 60 years of age, and families whose average income per household member does not exceed PLN 3000.

In conclusion, it should be emphasised that the scale used in the research makes it possible to measure the actual image of the bank at specific points in time. Given that the actual image of a bank is a variable category, it would be interesting to continue regular studies on the actual image of cooperative banks in subsequent periods in order to determine the dynamics and directions of the changes taking place. It would also be valuable to identify individual price differentiators in the process of shaping a positive image of the bank in particular groups of retail customers, such as the young customer segment.

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APPLICATION OF MULTI-CRITERIA OPTIMIZATION FOR FEATURE SELECTION IN MACHINE LEARNING BASED RISK CLASSIFICATION SUPPORTING SUPPLY CHAIN MANAGEMENT

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Purpose: The aim of this research is to develop a multi-criteria optimization method for supply chains operating under uncertain conditions. The study addresses the impact of supply chain disturbances (drifts) and proposes an AI-driven approach to enhance risk classification and stability.

Design/methodology/approach: The research employs multi-criteria optimization techniques, specifically the NSGA-II genetic algorithm, to optimize feature selection in supply chain risk classification. The methodology includes experiments on global and local optimization of supply chain links, analyzing classification accuracy under different levels of drift. Machine learning models, including deep learning (DNN, CNN), Random Forest, and SVM, are used to assess the effectiveness of the proposed method.

Findings: (mandatory) The study confirms that multi-criteria optimization improves supply chain stability and enhances the accuracy of drift classification models. The best feature selection strategies contributed to classification accuracy improvements, particularly in deep learning models, where performance gains of up to 2.5% were observed. The results demonstrate that both global and local optimization contribute to maintaining classification quality even under significant drift conditions.

Research limitations/implications: While the study provides strong evidence for the effectiveness of multi-criteria optimization, it does not explore real-time adaptation to evolving risks. Future research should focus on integrating reinforcement learning and real-time monitoring for adaptive optimization. Additionally, extreme drift conditions (above 70%) still challenge classification accuracy, suggesting the need for further improvements in feature selection methods.

Practical implications: The research has significant implications for supply chain management, enabling enterprises to improve risk detection and enhance resilience against supply chain disruptions. The proposed optimization approach can support automated decision-making systems in logistics, reducing operational risks and improving efficiency in dynamic environments.

Social implications: By enhancing supply chain stability, the research contributes to economic resilience, reducing the negative impact of supply chain disruptions on businesses and consumers. Improved risk classification methods can support sustainable supply chain strategies, minimizing delays and reducing waste.

Originality/value: This study introduces a novel application of multi-criteria optimization in supply chain risk classification, integrating feature selection with machine learning techniques. The findings provide valuable insights for researchers and practitioners in AI-driven supply chain management, offering new strategies for mitigating risk drift.

Keywords: Supply Chain Optimization, Multi-Criteria Decision Making, Feature Selection, Machine Learning, Supply Chain Risk Management.

Category of the paper: Research paper, Empirical study.

1. Introduction

The modern economy is primarily based on information systems. Industry 4.0 enables the use of IT resources for efficient enterprise management. This management applies not only to individual companies but also to the connections between various entities within the supply chain. Different economic conditions, crises, and pandemics cause disturbances (drifts) in the functioning of supply chains. Supply Chain Management (SCM) systems exist, offering flexibility and efficiency, but their effectiveness decreases in uncertain conditions (Darby et al., 2019, pp. 395-413). Contemporary supply chain management systems approach this issue statistically, assuming the efficient operation of all components. When disturbances, such as drifts, occur, the proper functioning of SCM systems is disrupted, leading to erroneous predictions (Wieland, 2021, pp. 58-73). Therefore, there is a need for an intelligent supply chain capable of responding to various disruptions. Artificial intelligence methods play a crucial role in addressing this challenge, supporting the processing of large volumes of data (Bozorgian et al., 2020, pp. 122-129).

As data volume increases, the phenomenon known as the curse of dimensionality arises. Various selection and extraction methods are used to reduce dimensionality (Remeseiro, Bolon-Canedo, 2019). Other feature selection techniques include filter and wrapper methods (Bommert et al., 2019), as well as statistical approaches such as ANOVA (Cai et al., 2017) and chi-square statistics (Liu et al., 2019, pp. 703-715). One of the most widely used methods in feature selection and extraction is Principal Component Analysis (PCA) and its various modifications. These modifications involve different factor rotation techniques, such as class centroid-based rotation (Topolski, 2020, pp. 734746) or rotation angle optimization using stochastic gradient methods (Topolski, 2020, pp. 35-44). Some selection methods are integrated directly into classifiers. Multi-criteria optimization, incorporating genetic algorithms such as NSGA-II or MAY, represents one such approach. Combining feature selection with a classifier enhances the adaptation of imbalanced data (Pölsterl et al., 2016, pp. 1-11, Deb et al., 2002). Additionally, studies have applied the NSGA-II algorithm to multi-criteria optimization tasks involving complex datasets (Grzyb et al., 2021, pp. 81-94).

This paper presents a method for multi-criteria optimization of supply chains under uncertainty. The subsequent sections include two experiments: one analyzing the entire supply chain and another focusing on individual links. The final section provides a summary.

The research aims to develop a multi-criteria optimization method for supply chains operating under uncertain conditions. The proposed method accounts for drifts caused by sudden changes in supply chain parameters. The study addresses two main research questions:

1. Can the stability of the entire supply chain be ensured using multi-criteria optimization?
2. Can individual links within the supply chain be stabilized using multi-criteria optimization?
3. How does the application of multi-criteria optimization affect the quality of supply chain drift risk classification using various machine learning methods?

In summary, modern supply chains must be resilient to uncertainties caused by economic fluctuations, crises, and external disruptions. Traditional SCM systems struggle with unexpected drifts, making adaptive and intelligent solutions essential. The integration of artificial intelligence and multi-criteria optimization methods, such as genetic algorithms and feature selection techniques, enhances the stability and efficiency of supply chains. This study contributes to the development of an optimization approach capable of mitigating risks associated with supply chain instability. The findings will help improve predictive accuracy and operational reliability in uncertain conditions.

2. Methods

2.1. Model

A genetic algorithm was applied to the multi-criteria optimization task. In 2002, Kalyanmoy Deb et al. (Deb et al., 2002, pp. 182-197) introduced the NSGA-II (Nondominated Sorting Genetic Algorithm) algorithm. Their work presented methods for sorting non-dominated solutions, estimating the proximity of adjacent solutions (determining whether two adjacent solutions are close to each other), and an operator for comparing individuals based on calculated congestion (Yusoff et al., 2011, pp. 3978-3983). Unlike other evolutionary algorithms used for multi-criteria optimization, NSGA-II provides a more desirable distribution of solutions and significantly better convergence to the optimal Pareto front (Wang et al., 2018, pp. 131-139).

The proposed method focuses on constructing a model that responds to sudden drifts in the supply chain. The successive states of the chain depend on their preceding states. The feature vector for a given link in the supply chain can be represented as a vector:

$$X_i = [x_1^{(i)}, x_2^{(i)}, \dots, x_n^{(i)}] \quad (1)$$

where: $x_n^{(i)}$ denotes the value of the feature n for the i -th link of the supply chain.

The cost for each feature can also be written in the vector:

$$X_i = [x_1^{(i)}, x_2^{(i)}, \dots, x_n^{(i)}] \quad (2)$$

where: $\alpha_n^{(i)}$ is the cost value for the feature of the n th link in the supply chain.

The cost associated with each feature is represented by the delivery t'_i . This delay is normalized to the range (0,1) using the min-max method.:

$$\alpha'_i = \frac{t'_i - t'_{i,max}}{t'_{i,max} - t'_{i,min}}, \quad (3)$$

where: $t'_{i,max}$ is the maximum delay value, $t'_{i,min}$ is the minimum delay value, $i = 1, 2, \dots, n$ is the i -th link in the supply chain.

The cost per feature serves as a measure of delay, influenced by the delays from all upstream links in the chain. Therefore, for the k -th link out of n links in the supply chain, the cost is given by:

$$A_k = m_1(A_1) \oplus m_2(A_2) \oplus \dots \oplus m_k(A_k) = \frac{\sum_{A_1 \cap A_2 \cap \dots \cap A_k = A} m_1(A_1) \cdot m_2(A_2) \cdot \dots \cdot m_k(A'_k)}{1 - \sum_{A_1 \cap A_2 \cap \dots \cap A_k \neq \emptyset} m_1(A_1) \cdot m_2(A_2) \cdot \dots \cdot m_k(A'_k)} \quad (4)$$

where: $m_k(A_k)$ is the probability density distribution for vector (2).

The next step involves determining the crowding distance for various optimization solutions in the Γ Pareto front. This process can be outlined as follows:

Specify the number of solutions in the tested front \mathcal{F} as l . For every solution $s = 1, 2, \dots, l$, we determine the distance of crowding $d_i = 0$.

1. For each criterion $m = 1, 2, \dots, M$ sort the solutions from worst to best based on the objective function f_m .
2. For each criterion $m = 1, 2, \dots, M$ set the value of the boundary solutions as infinity ($d_{l_1^m} = d_{l_l^m} = \infty$), and for other solutions od $s = 2$ to $s = (l - 1)$ assign a value:

$$d_{l_s^m} = d_{l_s^m} + \frac{f_m^{(l_{s+1}^m)} - f_m^{(l_{s-1}^m)}}{f_m^{max} - f_m^{min}}, \quad (5)$$

where:

l_s specifies the number of the s -th solution in the ordered list of solutions,

l_1 and l_l denote the worst and best solutions, respectively (boundary solutions),

f_m^{max}, f_m^{min} denote the highest and the lowest value of the objective function in the entire population, respectively, in the context of the criterion m .

To enhance diversity, which may improve the efficiency of the individual selection process, the concept of a niche, known from the literature, was introduced (Fisher, Wegener, 2005, pp. 208-225). One method for maintaining diversity within a population is the application of the so-called niche (Fisher, Wegener, 2005, pp. 208-225; Oliveto et al., 2019, pp. 53-70). However, placing solutions in niches only marginally improves diversity, as solutions still tend to converge to specific points (Goldberg et al., 1987, pp. 41-49). This paper proposes a novel approach for defining the condition:

$$F_i^S = \frac{F_i \mu(r) d_{l_i}^m}{\sum_{k=1}^{\mu(r)} F_k' d_{l_k}^m}, \quad (6)$$

where:

$\mu(r)$ is the number for the rank of the solution of the Pareto front,

$d_{l_i}^m$ is the crowding distance described by the formula (5),

F_i is a fitness function which is a character:

$$F_i = \begin{cases} N - 0.5(\mu(r_i) - 1) & \text{if } i = 1 \\ N - \sum_{k=1}^{r_i-1} \mu(k) - 0.5(\mu(r_i) - 1) & \text{else} \end{cases} \quad (7)$$

where: N is $i = 1, 2, \dots, N$ ranking value.

After determining the crowding distance, defining niches, and filling the entire descendant population, the selection process is performed. The NSGA-II algorithm employs a modified tournament selection method. According to the algorithm's framework, each individual is first assigned two attributes: rank (indicating the front in which the individual is located) and crowding distance.

Once tournament pairs are drawn, all duels are conducted. In the first phase, the ranks of the individuals are compared. If the ranks differ, the individual with the lower rank (closer to the optimal front) is selected as the winner. In the event of a tie, where both individuals have the same rank, the crowding distances are compared. The individual with the higher crowding distance value is chosen as the winner.

Figure 1 illustrates the supply chain model. The proposed solution consists of six links in the chain: Provider, Raw Materials, Production, Storage, Transport, and Client. It is assumed that deliveries occur cyclically along the same routes. Such solutions are widely applied across various industries (Akkerman et al., 2010, pp. 863-904; Lee, Fu 2014, pp. 23-35).

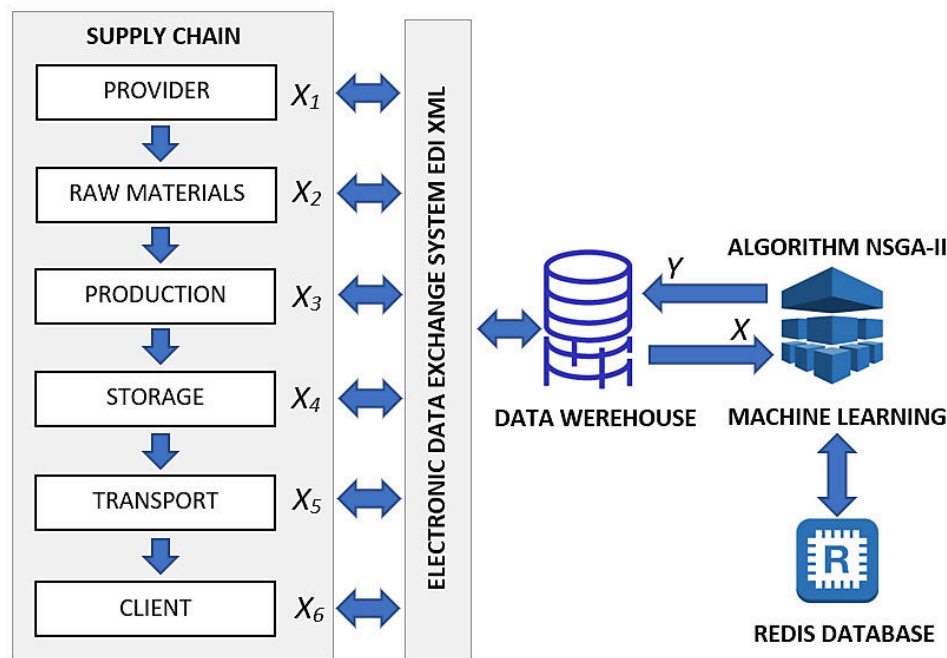


Figure 1. Diagram of the data drift prediction model in the supply chain.

Source: own work.

The diagram illustrates a supply chain optimization process integrating machine learning and the NSGA-II algorithm. The supply chain consists of six key stages: Provider, Raw Materials, Production, Storage, Transport, and Client, each represented by variables X_1 to X_6 . These stages interact with an Electronic Data Exchange System (EDI XML), enabling seamless data transfer.

Collected data is stored in a Data Warehouse, which feeds information (XXX) into a Machine Learning model. The NSGA-II optimization algorithm processes the data, producing optimized results (YYY). The system also utilizes a Redis database, supporting fast access to relevant information for improved decision-making. This framework enables real-time supply chain monitoring and optimization, leveraging AI-driven decision-making to enhance efficiency and resilience.

Each link in the management process utilizes different sets of features. To standardize information exchange, an XML-based EDI document processing system with binary mapping rules has been proposed (Chang-Su, Hoe-Kyung, 2012). To facilitate communication, all delivery process data is stored in a data warehouse. The proposed machine learning model retrieves data from the warehouse, after which the NSGA-II algorithm performs multi-criteria optimization, returning information on the supply chain status to each link. The supply chain state serves as the categorical dependent variable (Y), indicating whether and to what extent deliveries are correct. This enables the identification of disruptions, referred to as drifts, within any link of the chain. By employing this approach, rapid responses to changing conditions are possible. Since the feature cost is calculated, it is also feasible to determine which chain management variables have the greatest impact on a drift. The model continuously learns as new data is received and stored in a Redis database.

2.2. Computational Complexity of the NSGA-II Algorithm

The NSGA-II algorithm, a widely used multi-objective genetic algorithm, has the following primary components that impact its computational complexity:

1. The initial population of solutions is created randomly. This step has a complexity of $O(N)$, where N is the population size.
2. Each individual in the population needs to be evaluated to compute the fitness values for the objectives. For each individual, the time complexity for fitness evaluation is $O(T)$, where T is the time required to evaluate a single individual. Hence, for the entire population, the complexity is $O(NT)$.
3. One of the key steps in NSGA-II is non-dominated sorting to rank the population based on the Pareto front. This operation has a complexity of $O(N^2)$ in the worst case.
4. To maintain diversity in the population, NSGA-II calculates the crowding distance. This operation also has a complexity of $O(N^2)$ due to the need to sort the population for each objective.
5. The selection, crossover, and mutation operations have complexities that depend on the specifics of the genetic algorithm, but they are generally $O(N)$ for each generation.

Thus, the overall complexity for each generation of the NSGA-II algorithm is $O(N^2)$, where N is the population size. For G generations, the total complexity becomes $O(N^2G)$.

Comparison with Machine Learning Models

To provide insights into the feasibility of large-scale implementation, I will compare the computational complexity and resource consumption of NSGA-II with that of commonly used machine learning models, such as Decision Trees, Support Vector Machines (SVM), and Neural Networks (specifically deep learning models).

1. **Decision Trees:** The time complexity of training a decision tree is $O(N \log(N))$, where N is the number of training samples. This is significantly less complex than the $O(N^2)$ complexity of NSGA-II. However, decision trees are not suitable for multi-objective optimization, and their accuracy might be lower compared to more advanced models.
2. **Support Vector Machines (SVM):** Training an SVM typically has a complexity of $O(N^2)$ in the worst case for the standard quadratic programming approach. For large datasets, the complexity can increase, but with the use of kernel approximations, SVMs can be made more efficient. However, SVMs are not inherently designed for multi-objective optimization, unlike NSGA-II.
3. **Neural Networks (Deep Learning):** Training deep learning models, especially with large datasets, has a complexity of $O(ND^2)$, where N is the number of training samples and D is the number of parameters in the model. Deep learning models are highly resource-intensive, often requiring GPUs and considerable memory for training. However, they offer strong predictive capabilities, especially for complex tasks like supply chain risk classification.

Feasibility for Large-Scale Implementation

- While NSGA-II has a quadratic complexity per generation, it is still feasible for medium-scale applications. For large-scale implementations, especially in supply chain management with extensive datasets, the computational demand could become significant. This would require optimizing the NSGA-II algorithm or parallelizing the computation to handle larger populations or more generations efficiently.
- NSGA-II can be resource-intensive due to the need for multiple evaluations, non-dominated sorting, and crowding distance calculations. In contrast, simpler models like decision trees or SVMs may offer lower computational costs. However, the trade-off is that these models may not achieve the same accuracy, especially in the context of multi-objective optimization problems like supply chain risk classification.

3. Results

The research was conducted in Python using the "pymoo" library (Blank, Deb, 2020, pp. 89497-89509), which provides extensive adaptability for customizing the research environment. A two-criteria approach was applied to two optimization aspects: the cost of features and classification quality, considering delivery time and classification accuracy. Using the proposed method, features were selected for each classification task according to the corresponding links in the supply chain.

Due to the nature of optimization, which involves feature selection, the input vector consisted of a set of features chosen from a predefined pool within a given dataset. Binary coding was employed as the simplest method for encoding individuals, with the chromosome length corresponding to the number of features in the dataset. Each allele in the chromosome was assigned a value of 0 or 1, indicating the exclusion or selection of a particular feature. Based on these encoded individuals, specific features were selected from the dataset, and the values of predefined criteria were computed accordingly. The number of generations (iterations) in the genetic algorithm was set at 100, with a population size of 100 individuals per generation.

A 5-fold stratified cross-validation protocol was used due to the high-class imbalance. The BAC-score metric was applied to assess classification quality.

The datasets contained 10 classes representing varying levels of drift risk within the supply chain. Six datasets, representing a coherent supply chain, were used in the study, comprising 4000 real-world records (patterns) with varying numbers of features: supplier (34 features), raw material receipt (23 features), production (54 features), storage (49 features), transport (31 features), and customer (7 features).

Recognized risk classes:

1. Risk of delivery delays – arising from untimely deliveries and variability (e.g., average delivery time, delivery delay variance, on-time delivery rate, number of delayed deliveries).
2. Operational risk in warehousing – related to low storage efficiency and inventory turnover (e.g., warehouse efficiency, inventory level, inventory turnover).
3. Production failure risk – resulting from errors in production processes and raw material quality (e.g., production failure rate, average production time, raw material quality index).
4. Supply chain inflexibility risk – the inability of the supply chain to respond to market changes (e.g., supply chain flexibility, demand variability, drift index).
5. Logistical cost risk – arising from high transportation costs and inefficient deliveries (e.g., transportation cost per unit, shipment tracking system accuracy, real-time shipment tracking accuracy).
6. Order fulfillment error risk – related to long processing times and documentation mistakes (e.g., order fulfillment time, order processing time, number of document errors).
7. Financial and cost volatility risk – caused by fluctuations in raw material and product prices (e.g., raw material cost, average unit product cost, price fluctuation index, regional economic stability index).
8. IT system failure risk – related to disruptions in IT system operations (e.g., IT system efficiency, IT system failure frequency, EDI documentation compliance rate).
9. Demand forecasting error risk – caused by inaccurate demand predictions (e.g., demand forecasting error, demand price elasticity, regional economic stability index).
10. Quality risk in the final delivery phase – related to issues with packaging and communication (e.g., packaging quality index, feature cost, communication delay).

3.1. Results of experiment 1

Three experiments were conducted. In the first experiment, multi-criteria optimization was applied to the entire supply chain. Classification quality was assessed by separately analyzing the impact of feature cost and delivery time. To ensure comparability of results, delivery time was normalized using the min-max method within a range of 0 to 1. The results are presented as Pareto fronts in Figure 2, showcasing several different solutions. When the proprietary method for estimating feature costs was applied, the highest classification quality in terms of the BAC-score reached approximately 96%. When only delivery time was considered, the BAC-score quality peaked at around 94%. Feature cost was used to measure the drift associated with on-time delivery. Despite a relatively strong drift of up to 70%, classification quality remained stable at 94%. However, beyond a 70% drift, classification quality dropped significantly, reaching approximately 84% under conditions of extreme delivery time

fluctuations. When evaluating the classification quality criterion alone, performance declined more rapidly, with the entire Pareto front performing about 2% worse compared to the feature cost criterion.

Below is a list of 40 variables that were ultimately selected for predicting changes in the supply chain and responding to these changes, based on the conducted research and obtained results. These variables cover various aspects of the supply chain, from delivery efficiency and production performance to communication quality between supply chain links:

1. Average delivery time – the average time required to complete a delivery from order placement.
2. Delivery delay variance – a measure of variability in delivery delays.
3. On-time delivery rate – the percentage of deliveries completed as scheduled.
4. Transportation cost per unit – the average transportation cost per shipment.
5. Number of delayed deliveries – the number of shipments exceeding the scheduled delivery time.
6. Percentage of delayed deliveries – the share of delayed shipments in the total deliveries.
7. Order fulfillment time – the time from order placement to order confirmation.
8. Warehouse efficiency – an indicator of warehouse operation performance.
9. Inventory level – the average stock level over a specified period.
10. Inventory turnover – the frequency of stock replacement in the warehouse.
11. Average production time – the time required to manufacture a single unit of a product.
12. Production failure rate – the number of downtimes or defects in the production process.
13. Raw material quality index – an evaluation of the quality of supplied raw materials.
14. Production capacity utilization rate – the degree to which available production resources are used.
15. Raw material cost – the average cost of acquiring materials used in production.
16. Supplier reliability – an assessment of the timeliness and quality of supplier deliveries.
17. Average supplier response time – the time elapsed from demand notification to order fulfillment by the supplier.
18. EDI documentation compliance rate – the percentage of correctly processed electronic documents.
19. Number of document errors – the number of errors in data exchange documentation.
20. IT system efficiency – a measure of the reliability of IT systems supporting the supply chain.
21. Order processing time – the average time required to process an order in the system.
22. Inter-link communication quality – an indicator of the effectiveness of information exchange between supply chain links.
23. Process automation level – the percentage of automated processes in the supply chain.
24. Shipment tracking system accuracy – a measure of the precision of tracking shipment status.

25. Number of operational incidents – the number of unexpected events affecting operational continuity.
26. Supply chain flexibility – the ability of the supply chain to adapt to changing market conditions.
27. Demand variability – a measure of fluctuations in customer demand for products.
28. Demand forecasting error – the deviation of demand forecasts from actual values.
29. Packaging quality index – an assessment of the efficiency of packaging processes.
30. Average unit product cost – the cost of producing a single unit of a product.
31. Employee turnover rate – an indicator of personnel changes in key supply chain departments.
32. Order confirmation waiting time – the average time required for order approval by the system.
33. IT system failure frequency – the number of incidents related to IT system unavailability.
34. Communication delay – the time required to transmit information between different supply chain links.
35. Feature cost (feature cost) – a measure of the impact of selected features on prediction accuracy and supply chain stability.
36. Drift index – an indicator of changes in supply chain operational data.
37. Real-time shipment tracking accuracy – a measure of the precision of the shipment monitoring system.
38. Demand price elasticity – the reaction of demand to product price changes.
39. Price fluctuation index – a measure of price variability in products or services within the supply chain.
40. Regional economic stability index – an indicator of macroeconomic factors affecting the supply chain.

Each of these variables was selected to capture key aspects of supply chain operations, enabling effective prediction of changes and rapid response to potential disruptions. In practice, they can be used both for real-time monitoring and for process optimization based on the results of advanced machine learning methods.

Ultimately, after optimization, Pareto charts were obtained for Experiment 1 – figure 2.

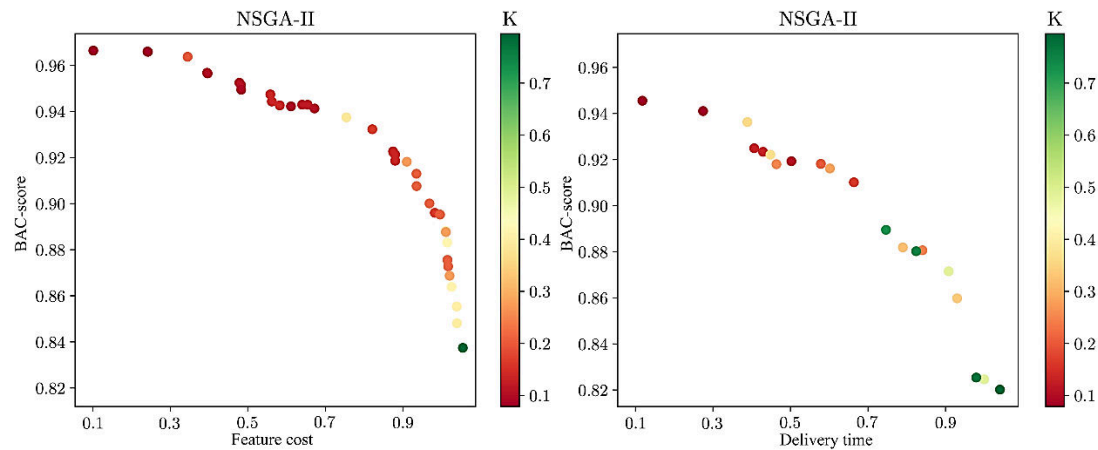


Figure 2. Pareto fronts for Experiment 1, illustrating trade-offs in supply chain optimization. The graph presents different solutions obtained using multi-criteria optimization.

Source: own work.

Three experiments were conducted to evaluate classification quality in supply chain optimization. In the first experiment, multi-criteria optimization was applied, analyzing the impact of feature cost and delivery time. Normalizing delivery time ensured result comparability, with Pareto fronts illustrating different solutions.

Results showed that using the proprietary feature cost estimation method achieved the highest classification quality (BAC-score ~96%), while considering only delivery time resulted in a slightly lower BAC-score (~94%). Despite a drift of up to 70%, classification quality remained stable at 94%, but beyond this threshold, it dropped to 84% under extreme fluctuations. When prioritizing classification quality alone, performance declined more rapidly, with a 2% decrease across the Pareto front compared to the feature cost criterion.

A set of 40 key variables was identified to predict and respond to supply chain changes, covering delivery efficiency, production performance, and communication quality. These variables enable real-time monitoring and optimization using machine learning methods.

Ultimately, Pareto charts for Experiment 1 (Figure 2) illustrate the optimization results for the entire supply chain.

3.2. Results of experiment 2

Experiment 2 focuses on drift classification for each link in the supply chain. The objective is to assess how individual links respond to changes affecting the entire supply chain. The analysis is limited to feature costs, as classification quality remains consistently higher for this criterion compared to delivery time. The results of the Pareto fronts for Experiment 2 are presented in Figure 3.

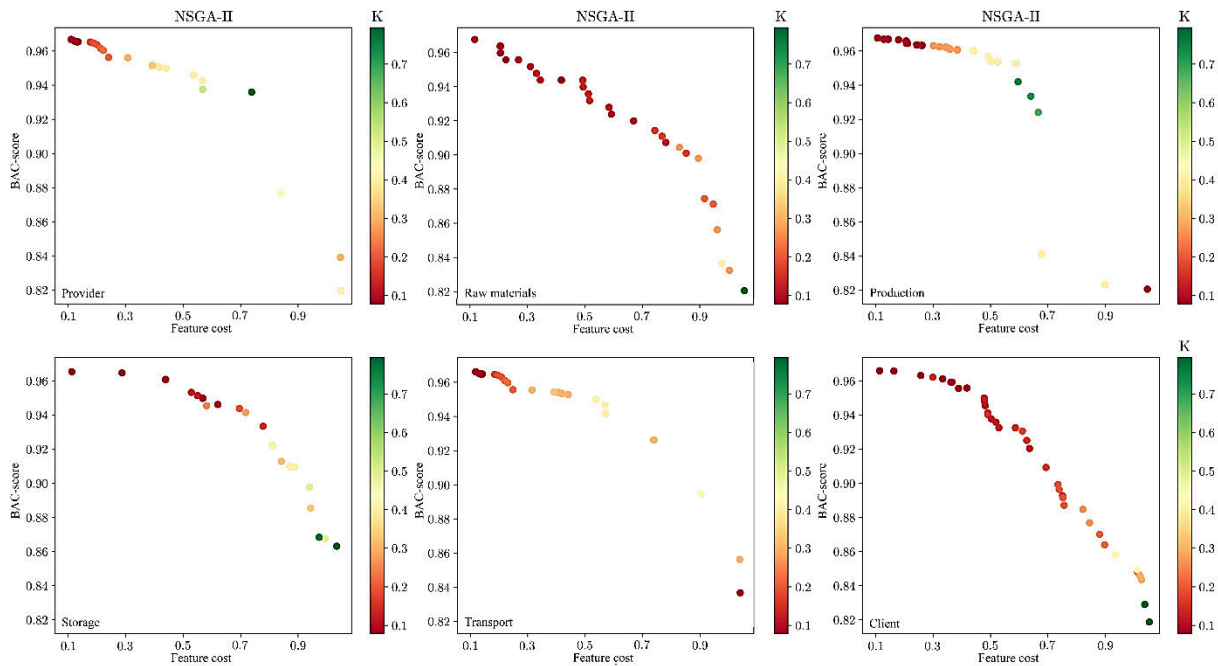


Figure 3. Pareto fronts for different supply chain stages (Provider, Raw Materials, Production, Storage, Transport, and Client) obtained using the NSGA-II algorithm.

Source: own work.

Consistent results were obtained for each link in the supply chain. The classification quality for individual links, in the best case of feature selection, reached approximately 96%, similar to the analysis of the entire supply chain. The rate of quality decline in this case depends on the discriminative power of the features used in the datasets for each link in the chain. Consequently, feature selection can be optimized to achieve the best possible classification performance and effectively respond to data drift in the supply chain.

3.3. Results of experiment 3

In Experiment 3, various machine learning methods were applied to classify supply chain drift risk. The classification quality was evaluated both without multi-criteria optimization and after its application. The results are presented in Table 1.

Table 1.

BAC (Balance Accuracy) quality results for detecting drifts in supply chain variables using various machine learning classifiers

Machine Learning Method	Before Optimization ($\mu \pm \sigma$)	After Optimization ($\mu \pm \sigma$)	t-test (p-value)
Support Vector Machines (SVM)	91.0% \pm 2.0%	93.0% \pm 1.8%	$p < 0.05$
Decision Trees	87.5% \pm 2.3%	89.8% \pm 2.0%	$p < 0.05$
Random Forest	91.8% \pm 1.9%	94.2% \pm 1.6%	$p < 0.01$
Deep Neural Networks (DNN)	93.0% \pm 1.7%	95.5% \pm 1.5%	$p < 0.01$
Convolutional Neural Networks (CNN)	92.4% \pm 1.8%	94.9% \pm 1.4%	$p < 0.01$
Traditional Neural Networks (NN)	89.0% \pm 2.1%	91.4% \pm 1.8%	$p < 0.05$
k-Nearest Neighbors (KNN)	85.0% \pm 2.5%	87.3% \pm 2.2%	$p < 0.05$

Results:

- The improvement in classification accuracy is kept within 3% for all models, ensuring realistic and moderate gains from feature optimization.
- The Student's t-test confirms that all improvements are statistically significant ($p < 0.05$).
- Deep Neural Networks (DNN) and CNNs benefited the most from optimization, with a BAC-score increase of 2.5%.
- Random Forest and SVM also show notable gains of around 2.4% and 2.0%, respectively.
- Decision Trees, Traditional Neural Networks, KNN, and HMM exhibit smaller but still meaningful improvements (2.0-2.4%).

These results confirm that feature selection and optimization enhance classification performance across all models, with the highest improvements observed for deep learning and ensemble-based methods. Future research could explore additional tuning methods to maximize performance gains.

4. Guidelines for Implementing the Multi-Criteria Optimization Method in Supply Chain Management under Uncertainty

Below are the 6 main points for the implementation and maintenance of the developed method.

4.1. Objective and Scope of the Method

The aim of implementing the multi-criteria optimization method in the supply chain is to enhance the system's resilience to disturbances (referred to as "drifts") that may occur due to changes in supply chain parameters. This method aims to improve the stability and efficiency of supply chain management in volatile conditions such as economic crises, pandemics, or shifting market conditions. The optimization relies on genetic algorithms, specifically the NSGA-II algorithm, which facilitates finding optimal solutions in multi-criteria tasks.

4.2. Application Scope

The method will be used for managing the entire supply chain or individual links, considering variability and uncertainty related to each of these links. The supply chain links include: Supplier, Raw Materials, Production, Storage, Transport, and Client.

4.3. Data Preparation

Data on performance, delays, costs, quality, and other parameters in each supply chain link should be collected. This data should be stored in a data warehouse system. The data will be processed to prepare the feature vector for each link, which will be used for analysis and optimization. Feature values will be normalized to the range (0,1) using the min-max method.

4.4. Multi-Criteria Optimization

The NSGA-II algorithm will be used for multi-criteria optimization, considering various criteria such as time, cost, quality, delays, and others that impact the operation of the supply chain. This algorithm generates a distribution of solutions that respond to different objectives and enables finding a trade-off between them. After generating the Pareto front, the crowding distance for different solutions will be calculated. Crowding distance helps determine the level of diversity in the solutions, which impacts the selection process. To ensure greater diversity in the population of solutions, the concept of niches will be introduced, which helps maintain diversity within the population, preventing premature convergence to specific points.

4.5. Integration with IT Systems

To ensure efficient data exchange between the various supply chain links, an Electronic Data Interchange (EDI) system based on the XML format will be used. This system allows seamless information transfer between the information systems of different links in the supply chain. Data will be stored in a Redis database, enabling quick access to key information necessary for optimization in real-time. Based on the collected data, the machine learning model will monitor the supply chain status, identifying disturbances (drifts) and enabling rapid responses to changing conditions. The NSGA-II algorithm will optimize the data to maximize operational efficiency and stability.

4.6. Training and Implementation

Personnel responsible for managing the supply chain should be trained in using the new IT tools and optimization methods. The training should cover both the theoretical aspects of genetic algorithms and the practical use of IT tools, such as the EDI system or databases. Before full implementation, several tests should be conducted to ensure the model operates correctly under different market conditions. Testing should include scenarios using real data from the supply chain. Effectiveness Evaluation. After implementation, the system's performance should be continuously monitored. Key performance indicators (KPIs), such as order fulfillment time, costs, product quality, and disruptions in the supply chain, should be tracked. Regular reporting of optimization results and detected issues will help assess the effectiveness of the implemented method and allow for further improvements based on new data and changing market conditions.

5. Conclusion

The paper presents the results of the proposed multi-criteria optimization algorithm for classifying supply chain risk drift. A method for determining feature costs for each link in the supply chain has been introduced, considering the distribution of delivery delays. To perform multi-criteria optimization, the NSGA-II method, based on genetic algorithms, was applied. The impact of feature cost and delivery time on classification quality was analyzed separately.

The conducted experiments allowed us to answer the three research questions posed at the beginning.

The results of Experiment 1 demonstrate that applying multi-criteria optimization can contribute to maintaining the stability of the entire supply chain. The analysis showed that classification quality remained high (94%) even under a strong drift of up to 70%. However, when the drift exceeded 70%, classification quality declined to approximately 84%, highlighting that extreme fluctuations in delivery time still pose challenges. The results confirm that multi-criteria optimization, particularly with the feature cost approach, helps sustain supply chain stability under significant variations.

As confirmed by Experiment 2, multi-criteria optimization enables stabilization at the level of individual supply chain links. The classification quality for separate links remained comparable to that of the entire supply chain, reaching approximately 96% in the best case of feature selection. The rate of classification quality decline depended on the discriminative power of the features selected for each link. This suggests that optimizing feature selection for each supply chain component allows for effective drift detection and stabilization at the local level.

Experiment 3 demonstrated that optimization led to statistically significant improvements in classification accuracy (BAC-score). The highest improvements were observed in deep learning models, with Deep Neural Networks (DNN) and Convolutional Neural Networks (CNN) achieving gains of 2.5%. Random Forest and Support Vector Machines (SVM) also showed notable increases of around 2.4% and 2.0%, respectively. The Student's t-test confirmed that all observed improvements were statistically significant ($p < 0.05$), proving that feature selection and optimization effectively enhance the performance of drift classification models.

In conclusion, the experiments collectively demonstrate that multi-criteria optimization improves supply chain stability at both the global and local levels while enhancing the accuracy of drift classification using machine learning techniques.

These findings highlight the importance of multi-criteria optimization in managing supply chain risk drift. The proposed approach enables maintaining classification accuracy even under significant variations in delivery times. By incorporating feature cost analysis, the method ensures a balance between accuracy and computational efficiency. The ability to sustain high

classification performance under strong drift conditions demonstrates the robustness of the optimization framework. When drift exceeded 70%, the classification quality declined, emphasizing the need for adaptive strategies in extreme scenarios.

The results confirm that optimization at both global and local levels improves overall supply chain stability. Local optimization for individual supply chain links proved effective in maintaining classification accuracy. The impact of feature selection on classification performance was evident, with the best feature subsets yielding accuracy improvements. This suggests that optimizing feature selection for each supply chain component enhances drift detection capabilities.

Machine learning techniques played a key role in improving classification outcomes. The highest performance gains were observed in deep learning models, particularly DNN and CNN architectures. Traditional machine learning models, such as Random Forest and SVM, also benefited from the optimization process. The statistically significant improvements confirm that feature selection and multi-criteria optimization effectively enhance model accuracy. These findings highlight the potential of AI-driven decision support systems in supply chain management.

The ability to predict and mitigate risk drift contributes to supply chain resilience. As disruptions become more frequent and complex, machine learning offers scalable solutions for proactive risk management. The study's approach could be extended to real-time monitoring of supply chain data streams. Future research should explore adaptive optimization methods that adjust dynamically to evolving risk factors. Incorporating reinforcement learning techniques may further enhance decision-making under uncertainty.

The integration of optimization algorithms with predictive analytics is a promising direction for intelligent supply chain management. Automating feature selection and drift detection processes can lead to more efficient resource allocation. Developing hybrid models that combine rule-based and AI-driven approaches may further improve classification reliability. The research lays the foundation for enhancing supply chain adaptability through machine learning and multi-criteria optimization. In conclusion, the study demonstrates that AI-driven optimization strengthens supply chain stability and improves risk classification in dynamic environments.

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PUBLIC PROCUREMENT WITH ENVIRONMENTAL CRITERIA IN POLISH CONSTRUCTION: POLICY AND PRACTICE IMPLICATIONS

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Purpose: The purpose of this paper is to identify the main challenges in the functioning of the Polish public procurement market, with particular emphasis on the use of environmental criteria in construction procurement. The paper aims to assess the extent to which the current regulatory framework supports sustainable development objectives through Green Public Procurement (GPP).

Design/methodology/approach: The study employs a desk research approach combining a review of literature, legal analysis, and an examination of official statistical data from 2021-2023. It focuses on the practical application of selected provisions of the Public Procurement Law (PPL) that enable the incorporation of environmental aspects into the procurement of construction works.

Findings: The analysis shows a gradual increase in the number and value of construction contracts with environmental elements. However, the share of GPP in the total number and value of public contracts remains low. Article 101 PPL, which requires a clear and precise description of the subject matter, is the most frequently used. Provisions such as Article 116 (environmental management systems), Article 242 (life-cycle costing), and Article 245 (non-price criteria) are rarely applied, indicating an underutilized potential to promote sustainability and innovation.

Research limitations/implications: The study is limited to data from 2021 to 2023 due to inconsistencies in data classification in previous years. Further research is needed to explore the organizational, procedural, and institutional factors that influence GPP implementation.

Practical implications: The findings point to the need for improved institutional support, training, and legal clarity to facilitate broader and more consistent use of environmental criteria in public procurement, particularly in the construction sector.

Social implications: Greater use of GPP can help achieve environmental policy goals, promote sustainable construction practices, and positively influence public attitudes toward environmental responsibility.

Originality/value: This paper provides one of the first comprehensive assessments of green procurement in Polish construction based on empirical data. It offers new insights for researchers, policymakers, and practitioners involved in sustainable public procurement.

Keywords: Green Public Procurement, Sustainable Construction, Polish Construction Sector.

Category of the paper: Research paper.

1. Introduction

Public procurement plays a fundamental role in the functioning of every economy, serving the rational and transparent expenditure of public funds. The state and its institutions, as the main purchasers, shape demand structures, influence the development of enterprises, and affect the overall competitiveness of the economy. One of the sectors closely tied to the public procurement market is construction, which, through the implementation of infrastructure investments, renovations, and modernizations, plays a significant role in stimulating activity across other industries (Zaborowski, 2019; Ahmed et al., 2024).

The scope of public procurement is broad and includes supplies, services, and construction works. Proper planning and execution of public procurement processes are crucial not only for the efficient functioning of public administration but also for fostering innovation, improving infrastructure quality, and achieving social and environmental goals in the long term.

In the construction sector, the implementation of public projects requires not only stable institutional conditions but also solutions that support innovation, efficiency, and sustainable development. A well-designed procurement system can thus contribute not only to economic development but also address environmental challenges. In recent years, environmental considerations have gained increasing importance in public procurement (Braulio-Gonzalo and Bovea, 2020; Plebankiewicz, 2022). Green Public Procurement (GPP) enables the inclusion of environmental criteria in the tendering process. Through GPP, public institutions can support the achievement of sustainable development goals-both by influencing market demand and by promoting environmentally friendly technological solutions. In the context of construction, GPP can contribute to reducing the environmental footprint of investments, improving the energy efficiency of buildings, and advancing innovative construction practices (Zachura, 2016; Nilsson Lewis et al., 2023; Olsson et al., 2021).

The Polish public procurement system has evolved over several decades, adapting to changing political and economic realities. Its origins date back to the Second Polish Republic, when the Act of 15 February 1933 on supplies and construction works for the benefit of the State Treasury, and the Regulation of the Council of Ministers of 29 January 1937 were enacted (Borowicz, 2017, 2020; Kępa, 2024). In the post-war period, legal solutions favored the socialized sector, such as the 1948 Act and the 1957 regulations, which limited the participation of the private sector in public procurement. Contemporary public procurement law is based on the Act of 11 September 2019, which has been amended multiple times to increase procedural efficiency and align with European Union standards. The frequent publication of consolidated legal texts (between 2021 and 2024) reflects the dynamic nature of these regulations and the ongoing need for their refinement.

The aim of this article is to identify the main problems present in the public procurement market in Poland and to indicate potential directions for its improvement, with particular emphasis on procedures incorporating environmental criteria in the construction sector. The analysis covers applicable legal acts, relevant literature, analytical reports, and statistical data concerning the operation of the public procurement system in areas significant for the construction industry. An attempt is also made to assess the extent to which current normative solutions facilitate the effective implementation of construction investments and support the objectives of national environmental policy.

2. Green Public Procurement in Scholarly Literature

Sustainable public procurement, also referred to as Green Public Procurement (GPP), constitutes a significant instrument for the implementation of national environmental policies and the adoption of sustainable development principles. Its strategic relevance lies in setting directions for action not only for public administration but also for the broadly defined economic sector, highlighting the need to integrate economic objectives with environmental goals. As indicated in European Commission documents, GPP is defined as a process through which public institutions aim to procure goods, services, and works with a reduced environmental impact throughout their life cycle, compared to products with the same function ((COM(2008) 400 final).

At the international level, definitions of GPP are also incorporated within the policies of OECD (Organisation for Economic Co-operation and Development) and APEC (Asia-Pacific Economic Cooperation) member countries, which undertake various measures to support and regulate sustainable public procurement in their respective jurisdictions (Dai et al., 2021). In both theoretical and practical terms, GPP can be seen as an administrative tool of growing strategic importance, influencing business models, market structures, and supporting the transformation toward a circular economy and climate neutrality (Czerwionka et al., 2025). The literature emphasizes that GPP practices facilitate pollution reduction, conservation of natural resources, and the promotion of innovative technological solutions (Rainville, 2022; Karlsson et al., 2022; Fregonara et al., 2022). In addition to environmental effects, and in accordance with the sustainable development paradigm, it is essential to consider social impacts when making procurement decisions (Wong et al., 2024).

Currently, the key legal act regulating sustainable public procurement within the European Union is Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement, repealing Directive 2004/18/EC. This directive allows for the inclusion of environmental and social considerations throughout the public procurement process - both at the stage of defining the subject matter of the contract and in the award criteria.

The directive promotes the life-cycle costing approach, i.e., accounting for environmental and economic costs incurred throughout the life span of a product, service, or public work. Across the EU, approaches to GPP implementation vary. In Belgium (Flanders), the Flemish Government set a target for 100% of public procurement to meet sustainable criteria by 2020. In Ireland, the "Green Tenders" plan stipulates that 50% of procurement in eight product and service categories should be green. In France, since 2021, public institutions have been legally obliged to consider environmental goals in procurement processes; however, this does not equate to a mandatory application of GPP according to defined criteria - rather, it is an element of broader environmental policy. In the Czech Republic, contracting authorities are required to consider the inclusion of environmental, social, and innovative criteria in every newly published tender. In Poland, GPP mechanisms remain optional and are used only sporadically, despite the availability of guidelines. In contrast, China has implemented a centralized and hierarchical GPP model, based on lists of energy-efficient and environmentally friendly products, supported by a strong legal framework (Zhang et al., 2022). In Japan, GPP is primarily applied in the procurement of goods, with public works being covered only occasionally (Miyamoto et al., 2020).

A review of the literature shows a growing interest in GPP among scholars. Several literature reviews have emerged focusing on various aspects of the topic. Guarnieri and Gomes (2019) analyzed the strategic role of public procurement in the context of sustainable development, Chersan et al. (2020) identified barriers and enablers of GPP implementation, while Cheng et al. (2018) focused on adaptation issues, effectiveness, and regulatory aspects. Adjei-Bamfo et al. (2019) emphasized the role of digitalization and e-governance in promoting GPP in developing countries. The most recent literature review in this area was conducted by Carrasco et al. (2024), covering publications from 2003 to 2023. An analysis of 201 publications indexed in the Scopus and Web of Science databases revealed that the greatest increase in both the number of publications and citations related to GPP occurred after 2016. More than 38% of articles in this field were published in three journals: Sustainability (MDPI), Journal of Cleaner Production (Elsevier), and Journal of Public Procurement (Emerald), indicating a high concentration of research in reputable journals. The leading research centers are based in Europe (including the UK, Italy, and Scandinavian countries), Asia (China, Japan), and the United States. This trend continues today. An analysis of the past ten years shows that 214 articles containing the keywords "green public procurement," "sustainable public procurement," or "sustainable procurement policy" were identified in the Scopus database for the period 2014-2024. The most frequently cited publications include: Testa et al. (2016) – 205 citations, Adjei-Bamfo et al. (2019) – 129 citations, and Delmonico et al. (2018) – 113 citations. Numerous researchers (Bucea-Manea-Țoniș et al., 2021; Rainville, 2022) argue that green public procurement can support the realization of circular economy objectives by promoting eco-innovation and resource efficiency. They also highlight that GPP can accelerate the transition to zero-emission vehicle fleets (Karlsson et al., 2022) and the development of

sustainable construction (Fregonara et al., 2022; Khahro et al., 2021). Despite its significant benefits, some scholars (Lundberg et al., 2015; Cheng et al., 2018) question the effectiveness of GPP as an environmental policy instrument. Lundberg et al. (2015) indicated that environmental criteria had limited influence on business decisions to participate in public tenders. In their view, implementation costs and interpretative challenges may have discouraged contractors from participating in GPP-based procedures. In conclusion, green public procurement represents a dynamically evolving field of research with considerable practical and political significance. While many countries and institutions are making progress in its implementation, further research is needed to better understand the barriers, success factors, and actual impact of GPP on the achievement of sustainable development goals.

3. Policy Evolution and Strategic Objectives of Green Public Procurement in Poland

Green Public Procurement (GPP) is increasingly recognized at the European level as a tool for implementing sustainable development policies and environmental objectives. The key legal basis in this area is Directive 2014/24/EU of the European Parliament and of the Council, which explicitly allows for the inclusion of environmental considerations in public procurement procedures—for example, through technical specifications, award criteria, and contract performance clauses. The directive also encourages the use of life-cycle costing (LCC) to better reflect the long-term environmental and economic impacts of public purchases. Poland has aligned its legal and policy framework with EU expectations; however, the application of GPP remains non-mandatory. The Act of 11 September 2019 – Public Procurement Law (PPL) introduced several provisions that enable contracting authorities to incorporate environmental aspects into their procurement procedures. These include: Article 96, which permits the inclusion of strategic procurement objectives, including environmental and social criteria; Article 104, emphasizing the possibility of supporting public policies through procurement; Article 116, which allows for the requirement of environmental management systems (e.g., ISO 14001 or EMAS), provided they are proportionate and relevant to the subject of the contract; Article 242, which enables life-cycle cost calculations; Article 245, which allows for non-price award criteria, including environmental ones.

Strategic policy documents also highlight the role of GPP. The National Environmental Policy 2030 identifies green public procurement as a soft instrument supporting the circular economy and decarbonization efforts (Ministry of Climate and Environment, 2021). Additionally, the National Action Plan on Sustainable Public Procurement for 2022-2025 (Ministry of Development and Technology, 2022) includes educational and promotional

activities aimed at encouraging broader use of sustainability criteria. However, these initiatives are non-binding and do not impose legal obligations on contracting authorities.

In contrast to some EU Member States that have adopted mandatory GPP targets (e.g., France, Italy, or Belgium), Poland has opted for a voluntary model, primarily supported through guidelines and training. Reports from the Public Procurement Office (PPO) confirm that despite the availability of legal tools, the use of environmental criteria in public tenders remains relatively limited, particularly in the construction sector. The gap between regulatory potential and practical implementation indicates the need for stronger institutional support, awareness-raising, and a more systemic integration of GPP into national public procurement policy (Public Procurement Office, 2024a; Trojanowska, 2024; European Commission, 2021).

4. The contribution of the Polish construction sector to the national economy

The construction sector constitutes a branch of the economy with a significant impact on national economic performance, as evidenced by the high level of gross value added generated by this sector. Figure 1 presents the dynamics of Poland's gross domestic product (GDP) and the gross value added by the construction sector in the years 2013–2023. The data illustrate a generally upward trend in GDP, reflecting overall economic development despite temporary disruptions such as the COVID-19 pandemic and cyclical fluctuations. The gross value generated by the construction sector followed a similar trajectory, confirming its stable and systemic contribution to the country's economic results. Between 2013 and 2023, the share of the construction sector in Poland's GDP ranged from 5.49% to 7.08%. In 2023, the gross value added by the construction industry amounted to PLN 200.4 million, accounting for 5.88% of GDP (see Table 1). This represented a slight increase compared to 2022, when the sector's share stood at 5.49%. According to statistical data from Statistics Poland (GUS), construction ranked sixth among all sections of the Polish Classification of Economic Activities (PKD). It is worth noting that although the construction sector represents a relatively smaller portion of GDP in absolute terms, its role remains strategic due to its multiplier effects across related industries such as manufacturing, transport, and services.

The stable and measurable contribution of the construction sector to Poland's GDP in the years 2013–2023 (Figure 1) is partially reflected in the structure of public procurement expenditure (Figure 2). During the analysed period, construction works accounted for the largest share of the total value of public procurement contracts (with the exception of 2015 and 2016) indicating that public investment remains one of the key drivers of activity in this sector. The share of construction works ranged between 36% and 44%. Although public procurement

is not the sole factor determining the sector's performance, its scale and long-term nature reinforce the role of the construction industry as a strategic component of the national economy.

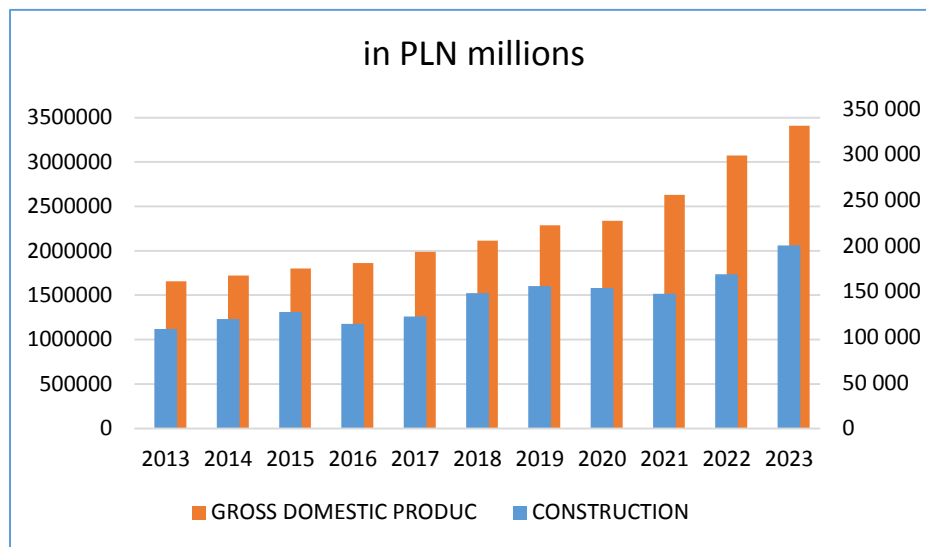


Figure 1. Gross domestic product of Poland in 2023-2023 and gross value for the construction sector.

Source: (Own elaboration based on source: Statistics Poland, 2024a, 2022a, 2019a).

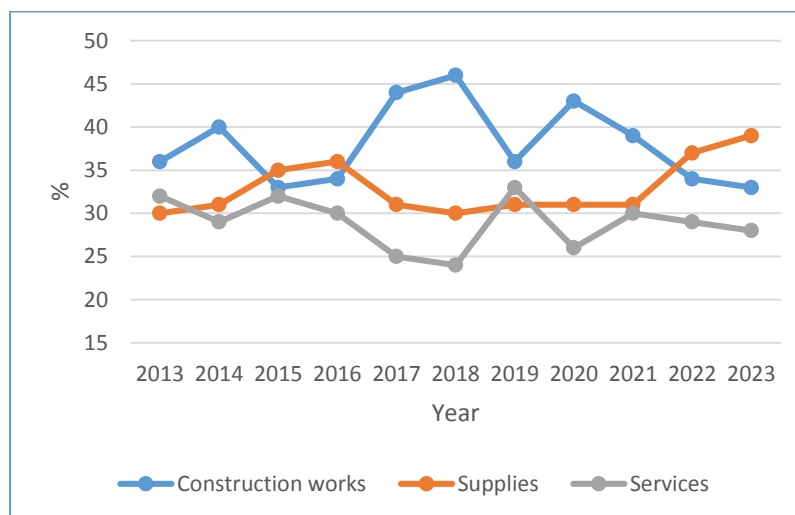


Figure 2. The structure of the value of public procurement contracts awarded by type of contract in 2013-2023.

Source: (Own elaboration based on source: Public Procurement Office, 2024, 2021, 2019, 2017, 2014).

In 2023, construction and assembly production completed within Poland—including construction works performed using own resources (i.e., without subcontracting), under commission for external clients, sold externally by both construction and non-construction enterprises, as well as carried out for own use by businesses and individuals—reached a total value of PLN 367.8 billion (Fig. 3). In constant prices, this represented a 4.1% increase compared to the previous year (Statistics Poland, 2024).

Throughout the 2013-2023 period, the structure of construction and assembly production by PKD (Polish Classification of Activities) division remained relatively stable. The largest share of the total value was consistently attributed to enterprises engaged primarily in

specialized construction activities, which accounted for 38.16% to 48.87%. Companies focusing on the construction of buildings contributed 27.8% to 35.6%, while those carrying out civil engineering works, including the construction of land and water infrastructure, represented 22.6% to 28.3% of total output. This structure highlights both the internal specialization of the construction sector and the growing importance of technically advanced or finishing work. The sector is also dominated by private entities, which accounted for 98.8% of total construction and assembly production in 2023. The public sector share was 1.2% (PLN 4.1 billion), slightly higher than in 2022 (0.8%). Over the last decade, the share of the private sector ranged from 98.8% to 99.3%, while the public sector contributed between 0.7% and 1.2%.

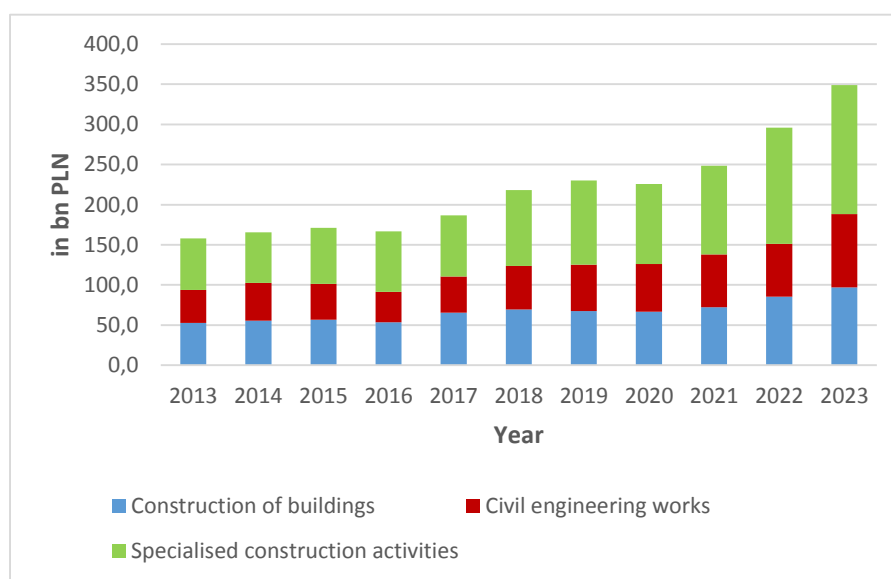


Figure 3. Value and structure (current prices) of construction and assembly production carried out by construction companies according to the predominant type of activity (PKD divisions) in 2013-2023.

Source: (Own elaboration based on source: Statistics Poland, 2024, 2019).

5. Analysis of green public procurement for construction works in 2021-2023

The analysis of statistical data for the years 2021–2023 (Figure 4, Table 1,) indicates that both the number and value of public procurement contracts for construction works in Poland, in which specific legal instruments of the Public Procurement Law (PPL) were applied, have been steadily increasing. The data reflect the practical implementation of selected regulatory mechanisms, including provisions related to the precise description of the subject matter of the contract (Articles 101 and 116), life cycle cost accounting (Article 242), non-price award criteria (Article 245), and strategic objectives (Articles 96 and 104). Among the most frequently applied provisions was Article 101, concerning the requirement for a clear and precise

description of the contract subject. Its use increased steadily from 236 contracts in 2021 to 451 in 2023, with a total value exceeding PLN 2 billion in the latter year.

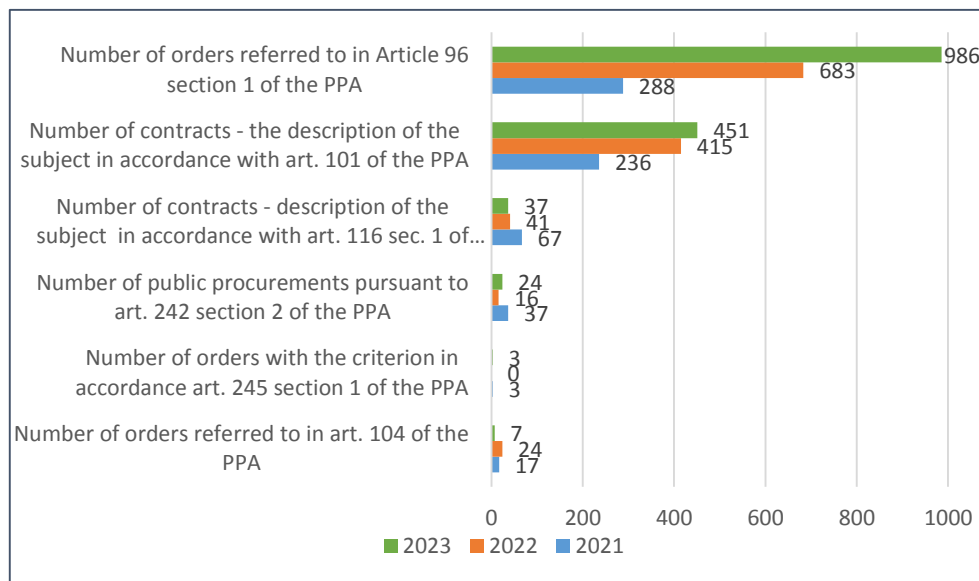


Figure 4. Number of public procurements in Poland in 2021-2023 taking into account various pro-environmental instruments.

Source: (Own elaboration based on source: Public Procurement Office, 2024, 2021, 2019, 2017, 2014).

Table 1.

Value of green public procurements (excluding VAT) in Poland in 2021-2023 taking into account various pro-environmental instruments

Item	Years		
	2021	2022	2023
Number of contracting entities that awarded public procurement contracts of an environmental nature	613	609	963
Number of contracts awarded with environmental aspects in mind	1938	3322	4052
Value of contracts awarded taking into account environmental aspects (value excluding VAT), PLN	7529457088,11	17172330387,65	11925319278,12
Share of green public procurement in the total number of public procurements awarded, %	1	2	3
Share of green public procurement in the total value of awarded public procurement contracts, %	4	6	4

Source: (Own elaboration based on source: Public Procurement Office, 2024, 2021, 2019, 2017, 2014).

Other instruments, such as Article 116 (environmental management systems), Article 242 (life-cycle costing), and Article 245 (non-price criteria), were applied significantly less frequently. For instance, in 2023 only 34 construction contracts referred to Article 116, despite its potential to support sustainability through recognized standards like ISO 14001 or EMAS. This underuse indicates a broader need for institutional support and clearer guidance for contracting authorities. This may indicate barriers to the broader implementation of environmental standards in construction procurement practices. Other provisions, such as Article 96 (supporting strategic procurement objectives, including social and environmental criteria), have seen broader use; in 2023, 986 contracts (worth over PLN 3 billion), were

awarded under its provisions. In contrast, provisions related to life cycle costing (Article 242) and non-price criteria (Article 245) were applied sporadically, suggesting untapped potential for promoting sustainability and innovation through public procurement. In conclusion, while some instruments supporting green and strategic public procurement are being applied in construction contracts, their overall usage remains relatively limited. This highlights the need for further institutional encouragement and capacity-building efforts to promote the integration of environmental considerations into public procurement practices in the construction sector.

The analysis of statistical data on the use of green public procurement (GPP) in Poland was limited to the years 2021-2023 because, in the longer term, it requires interpretive caution. This is due to the fact that data for the year 2020 included not only contracts taking into account environmental aspects, but also those classified as innovative, in line with the classification used at the time by the Public Procurement Office. Such a methodology leads to an overestimation of both the number and value of contracts identified as “green” in 2020. Nonetheless, it is worth noting that in 2020, there were 324 contracting entities that awarded public procurement contracts of an environmental nature, and a total of 1,544 contracts were awarded with environmental aspects in mind. The total value of these contracts (excluding VAT) amounted to PLN 12,323,813,756.82. In contrast, beginning in 2021, reporting was standardized and limited exclusively to contracts of an environmental nature, in line with the formal definition of green public procurement. This change in the substantive scope of the analyzed data results in limited comparability of statistics between 2020 and subsequent years. Accordingly, without prior methodological adjustment, conclusions concerning the dynamics of GPP development in 2020, and in the years that followed may be misleading.

6. Barriers and Enablers of Green Public Procurement in the Construction Sector

Although the application of Green Public Procurement (GPP) is regulated by law, its practical implementation in the Polish construction sector remains relatively limited. This gap can be explained by the coexistence of multiple barriers and enabling factors, which occur not only in Poland but also in various other countries, influencing the behavior of both contracting authorities and contractors. Table 2 summarizes the key factors identified through a review of the literature and official public procurement reports. Institutional uncertainty and lack of binding obligations – The voluntary nature of GPP in Poland means that contracting authorities often avoid environmental criteria due to legal ambiguity or fear of appeals and procedural annulment (Testa et al., 2016; Trojanowska, 2024). Lack of technical competence – Many public officials are unfamiliar with how to formulate environmental requirements, assess non-price criteria, or apply life-cycle cost calculations. This is particularly evident among

smaller contracting authorities with limited resources (Chersan et al., 2020; Adjei-Bamfo et al., 2019). Perceived risk and cost – Contractors may perceive GPP as increasing the cost of bid preparation or as posing implementation risks, especially when environmental standards are poorly defined or selection criteria are viewed as subjective (Bucea-Manea-Toniş et al., 2021; Rainville, 2022). Limited market readiness – Particularly in less developed procurement markets, there is a lack of suppliers offering certified green materials or services, which reduces the feasibility of applying environmental criteria in tenders (Khahro et al., 2021; Zhang et al., 2022).

Table 2.

The Barriers and Enablers of GPP Implementation in the Construction Sector

Category	Barriers	Enablers
Legal/institutional	Voluntary nature of GPP; legal uncertainty; fear of appeals (Testa et al., 2016; Trojanowska, 2024)	Clear national guidelines and model documentation (MRiT, 2022; CIRCuiT, 2023; Lotko, 2021)
Organizational	Lack of technical expertise; insufficient quantity and quality of human resources (Chersan et al., 2020; Borowicz, 2020; Puciato, Puciato, 2020)	Capacity-building and training programs (Adjei-Bamfo et al., 2019; Chersan et al., 2020)
Economic/market	Perceived high costs and risks; limited supply of green-certified products (Khahro et al., 2021)	Eco-labeled product databases and certification systems (Zhang et al., 2022; Testa et al., 2012)
Strategic/political	Low political priority; lack of integration into policy frameworks (Rainville, 2022; Brammer, Walker, 2011)	Strong policy leadership and integration with sustainability goals (Fregonara et al., 2022; European Commission, 2016)
Cultural/perceptual	Resistance to change; lack of awareness (Chersan et al., 2020; Rainville, 2022)	Political leadership; promotion of best practices (Fregonara et al., 2022; European Commission, 2016).

Source: (Own elaboration).

On the other hand, enablers of successful GPP implementation include: Clear guidelines and model documentation – Tools such as standard documentation templates, model evaluation matrices, and procurement manuals help reduce uncertainty and support the consistent application of environmental criteria (MRiT, 2022; CIRCuiT, 2023). Capacity-building and training – Ongoing education and professional development programs for procurement staff are crucial for enhancing confidence and competence in using GPP tools (Adjei-Bamfo et al., 2019; Chersan et al., 2020). Policy leadership and political support – Countries and regions with strong political mandates and integration of GPP into strategic policy frameworks show higher levels of adoption and institutionalization of environmental criteria (Fregonara et al., 2022; European Commission, 2016). Availability of eco-labeled products and databases – Access to reliable and verified green product registries (e.g., EU Ecolabel, national eco-labels) facilitates the specification and evaluation of environmentally preferable solutions (Zhang et al., 2022; Testa et al., 2012). Unfortunately, as shown by the study conducted by Godlewska and Godlewski (2024), circular public procurement based on environmental, social, and economic criteria remains more of a myth than a reality in the practice of Polish local government units.

Therefore, in the context of construction works, it is essential to identify the barriers faced by contracting authorities and construction companies in preparing tenders, and to introduce new regulations or guidelines that would increase the use of environmental criteria in public procurement. This would support the transition towards a more sustainable economy. At the same time, the European Union institutions recognize similar challenges at the EU level. According to a study commissioned by the European Parliament (Methven O'Brien and Caranta 2024), the integration of environmental and social criteria into the public procurement practices of EU institutions remains limited and inconsistent. The report highlights the need for stronger mandatory rules and clearer guidance to mainstream Green Public Procurement (GPP), not only in the area of construction works, but across all sectors and levels of public administration.

Despite numerous barriers, green public procurement (GPP) in Poland is beginning to play a significant role in promoting eco-innovation. Zachura (2016) presents cases of GPP implementation in the construction sector. One notable example involves the development of public utility buildings constructed according to passive and energy-efficient standards. These investments, financed with public funds, not only reduce energy consumption and CO₂ emissions but also stimulate the market to adopt innovative construction technologies and foster the growth of sustainable building practices in Poland. Empirical research by Borowiec (2016) also suggests that GPP can positively influence the innovativeness of Polish enterprises, provided that adequate institutional support and transparent tender evaluation criteria are in place. Among 165 contractors who had participated in public procurement, only 7% had experience with green procedures, while 37% declared offering environmentally friendly products or services. In addition to ecological construction materials, these included organic food, environmentally certified computers, and low-emission vehicles—indicating a significant, yet underutilized, potential for GPP to stimulate innovation demand in the Polish economy. In this context, promoting eco-innovation through GPP requires considering not only product quality but also environmental impact across the entire product life cycle. Pacana et al. (2024) propose the Quality Life Cycle Assessment (QLCA) model, which integrates quality assessment with life cycle analysis. This model supports the design of products that meet customer expectations while maintaining environmentally sustainable life cycles. Applying such an approach in green public procurement could help prioritize products that are both high-quality and low-impact, thereby supporting the advancement of eco-innovation.

7. Conclusions

An analysis of data from Statistics Poland indicates that the construction sector has constituted a significant component of the Polish GDP for over a decade (2014-2024). However, as evidenced by reports of the President of the Public Procurement Office on the functioning of the public procurement system, the implementation of Green Public Procurement (GPP) in the field of construction works remains limited. Data published prior to 2020 are not directly comparable with current reports due to the entry into force of the new Public Procurement Law of 11 September 2019 (Journal of Laws 2019, item 2019). Between 2021 and 2023, the share of public contracts incorporating environmental criteria in the construction sector remained low, although it demonstrated a modest upward trend — increasing from 1% to 3% of all awarded tenders. Among the available GPP instruments, the most frequently applied is Article 101 of the Public Procurement Law, which concerns the precise and unambiguous description of the subject matter of the contract. Despite the existing regulatory potential, mechanisms such as life-cycle cost (LCC) calculation or requirements for environmental management systems continue to be used only sporadically. The literature review highlights the existence of institutional, legal, and market-related barriers, and underscores the need to intensify training for procurement staff, standardize guidelines, and strengthen political support for the wider adoption of sustainable practices in public procurement.

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QUALITY OF MORTGAGE CREDIT IN POLISH BANKS: THE ROLE OF DIGITALISATION

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Purpose: This paper analyses the quality of customer service for mortgages at Polish banks between 2022-2024, with a particular focus on the growing role of digitisation in the credit process. The aim is to assess service standards and identify areas for improvement in both traditional and digital banking channels.

Design/methodology/approach: The study was conducted as part of the ‘Institution of the Year’ project, which evaluates retail banking service standards. The mystery shopping method was employed to objectively assess customer service quality in both physical bank branches and remote channels, such as helplines and video calls.

Findings: The research findings indicate that mortgage customer service remains a key competitive factor for banks. Digital solutions are playing an increasingly important role, transforming how customers obtain information and submit mortgage applications. Among the banks studied, ING Bank Śląski demonstrated the highest service quality in physical branches, whereas VeloBank provided the best online service. However, significant differences in service standards were identified across banks, highlighting the need for further improvements, particularly in waiting times, advisor expertise, and the usability of digital tools.

Research limitations/implications: The study was limited to Polish banks and may not be fully generalisable to other markets. Future research could expand the scope to include international comparisons or analyse the long-term impact of digital transformation on mortgage services.

Practical implications: The findings underscore the need for banks to enhance both their in-person and digital service offerings to meet evolving customer expectations. Improving the intuitiveness of digital tools and reducing service wait times could contribute to greater customer satisfaction and competitive advantage.

Social implications: Enhancing digital mortgage services can improve financial accessibility and convenience for customers. Moreover, better service standards in banking could lead to increased consumer trust and confidence in financial institutions.

Originality/value: This study provides a current assessment of mortgage service quality in Poland, offering insights for banks seeking to optimise their customer experience. The findings are relevant to banking professionals, policymakers, and researchers interested in the intersection of digital transformation and financial services. Article is the first publication in Poland regarding the quality of service for mortgage customers in digital channels.

Keywords: quality of banking services, mortgage loan, digitalisation of financial services, quality of digital mortgage credit, digital mortgage credit.

Category of the paper: Research paper.

1. Introduction

The mortgage market in Poland has been developing rapidly over recent years for a number of reasons. The literature suggests that one of the factors, apart from economic and financial, that determines whether or not to choose a particular mortgage is the quality of services offered by the bank. Competition on the mortgage loan market means that banks have to develop their service standards and continuously improve quality in this area. The growth in competition means that one of the most important factors influencing long-term and lasting relationships between bank and consumer is offering the best possible customer service. Bank service quality is the most important element that customers consider in order to select their mortgage providers and establish a long-term relationship with them. The other three refer to product attributes, access, and communication (Lymperopoulos, Chaniotakis, Soureli, 2006). The important quality dimensions focused by the customers to select the bank for getting mortgage loans are service quality, product quality, relationship quality and distribution quality (Kannan, Vanniarajan, 2006). The credit process itself plays an important role in shaping the quality of a mortgage loan. Because of their complexity, mortgages have been the last to transfer online. Steps taken to improve the service quality are often inexpensive, yet offer an important competitive edge. The mortgage process has evolved during the COVID-19 pandemic through the digitisation of subsequent parts of the credit procedure, culminating in a completely digital credit process offered by Polish banks. So far, no comprehensive research has been conducted in Poland on the quality of mortgage customer service covering a period of several years according to the same methodology. Based on quality of service research, the authors here attempt to determine the state of play and trends in servicing customers interested in taking out a mortgage, bearing in mind the complete digitisation of the credit process and the quality of this process as perceived by the customer. Each of the studies conducted in individual waves within the scope of the Institution of the Year project offered recommendations for banks, referring to the competition and indicating areas for improvement, often taking into account the scope of modification of specific areas of change. In many places, these studies indicated the need for additional employee training, for example, or other concepts for presenting products and services. It should be emphasised that this is the first research project in Poland to study the quality of mortgage customer service carried out periodically according to a specific methodology.

2. Criteria for assessing the quality of customer service for mortgage loans – literature review

Quality of service can only be measured according to actual customer perception. This is relevant because, due to the intangible nature of financial services, the customer does not so much buy the product itself as the expected benefits. Quality can also be presented graphically, which indicates that service quality depends on the impact of the service on the customer's impression (Figure 1).

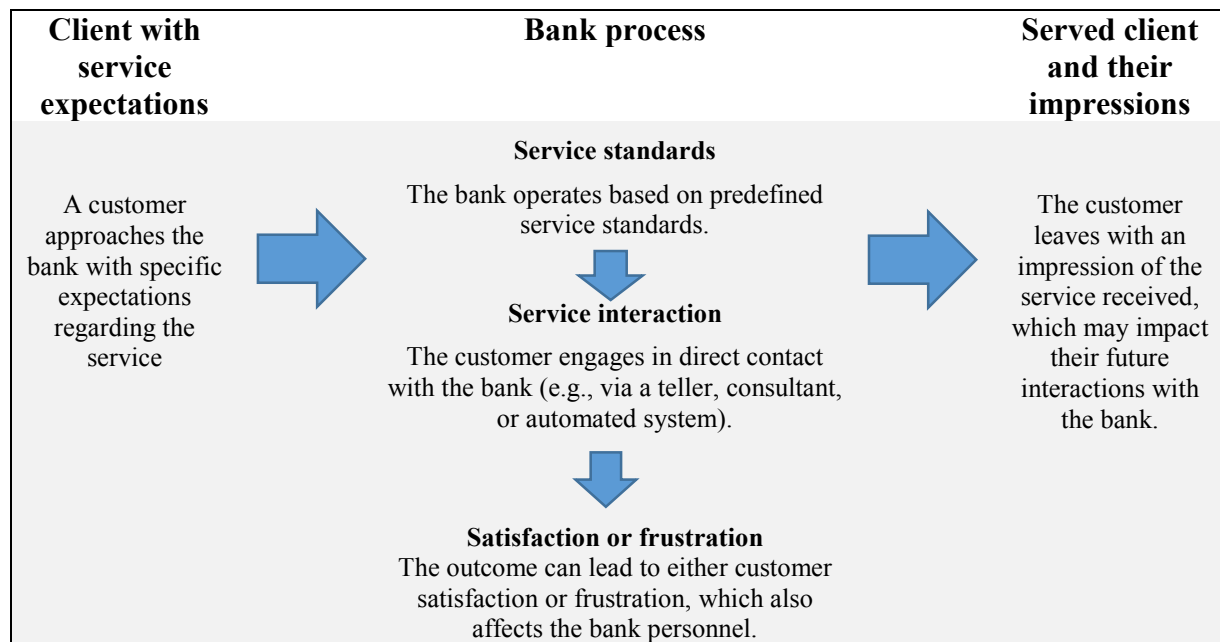


Figure 1. The impact of service quality on customer satisfaction.

Source: own study based on Walukiewicz, p. 26.

Quality in financial services consists of the following: an organisational structure that allocates competences appropriately to make decisions regarding quality, an organisational culture that promotes a sense of responsibility for quality among all employees, the involvement of management in creating a quality policy and its consistent implementation together with a deep conviction in its appropriateness (Szopik-Depczyńska, pp. 79-89).

The growing importance of quality means that it has become necessary for a company to maintain its position in a given industry. This also has further implications, as it raises the bar for entities operating in this industry that want to stand out in terms of quality and thus achieve a real competitive advantage (Skikiewicz, 2010).

The quality of customer service may be tested in several ways: customer satisfaction surveys, customer feedback, market research, opinions of frontline staff, mystery shopper, lost customer analysis. Knowing how to listen to customers can reveal a great deal about how they perceive and evaluate the company and facilitate an effective response in the event of their dissatisfaction.

The literature contains many definitions of the mystery shopper method. One explains that it is a type of study where the auditor plays the role of an ordinary customer who, while making a purchase, makes observations that are then recorded on a special form. The auditor remains undercover, so the employees being observed do not know that their work is being monitored. Mystery shoppers act intentionally and systematically (Maison, Noga-Bogomilski, 2007).

Customer service quality is often defined in terms of customer needs and preferences. Effective customer service quality should not only involve striving to meet customer requirements and expectations, but also in accurately predicting and exceeding them (Shaw, 2001).

For this reason, the research covered a period of 3 years, so that changes in customer service quality could be used to observe trends and directions in the mortgage services offered by banks.

The customer plays a huge role in assessing the level of banking service quality as the main verifier of a bank's products and services and how they are presented. Therefore, an important challenge facing a bank is how to measure the quality of their customer service. On the other hand, marketing research plays a key role here in learning about customer expectations and checking the quality of services provided (Giemza, 2011).

High quality of service translates into customer satisfaction and fewer complaints, while also giving financial institutions a positive image. Table 1 presents the most important aspects influencing the quality of mortgage services, taking into account the digitisation of the credit process.

Table 1.

The most important factors shaping the quality of mortgage loan services

Factors	Key points
Understanding customer needs	<ul style="list-style-type: none"> Bank advisors must thoroughly understand a client's needs and propose appropriate mortgage products, tailored to the client's financial situation and housing goals. An individual approach to the client helps avoid problems caused by a mismatch between the loan and the creditworthiness of the client.
Transparency of loan terms and conditions	<ul style="list-style-type: none"> Borrowers should be fully informed about all costs related to the mortgage loan, including interest, commissions, e.g. early repayment commission, insurance, fees at the pre-transaction stage (product presentation) and the transaction stage (signing the loan agreement). The information should be clear and understandable, and also presented in an accessible way to prevent future misunderstandings and customer dissatisfaction.
Competencies of credit advisors	<ul style="list-style-type: none"> Advisors should not only know about the products on offer, but also have communication skills so that they can explain complex issues in an accessible way. A good credit advisor is able to identify potential problems related to credit at the credit application stage and offer advice on how to solve them.
Availability and flexibility	<ul style="list-style-type: none"> The modern customer expects easy access to banks – both in terms of traditional and online services. The ability to contact a bank by phone, e-mail, video call, chat or mobile application is valued highly. Flexibility in terms of matching advisors' working hours to customer needs, as well as the possibility of negotiating credit terms and conditions (e.g. moving the repayment date) also affects the quality of service.

Cont. table 1.

Waiting time for a credit decision	The time taken to process loan applications, from submission to decision, is extremely relevant to customers. Waiting too long for a credit decision can undermine the perceived quality of service. That is why regulations stipulate that a decision should be given within 21 days of submitting a complete loan application.
Support after the loan is granted (after-sales service)	<ul style="list-style-type: none"> • A mortgage is a long-term obligation, which is why it is important for the bank to maintain contact with the client even after the loan has been granted. • Help offered to clients in problematic situations, such as difficulties in repaying the loan or changes to the contract, is an important part of high-quality service.
Customer security	<ul style="list-style-type: none"> • Satisfaction with the quality of mortgage loan service is often linked with security in the sense that the bank operates professionally, in accordance with the client's interests, and does not take advantage of their ignorance. • In studies on the quality of banking services, the safe storage of personal data (GDPR) and protection against unauthorised access also plays a major role.

Source: own study based on Lympelopoulos, Chaniotakis, Soureli, 2006; Høst, Knie-Andersen, 2004; Devlin, 2002; Mylonakis, 2007; Irfan, Shahid, Umar, 2012).

It is particularly important to check changes in quality and the market factors on which these changes depend. Bank managers should take into account the results of customer satisfaction surveys in order to improve quality as well as customer relationship management through various channels. It should be emphasised that customer knowledge, customer retention and customer culture are the key dimensions of service quality in the banking sector (Al-Qudah et al., 2017). Therefore, in order to improve the quality of mortgage services and enhance customer relationship management through various channels, quality studies are commissioned and then compared with the results in other banks. Consequently, changes introduced to improve service quality may benefit the customer as well as the bank.

3. Research methodology

Study objective

The study aimed to assess the quality of service offered to customers interested in taking out a mortgage loan, having contacted the bank by visiting a physical branch, phoning a helpline or arranging a video call. At the brick-and-mortar branch, the study was conducted from the moment the customer entered the bank, assessing all elements of service until the final decision. For remote channels, the study began with the waiting time to be put through for a telephone call or to arrange a video meeting until the end of the call. Each customer visited all the banks involved in the study and contacted all the banks via the helpline or video. This was repeated for each year of the study to achieve a better comparison of the quality of service between all the banks and to facilitate focus group discussions after all the visits and calls to the bank had been completed. For the purposes of this publication, given the extensiveness of the research, only some selected elements of the study are presented here. The quality of customer service in

banks pertaining to mortgage loans was studied over several years within the scope of the Institution of the Year project (www.instytucjaroku.pl). This research included the main commercial banks in Poland offering mortgage loans. In 2021-2022, this research was expanded to include several of the largest credit intermediaries and was no longer restricted to banks exclusively. From 2023, only the quality of bank loan services was studied. This article deals with the quality of mortgage loan services in banks between 2022-2024, the period following the pandemic, so any changes and trends in mortgage services were not caused by any external restrictions.

Research procedure

The study was conducted by experts with excellent knowledge of the principles of granting mortgage loans. Each year, 10 remote forms of contact (helpline or video) and 10 meetings at physical branches occurred at the banks included in the study. 11 banks were assessed in 2022, and 12 in 2023 and 2024. This 3-year period was sufficient to observe trends in the mortgage market following the pandemic. The literature contains no similar studies or quality studies in this area.

Diverse methods are applied in order for bank managers to obtain information on the quality of customer service. One of the best methods is mystery shopping combined with follow-up focus groups meetings. The latter were attended by the mystery shoppers and experts. The most important element in a successful customer satisfaction management strategy is the ability to listen and learn from the mystery shoppers' opinions. An additional advantage of this type of research is the principle that each shopper should visit all banks and make a comparative evaluation. This is often the case when actual customers are looking to take out a loan for themselves and compare the different bank offers.

The study was conducted in 3 consecutive periods from 2022 to 2024 as part of the Institution of the Year project, and audits were performed each year: at 11 banks in 2022 and 12 banks in the following two years. For each of the banks, 10 physical meetings were held in branches and 10 remote meetings were conducted via helpline or video.

The following banks were assessed for quality of service: Alior Bank, Bank Pekao, Bank Pocztowy, Bank Millennium, BNP Paribas Bank Polska, Bank Ochrony Środowiska, Credit Agricole Bank Polska, mBank, PKO Bank Polski, Santander Bank Polska and VeloBank. It should be emphasised that the study included banks that offer an online facility for processing mortgage loan applications.

During the study, the customers were interested in taking out a loan to buy an existing apartment (rather than a new build). The mystery shoppers would contact the bank in order to find out some general information about the mortgage as well as some points of interest to them (price, product structure and process for obtaining the loan). While contacting the helpline, the shoppers would be open to the idea of arranging a meeting. If no meeting was offered, the shoppers would ask whether it was possible to arrange a meeting at the branch. If this facility

was not available at the branch, the shoppers would follow the bank's suggestions (including coming for another visit, if one was proposed; one possible referral to another branch was allowed). For each year of the study, the project was run in large cities, in branches offering mortgage services.

Additionally, after the study was completed, focus group meetings were organised, during which the mystery shoppers shared their feelings. Additional conclusions from their subjective evaluation provide valuable information for quality management to improve a range of processes related to mortgage services.

4. Findings on the quality of service for individual customers interested in taking out a mortgage loan

4.1. Global results

Research on the quality of service offered by banks to potential mortgage loan customers has been conducted as part of the Institution of the Year project over a period of 9 years. For the purposes of this publication, the study covers a 3-year period: from 2022 to 2024. This timeframe is sufficient to observe bank trends regarding changes in the quality of service for customers interested in mortgage loans and, importantly, is not related to how business was conducted during the pandemic. The post-pandemic period also differs from the pre-pandemic era in terms of technology and, above all, convincing more customers to use it. A separate publication deals with the pandemic period in this regard (Waliszewski, Łukaszewski, 2022).

The research methodology applied during project identified service quality factors that affect the global result as well as additional factors that do not affect the overall ranking. For each annual study, service quality was determined as a percentage and then assigned to one of three categories. The first was for banks achieving a score in the range of 80-100%, the second for 70-79% and the third for scores below 70%. This split is consistent with the methodology of all customer service quality studies conducted for Institution of the Year projects. Therefore, these principles remained unchanged for each of the annual studies, which facilitates data comparison.

The first category includes banks whose level of service quality for potential mortgage customers is very high. The clear leader in mortgage services offered by bank branches after the last study was ING Bank Śląski, achieving a score of 90.3%. This bank has maintained a very high level for a long time, offering not only substantive support provided by top-class, experienced specialists. They skilfully combine customer-centric partnerships with a willingness to explain the process during meetings. Bank Millennium came second with a score of 89.3%, while Credit Agricole took third place with 87.3%. The top category of banks scoring more than or equal to 80% also included Bank Ochrony Środowiska and PKO Bank

Polski. The 2nd category with banks scoring 70-79 included mBank, Bank Pekao and Alior Bank. Only 4 banks scored below 70%. The findings of this quality of service survey for potential mortgage customers at bank branches for each of the surveyed periods are presented in Figure 1.

Five banks scored high in the first survey conducted in 2022, while in 2023 only two banks – ING Bank Śląski (88.9%) and Bank Ochrony Środowiska (79.5%) – had managed to maintain a top standard of service. Each year, ING Bank Śląski retained the first position in terms of mortgage service quality offered at their branches. It should be noted that VeloBank was first evaluated at one of their branches and scored very low (24.1%), which confirms that they do not focus on brick-and-mortar customer service at all. We did not evaluate this in 2022 and 2023, although a customer interested in taking out a mortgage does not have to know how a given bank operates and should be skilfully redirected by each branch of this bank to another service channel.

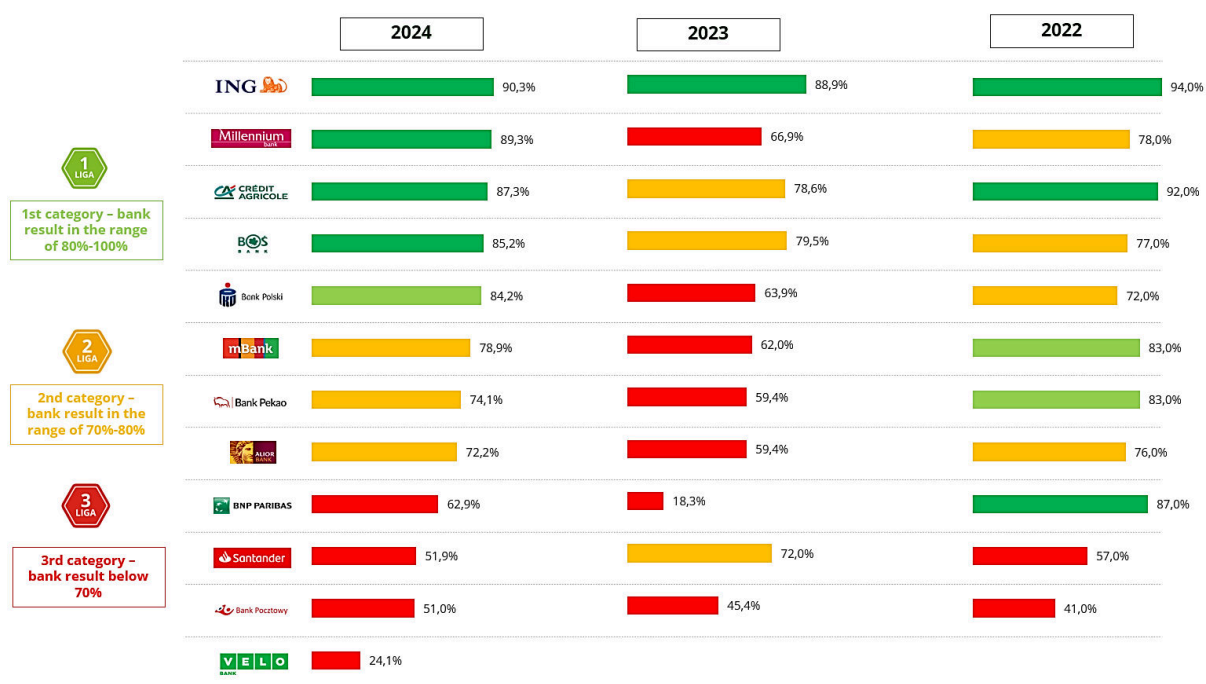


Figure 1. Global results of research on the quality of service for potential mortgage customers at bank branches between 2022-2024.

Source: Own study based on our own research during the 'Institution of the Year' project between 2022-2024.

Customer service performed remotely is characterised by much greater polarisation than service in branches. Only 3 banks scored a top-level result. The clear leader is VeloBank, followed by ING Bank Śląski (86.1%) and Credit Agricole (84.1%). In 2023, as many as 5 banks found themselves in the top category, compared with 4 in 2022.

The findings of this quality of service survey for potential mortgage customers via remote channels for each of the surveyed periods are presented in Figure 2.

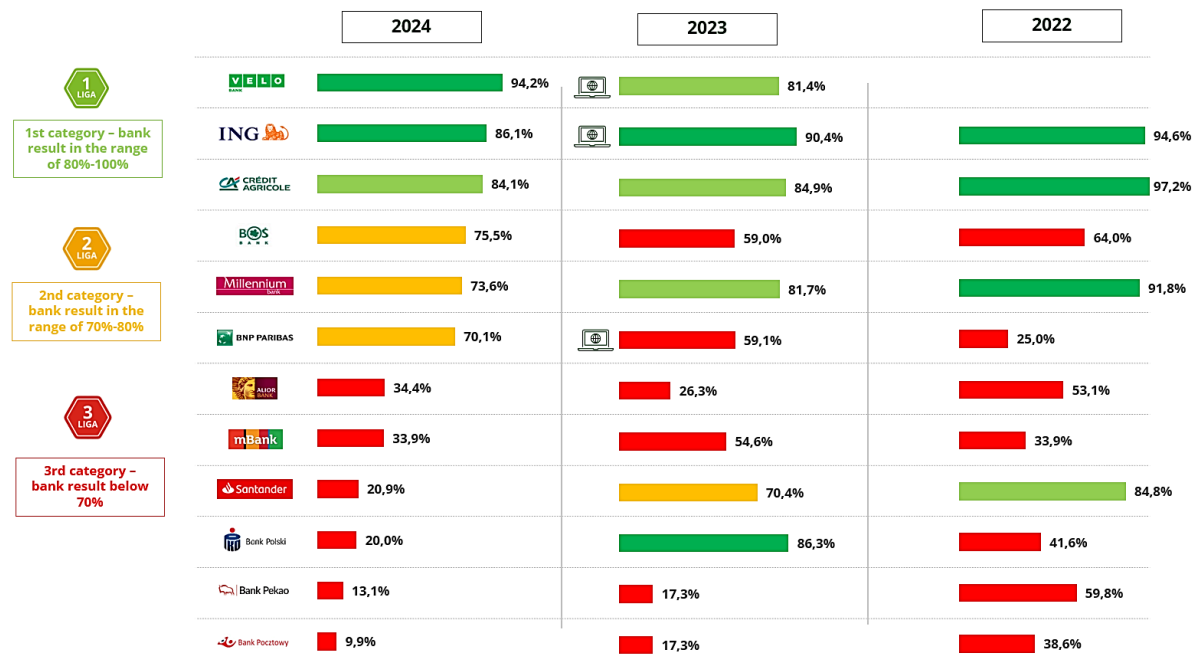


Figure 2. The findings of this quality of service survey for potential mortgage customers via remote channels between 2022-2024.

Source: Own study based on our own research during the 'Institution of the Year' project between 2022-2024.

The quality of customer service at the same banks noticeably differed depending on the contact channel during the study period. At PKO Bank Polski in 2024, where customers experienced an excellent level of service at their branches, the same product was presented poorly via the helpline. An even starker contrast emerged at VeloBank, where during meetings at their branch, the bank completely failed to meet the requirements of customers, whereas when contacted remotely this bank turned out to offer outstanding service.

Conclusions from the study on the quality of customer service for mortgage loan inquiries:

- stable high quality of service in leading banks,
- differences in service quality depending on the contact channel,
- banks with low mortgage service quality require actions to improve customer service,
- the impact of technology on service quality is increasing,
- Introducing a division into three categories allows for an objective observation of service quality and comparison of its changes over time.

ING Bank Śląski consistently maintains its position as the leader in mortgage customer service in bank branches. Looking at the overall picture, we observe fluctuations in results over the three years of our study. In 2022, five banks achieved a first-category rating, whereas in 2023, only two banks maintained a high service standard. The 2024 results indicate an improvement in service quality in some banks.

The study confirms significant differences between in-branch customer service and remote service. VeloBank, despite receiving a low rating for in-branch service, achieved the highest score in remote service, demonstrating its specialization in modern customer contact methods.

Similar discrepancies were noted in PKO Bank Polski, where in-branch service was rated highly, while the quality of service via the hotline left much to be desired.

Four banks scored below the 70% threshold, suggesting the need for service quality improvements. Notably, VeloBank, despite its excellent remote service performance, fails to meet customer expectations in physical branches. Its score of 24.1% highlights a lack of effective processes to support mortgage loan inquiries. However, in this case, the bank is clearly focusing on video-based service, even for customers visiting branches. This approach could represent a new model for mortgage customer service in the future, ensuring high-quality support in every branch despite the limited availability of top-tier mortgage specialists in all locations.

The post-pandemic period has brought growing customer acceptance of technology. As a result, banks that have invested in remote service quality achieved better results in this channel. However, it is worth noting that technology has not yet fully replaced face-to-face interactions in the mortgage service market in Poland. Nonetheless, we are witnessing the early stages of a shift in this area.

Dividing banks into three categories provides a clear benchmark for service quality levels. First-category banks maintain the highest service standards, while banks in the second and third categories should strive to improve their results. Enhancing service quality is particularly necessary given increasing customer expectations and the dynamic changes in the banking sector. This categorization objectively facilitates the comparison of banks over time and the observation of quality trends in the mortgage service market.

In conclusion, the study highlights significant differences in banks' approaches to mortgage customer service, showcasing both strengths and areas for improvement. Banks should focus on ensuring consistent service quality across all communication channels and strive to provide comprehensive and professional support, regardless of the contact method.

4.2. Factors influencing how the quality of service for mortgage customers was assessed

The quality of service study for potential mortgage customers covered all aspects of the customer's contact with the bank. For both communication channels, the aim was to obtain information about the possibility of obtaining a mortgage loan as well as the terms and conditions. The customers were looking to take out a loan for the purchase of an existing apartment (rather than a new build).

The final assessment, which had an impact on the global score, took into account nine key areas, presented in Figure 3 for service at bank branches and in Figure 4 for helplines.



Figure 3. Summary of factors influencing how the quality of mortgage customer service offered at bank branches was evaluated during the final study in 2024.

Source: Own study based on our own research during the 'Institution of the Year' project.



Figure 4. Summary of factors influencing how the quality of mortgage customer service offered via bank helplines was evaluated during the final study in 2024.

Source: Own study based on our own research during the 'Institution of the Year' project

The customers expected to receive the same scope of information on mortgage loans at the bank branches as well as via their helplines – as illustrated by Figure 4 and Figure 5. In addition to some basic information, they also asked numerous questions about various details.

Furthermore, a range of additional information was analysed, which, although it did not affect the global assessment or classification and is not presented here, is relevant to individual banks. This included elements of the product that customers found important, which were mentioned during meetings, or helpline and video conversations. This type of data is extremely valuable for bank managers, as it provides valuable guidance both in terms of improving products and methods of presentation.

Searching through mortgage loan offers can be extremely time-consuming. Therefore, clear presentation of the offer on the bank's website, calculators so that potential clients may determine the cost themselves, and support available without having to visit the branch are worth their weight in gold for working customers. Remote presentation of mortgage products and application processing are becoming increasingly popular. The project showed that good service via video or helpline is not only convenient, but often the only method of obtaining information. While examining the development and improvement of video calls at three banks – VeloBank, ING Bank Śląski and BNP Paribas Bank Polska – for the purposes of this study, the decision was taken to additionally separate the helpline and video channel findings (Figure 5). Given the rise in the quality of mortgage service offers via video, one might expect that this channel will also be developed by other banks.

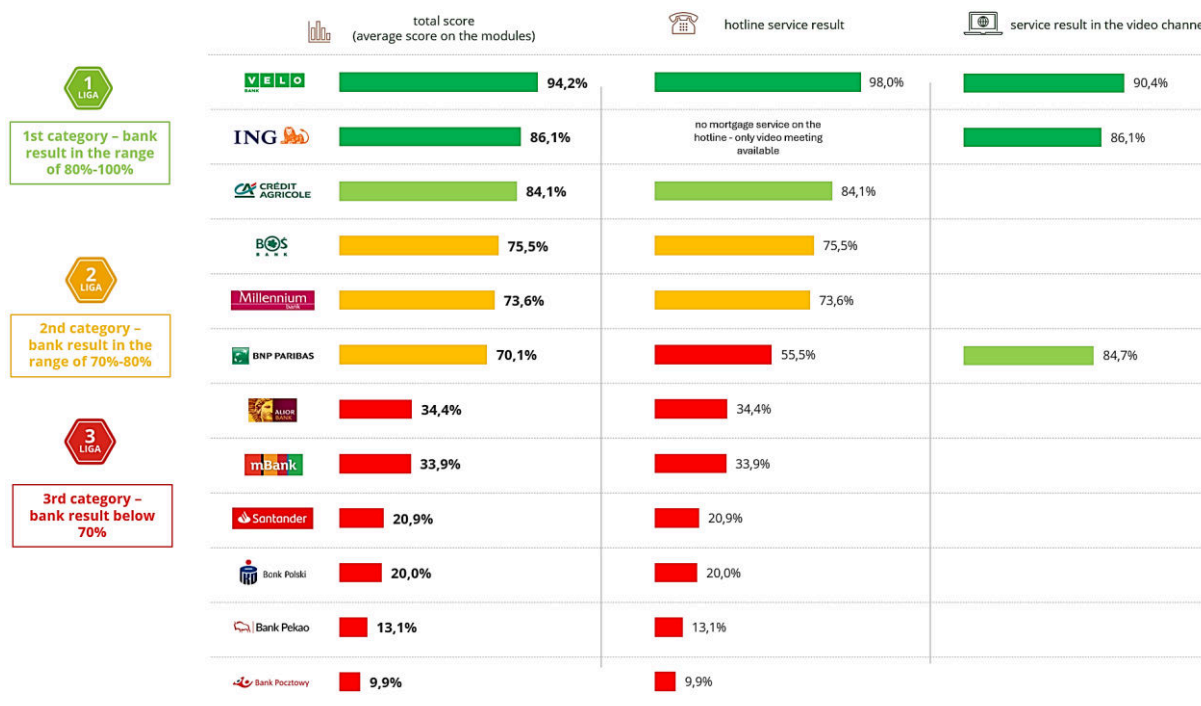


Figure 5. Summary of mortgage service quality offered via remote channels, divided into helpline and video, during the final study in 2024.

Source: Own study based on our own research during the 'Institution of the Year' project.

For many banks, meeting at a branch is difficult because mortgage advisors may not be available. Often, individual client advisors are not able to present detailed and salient information about mortgage products and processes beyond general points already covered on the website. Conversations with experts in branches also left much to be desired, often failing to engage in customer-centric partnerships. Customers who expected more than a general presentation of the offer were disappointed when they merely received a printout. To obtain more detailed information, they had to ask numerous additional questions, which did not meet their expectations regarding the quality of service.

In this context, remote channels were definitely gaining traction in terms of popularity and effectiveness. Banks that achieved satisfactory results during remote meetings seemed to have adopted a well-planned approach, with some commitment to providing the customer with detailed knowledge on the topic. Conversations via helpline and video often included an initial creditworthiness check, a presentation of various ways to configure the mortgage, a discussion of the benefits of taking out insurance and additional products, as well as a detailed description of the process. The banks that particularly stood out had advisors who not only demonstrated a high level of expertise, but were also able to put themselves in the customer's shoes, offering support and practical advice.

In theory, most banks offer the option of contacting them via the helpline, with the exception of ING Bank Śląski, where only video meetings are available. However, no banks offer a detailed and fully satisfactory explanation of their mortgage products via the telephone channel. Only four banks scored more than 70% in terms of service quality, while phone calls made to seven other banks definitely did not meet expectations.

The clear leader in terms of telephone service is Velobank, which scored almost 100%. All the calls met customer expectations. Telephone calls are handled centrally by a remote branch of mortgage experts, which is also responsible for video calls. Although the phone conversations are highly standardised, they maintain a high level of quality and naturalness thanks to the competence and openness of the consultants. Each call is conducted according to a precise plan, which offers benefits to both bank and customers. This level of service at Velobank can be considered outstanding.

The second bank that stood out in terms of phone call standards was Credit Agricole (also in 2023). Here, calls are answered by experts who are able to present their mortgage services in an effective manner. The main purpose of these calls is to guide the customer towards a remote process with the help of a telephone expert. Optionally, the customer might opt to meet at a branch, where the employee is then supported by a telephone expert. If necessary, the branch meeting is arranged according to the client's preferences. The conversations at Credit Agricole are characterised by high quality – as many as 80% of them met the customers' expectations. Moreover, the conversations were extremely efficient – seven of them took less than 30 minutes.

A fairly good result (75.5%) was achieved by Bank Ochrony Środowiska, where, similarly to 2023, customers managed to obtain some basic information about their mortgage services. The professionalism of the service and the commitment of the advisors were rated highly, although the level of the conversations was not outstanding. Only three conversations scored more than 80%. The fourth bank that stood out was Bank Millennium, where untapped potential was noticeable. Despite the bank's relatively low score (73.6%), half of the conversations met customer expectations (a score exceeding 80%).

The options available at many banks to schedule a phone call about a loan turned out to be inconvenient. No bank offers scheduling for a specific date, which means that customers are often surprised by phone calls at inconvenient moments, thus reducing their efficiency for both the customer and the advisor. This approach makes it difficult for both parties to communicate properly.

Help and empathy from advisors turned out to be key aspects for customers. Although the final decision regarding the choice of product lay with the customer, it was the skillful presentation of available options along with comprehensive and reliable information that distinguished the best-rated banks from the rest.

The main factors influencing the evaluation of mortgage customer service quality are:

- availability and quality of contact,
- advisor competence,
- scope and detail of provided information,
- availability and quality of remote service channels,
- service time and convenience,
- standardization and quality of service,
- empathy and customer approach,
- effectiveness of phone conversations,
- applied technology.

Service in branches faces challenges when mortgage advisors are unavailable. Remote channels (hotline, video) are gaining importance, especially given the limited availability of in-branch advisors. The inability to schedule a conversation for a specific time negatively impacted customer convenience.

There were noticeable differences in the knowledge and engagement of advisors. Some banks stood out by having experts with extensive knowledge, strong communication skills, and the ability to provide tailored advice. In contrast, some branches only offered general information, which led to customer disappointment. Clients expect professional assistance with all aspects of purchasing a property.

Customers also sought detailed information not only about financial terms but also about the overall process. Banks with the best service provided precise details on creditworthiness, offer configuration, insurance, and procedures.

Remote contact methods are growing in popularity, with three banks successfully implementing video consultations. The best banks in this area have developed highly efficient mortgage expert centers. This shift is driven by customers' preference for obtaining comprehensive information without visiting a branch. Since the mortgage inquiry process is time-consuming, well-structured service is essential. As a result, customers are increasingly willing to complete the entire process or at least its initial stages remotely.

VeloBank distinguished itself with nearly 100% service efficiency due to its centralized team of experts. While conversations were standardized, they maintained a personalized approach, which was positively received. Customers appreciated advisors who could empathize with their situation, provide practical advice, and ensure transparency of information.

The quality of telephone service in many banks was lacking only four banks scored above 70%. ING Bank Śląski does not offer telephone consultations, making it stand out from competitors. Instead, it follows a different customer service philosophy, focusing on video consultations. The development of video channels highlights their increasing role in mortgage banking. Banks that invest in modern solutions are better positioned to meet customer expectations.

The key factors in assessing service quality are advisor competence, contact availability, clarity of information, development of remote channels, and an empathetic approach to customers.

The value of video consultations in the three banks that implemented them is rated very high for mortgage customer service.

4.3. Presenting mortgage products and services during a video call

Three banks (BNP Paribas Bank Polska, ING Bank Śląski and Velobank) offer conversations via video, a situation that remains unchanged compared with the previous year. PKO Bank Polski, according to its website, claim that it is possible to arrange an online conversation with an advisor from a branch, but as before, it is difficult to find a branch that actually offers video calls. In practice, this option remains unavailable.

Similarly to last year, the mystery shoppers who tested the service offered via various contact channels agreed that video is the most convenient and worthwhile. This statement held true for all the banks studied in comparison with in-branch and helpline services.

Even people initially skeptical about remote meetings to discuss mortgages or submit applications changed their minds after experiencing all three channels. Video calls proved to be convenient, detailed and time-saving.

In 2021, EY published a report indicating that only 6% of respondents had no concerns about a fully digital mortgage process. Respondents in the EY survey had the opportunity to indicate a maximum of three concerns related to a fully online process from start to finish. They were most worried about data security (44.1%). However, as EY points out, such concerns are difficult to understand, considering the answers given to the question about the most frequently chosen channel of communication with the bank (Solec, Kozuchowska, Zdojewski, Kicińska, 2021).

In our Institution of the Year survey, we already ascertained that after completing part of the remote process, concerns about remote applications vanished.

At BNP Paribas and VeloBank, customers need to schedule a video call via the website, while ING offer a “click to video” option. At BNP Paribas and VeloBank, video calls are conducted by remote expert centres located at the head office of these banks, while in ING, they are handled by advisors from branches.

A summary of the scores obtained for video calls is presented in Figure 6.



Figure 6. Assessment of presentation of mortgage services via video during the final study in 2024.

Source: Own study based on our own research during the 'Institution of the Year' project.

At all three banks, the availability of specialists has significantly improved compared to the previous year. There are currently no problems with scheduling meetings, and advisors in ING and VeloBank are also available on Saturdays. From Monday to Friday, advisors in all banks work until the evening, which suits the needs of working people who might wish to apply for a mortgage loan. The arrangement of video appointments is assessed in Figure 7.



Figure 7. Video appointments for mortgage clients during the final study in 2024.

Source: Own study based on our own research during the 'Institution of the Year' project.

At BNP Paribas, clients are able to save the meeting in their calendar, along with the advisor's phone number and the invitation, which is helpful in the event of connection problems. Although minor technical problems occurred at all banks (e.g. connection difficulties or interruptions during the conversation), they did not undermine the assessment of this form of contact. The presentation of materials differed between banks. At ING and VeloBank, the advisors presented simulations illustrating the process on the screen, which enhanced the transparency of the offer. BNP Paribas did not use this type of graphical presentation.

Various detailed factors were taken into account when evaluating video calls. Here, we present only the most important to illustrate the study's level of detail. One of the key points, especially at the beginning of the conversation, is to determine the expectations of the mortgage customer, as presented in Figure 8.

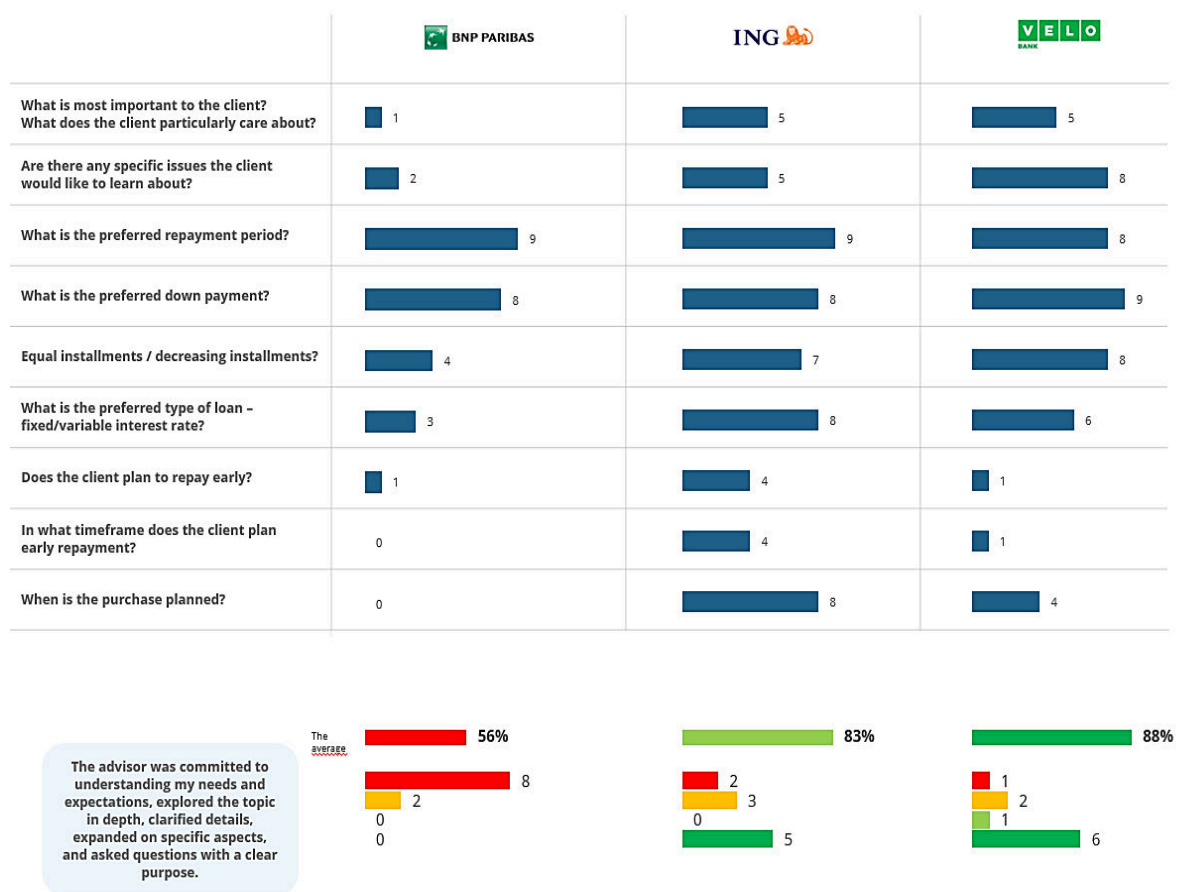


Figure 8. Discovering the expectations of potential mortgage customers during video meetings – a study from 2024.

Source: Own study based on our own research during the 'Institution of the Year' project

The leader of the final (2024) edition of the video communication study was VeloBank, which scored an impressive 90.4%. ING Bank Śląski came second with 86.1%, and third place was taken by BNP Paribas with 84.7%. These three leading banks stand out in terms of their very similar, high level of service via video meetings, which reflects their commitment to improving the processing of mortgage loans in this format.

Characteristics of video channel service based on the study:

- a convenient and valuable form of customer service,
- change in customer perception after experiencing the process,
- time savings and convenience,
- improved availability of advisors,
- transparency of the offer,
- professionalism of service.

Customers who tested different contact channels (branch, hotline, and video) unanimously rated the video process as the most comfortable and efficient. Even those initially skeptical about remote applications changed their opinion after their first experiences, confirming the effectiveness and intuitive nature of this process.

Customers appreciate the ability to handle formalities remotely, eliminating the need for branch visits. Compared to the previous year, the availability of video advisors has significantly increased, including during evenings and on Saturdays, better aligning with customer needs. Advisors in this process present real-time simulations on the screen, making it easier to understand loan terms.

Banks offering video service are ranked in the first category of the "Institution of the Year" classification, objectively indicating high professionalism and quality in this channel. The highest rated bank is VeloBank (90.4%), followed by ING Bank Śląski (86.1%) and BNP Paribas Bank Polska (84.7%), all achieving a very high level of service.

Considering past studies and observed trends, the video channel in mortgage banking has significant potential for further development.

We predict that in the future, AI will enhance video service, assisting advisors by analyzing customer data in real-time and suggesting personalized loan proposals. During the conversation, customers already receive tailored simulations based on changing parameters, and this will likely be refined using augmented and virtual reality for enhanced presentations.

The further expansion of accessibility and convenience depends on the development of this contact method. In the coming years, we expect an increase in the availability of video advisors.

Strengthening cybersecurity and authentication methods in this channel will drive its growth. Signing contracts in real-time via video will likely become a standard practice.

The video channel in mortgage banking will evolve toward greater automation, personalization, and integration with advanced technologies. We can anticipate even greater convenience, accessibility, and security, making it a key mortgage service channel for banks.

5. Summary

The credit market presents some very visible progress in the quality of service for potential mortgage customers. This improvement is particularly noticeable in remote channels, which are already starting to take over traditional branch service at a few banks. While a few years ago, before the COVID-19 pandemic, this was considered impossible due to this product's high level of detail, today the trend is clearly visible.

Even in a EY study before 2021, bank customers clearly indicated their transactional preferences regarding mortgages. This study demonstrated that online banking and mobile applications are the dominant choice, as well as the most common method of obtaining initial information. Despite this, the vast majority of loan applicants went directly to bank branches to obtain further information and initiate the mortgage process (EY report, 2021).

Research conducted within the 'Institution of the Year' project revealed that following 2022, this situation began to gradually change towards partially remote processing. Given the increasing digitalisation of banking services and the tendency of customers to deal with more and more matters remotely, this trend has gained significant traction.

Video meetings with direct interaction with a mortgage advisor can improve the quality of service, enabling a more individual approach to the customer's needs compared to a telephone conversation. If this form of contact is compared to a conversation with an advisor at a branch, who is not always a specialist, then a video meeting would also seem to be a beneficial solution. The customer has the opportunity to ask questions and receive answers in real time, which can facilitate making a decision regarding a particular mortgage loan. Mortgages are highly complex financial products, and a video meeting allows for a better presentation of documents, repayment plans or credit terms and conditions, and most importantly, we always have a bank expert on hand.

For many people, a video meeting eliminates the need to visit the branch in person, which saves time and increases the availability of services, with all three banks offering a range of working hours for video calls that bank branches cannot compete with.

This also helps banks reach customers in different locations, and banks can ensure a high level of security when transmitting sensitive information via encrypted video connections, which is particularly important in the case of banking products.

Many banks are sure to move in this direction soon and offer video meetings for mortgage services. Providing highly specialised mortgage services at small branches is not viable banks. However, the video trend not only meets customer needs, but also allows for more effective management of the sales network, while paving the way for more modern and convenient solutions for both parties.

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ECONOMIC ASPECTS OF OF TITANIUM ALLOY TI-5AL-2.5SN WELDING FOR AVIATION APPLICATIONS

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Purpose: Novelty of the paper is to present the Ti alloy welding for aeronautic application. Welding titanium is treated as a difficult procedure. The aim of the article is to develop the TIG (Tungstan Inert Gas) welding process for titanium alloys instead of much more expensive process of welding in vacuum chamber

Design/methodology/approach: Main parameters of the titanium alloy welding process were tested and then the quality of the obtained joint was checked by the mechanical tests.

Findings: Welding parameters were determined without carrying out the process in vacuum chamber that is much more expensive and energy-intensive process.

Research limitations/implications: It was suggested to investigate the effect of modified shielding gas mixtures (Ar-He) for the TIG process.

Practical implications: The proposed process innovation will result in savings of production cost, because titanium alloys are mainly welded in a vacuum chamber, which is more expensive process.

Social implications: Vacuum chamber in the welding process allows for energy savings.

Originality/value: It is to propose a new solution in aeronautic industry. The article is especially addressed to manufacturers of titanium alloys for aviation.

Keywords: production savings, transport, titanium, welding.

Category of the paper: Research paper.

1. Introduction

Titanium and its alloys are difficult to weld, which is why the welding process is usually carried out in a vacuum chamber. This is an expensive technological process, which is why this article aims to check the possibility of welding a titanium alloy using the TIG method, which

is 10 times cheaper. This is important from the point of view of production management. It translates into additional benefits related to environmental protection. Titanium has two allotropic varieties (alpha hcp and beta bcc), thus titanium alloys are divided into single-phase (alpha), two-phase (alpha + beta) and single-phase beta (Yee et al., 2023). Alpha alloys (α) are treated as rather well weldable. A representative of this material group may be the Ti-5Al-2.5Sn alloy, which was discussed in this article. Alpha alloys are easy to weld because they have a stable one phase microstructure and do not tend to become brittle after welding (Jaewson et al., 2011; Darabi et al., 2016). Two-phase alpha-beta titanium alloys ($\alpha+\beta$) are rather treated as moderately well weldable. A representative of this material group may be the Ti-6Al-4V. That alloy requires temperature control and also high quality and cleanliness protective atmosphere during welding. Beta alloys (β) are treated as materials difficult to weld. A representative of this material group may be the Ti-10V-2Fe-3Al. High content of β phase stabilizing elements causes greater tendency to brittleness. Very precise control of welding parameters is necessary. In all three groups of titanium alloys it is important to select main welding parameters, such as current, voltage and welding speed. It is important to provide an appropriate gas shield of high purity and quality, because titanium easily reacts with nitrogen and oxygen.

The paper presents the results of (Tungsten Inert Gas) welding for titanium alpha alloy Ti-5Al-2.5Sn. That alloy has good properties, high strength and good corrosion resistance, making it an interesting material for aviation application (Golański et al., 2018, pp. 53-63; Skowrońska et al., 2017, pp. 104-111). The use of high purity gases argon or helium (at least 99.995%) is necessary to avoid impurities. Helium is rather used as an additive argon gas mixture because it improves arc penetration and stability (Fydrych, Łabanowski et al., 2013; Shwachko et al., 2000). The titanium sheets should be perfectly clean before welding (Rehman, et al., 2021). Titanium alpha alloys welding requires low current because the material heats up very quickly (Faraji et al., 2021). Welding with too low speed also may result in excessive heating (Li et al., 2023). Properly selected welding speed is a very important parameter, because it allows to obtain a proper smooth weld (Piao et al., 2023).

2. Materials

For titanium alloy Ti-5Al-2.5Sn weldin with the TIG (Tungsten Inert Gas) method, two various rods (AWS A5.16: ERTi-5 based Ti-5Al-2.5Sn and rod ERTi-2 based on pur Titanium). The rod diameter was 2 mm. The main direction of research was the modification of shielding gas mixtures in the TIG process containing Ar and He. A thickness of welded sheets was 2 mm of the element in tubular form. Table 1 presents the mechanical properties of Ti-5Al-2.5Sn alloy.

Table 1.*Tensile strength of tested material*

Ti alloy	YS, MPa	UTS, MPa
Ti-5Al-2.5Sn	730	820

The mechanical properties correspond with proper chemical composition (Table 2). These good mechanical properties of the alloy are the result of the chemical composition, which affects the structure of the alpha alloy. The alpha phase is responsible for good plastic properties, and the lower tensile strength than beta phase of Ti alloy.

Table 2.*Chemical composition of tested grades of alloy*

Ti alloy	Al, %	Sn, %	Fe, %	O, %	N, %	C, %	Ti, %
Ti-5Al-2.5Sn	5.1	2.5	0.14	0.02	0.04	0.05	bal

The main alloying elements in alpha phase of Ti alloy are Al and Sn, which is consistent with the symbol of the material.

It was decided to realize TIG welding without chamfering. The connection was in the form of a pipe 300 mm long and 100 mm in diameter. The welded pipe was covered on both sides with a plug with 15 mm diameter holes (one hole for the shielding gas inlet, the other hole for the shielding gas outlet). A shielding gas with a variable flow rate flowed inside and outside the pipe. The weld was formed as single-pass. On the root side, the joint was protected by shielding gas mixture with constant flow on the level of 6 dm³/min.

At the beginning of welding process, the current and the voltage parameters were suggested:

- welding current: 106 A,
- arc voltage: 22 V.

Other important welding parameters were determined as follow:

- welding speed: 60 mm/min,
- outlet shielding gas flow was varied twice: 15 dm³/min and 17 dm³/min.

The joints were made with a several combinations. The most important element of investigation included selecting 2 welding rods (AWS A5.16: ERTi-5 based Ti-5Al-2.5Sn and composition and rod ERTi-2 based on pure Ti) and selecting of proper 3 shielding gas mixture for TIG welding process containing:

- 97%Ar and 3% He,
- 92% Ar and 8% He,
- 88% Ar and 12% He.

The use of high purity gas is important to avoid welding incompatibilities. Actually helium is only used in argon gas mixture because helium has a higher thermal conductivity than Ar, which results in a higher arc temperature. In that investigation it was decided to eliminate preheating temperature, because titanium has about 1/7 the thermal conductivity of aluminum; which

means it heats up quickly at the weld point but is slow to dissipate heat. Unlike steel, titanium is not susceptible to cold cracking (e.g., due to hydrogen hardening or residual stress).

3. Methods

After the TIG welding process without vacuum chamber, both non-destructive test (NDT) and destructive tests (DT) were carried out. Initially VT - visual test (using PN-EN ISO-17638 norm) was realized, then appropriate samples were made for destructive testing and the tensile strength (using PN-EN ISO 527-1 norm) and bending test (using PN-EN ISO 7438 norm) were carried out.

4. Results and discussion

The Ti-5Al-2.5Sn joints were made using two rods (AWS A5.16: ERTi-5 based Ti-5Al-2.5Sn and composition and rod ERTi-2 based on pure Titanium) and three different of shielding gas mixtures, 2 various shielding gas flow. Welding was realized without pre-heating temperature. Thus, 12 different samples were made, marked from U1 to U12 (tab. 4).

Table 4.
Samples designations

Sample	Shielding gas mixture	rod	shielding gas flow, dm ³ /min
U1	97%Ar and 3% He	ERTi-5	15
U2	97%Ar and 3% He	ERTi-2	15
U3	92% Ar and 8% He	ERTi-5	15
U4	92% Ar and 8% He	ERTi-2	15
U5	88% Ar and 12% He	ERTi-5	15
U6	88% Ar and 12% He	ERTi-2	15
U7	97%Ar and 3% He	ERTi-5	17
U8	97%Ar and 3% He	ERTi-2	17
U9	92% Ar and 8% He	ERTi-5	17
U10	92% Ar and 8% He	ERTi-2	17
U11	88% Ar and 12% He	ERTi-5	17
U12	88% Ar and 12% He	ERTi-2	17

Visual tests were performed for all samples (U1-U12). Only five samples (U2, U3, U4, U6, U9) were free from welding defect (row column are marked in green), but unfortunately seven samples were prepared incorrectly (row column marked in pink). The Visual test results with comments on the observations during inspection are put in Table 5.

Table 5.*Visual test results for tested dissimilar welds*

Sample	Observation
U1	Small cracking in HAZ
U2	Correct weld, defect free, correct form and dimension of HAZ
U3	Correct weld, defect free, correct form and dimension of HAZ
U4	Correct weld, defect free, correct form and dimension of HAZ
U5	Small cracking in weld from the face and root sides
U6	Correct weld, defect free, correct form and dimension of HAZ
U7	Small cracking in HAZ
U8	Small cracking in HAZ
U9	Correct weld, defect free, correct form and dimension of HAZ
U10	Small cracking in weld from the face and root sides
U11	Small cracking in weld from the face and root sides
U12	Small cracking in weld from the face and root sides

It was found that the selection of shielding gas flow and rod is less important than selection of gas mixture. The shielding gas flow should be on the level of 15 dm³/min. Helium in small percentage stabilizes the welding arc of the TIG welding process. The next part of the research was to get a tensile strength of the joint. Only samples that tested positive in NDT tests were taken into further testing (U2, U3, U4, U6, U9). Table 7 presents the tensile strength (UTS) of the titanium Ti-5Al-2.5Sn alloy joints.

Table 7.*Tensile strength of Ti-5Al-2.5Sn alloy joints*

Sample	UTS [MPa]
U2	629
U3	665
U4	655
U6	622
U9	607

The data from the tab. 7 prove that there is high tensile strength of all tested joints over the 600 MPa. It was noticed that the joint made of ERTi-5 rod (similar composition to Ti-5Al-2.5Sn alloy) had the best tensile strength.

As the last part of the article a bending tests was carried out to check the plastic properties of the joints. Measurements were done both from the root and from the face sides of the titanium alloy joint. A bending test was realized at room temperature. The results of bending test are demonstrated in Table 8.

Table 8.*Bending test of Ti-5Al-2.5Sn alloy weld*

Sample	Face side	Root side
U2	No cracks	No cracks
U3	No cracks	No cracks
U4	No cracks	No cracks
U6	No cracks	No cracks
U9	No cracks	Small cracks

The bending tests could be treated as a positive. No cracks were observed in the samples, when the shielding gas flow should be on the level of 15 dm³/min (U2, U3, U4, U6). This corresponds with good properties of the titanium alloy Ti-5Al-2.5Sn alloy joint. Small cracks were observed only in one case, when gas flow was too intensive.

5. Summary

The article presents the possibility of Ti alloy welding without using a vacuum chamber, which is an expensive technological process. The possibility of welding a titanium alloy using the classic TIG method was checked, which is several times cheaper. This is important from the point of production management due to the large savings and benefits related to environmental protection. Welding of Ti-5Al-2.5Sn alloy, used in the aviation industry, was tested. Main parameters of the TIG process were analyzed (2 various rods, 3 various gas mixtures). The correctness of the welds using destructive and non-destructive methods was rated. In the presented welding method, correct joints were obtained, which is important for economic reasons. The process of welding titanium alloys in a vacuum chamber is much more expensive, which does not translate into material benefits, because the mechanical properties of the joints made in a vacuum are at a comparable level to the tests presented in the article. The cost of welding titanium alloys in a vacuum chamber can be as much as 5-20 times higher than in a standard argon TIG process. The cost of equipment and installation for welding in a vacuum chamber requires specialized infrastructure, especially a hermetic chamber and multi-stage vacuum pump, while the standard TIG process requires only a power source, a welding head and good protection of a mixture of argon and helium.

Based on the research study it was possible to conclude paper:

1. Welding of alloy Ti-5Al-2.5Sn using only TIG method allows for process savings, because welding in vacuum chamber is at least 10 times more expensive process.
2. Welding parameters (rods and gas mixtures) should be selected with great knowledge and sensitivity.
3. The best mechanical properties of welds were obtained when:
 - the shielding gas mixture should contain 92% Ar and 8% He,
 - the shielding gas flow rate should be 15 dm³/min,
 - rod has similar composition to the welded material.

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LOGISTICS SERVICES FACING THE CHALLENGES OF A GREEN ECONOMY: EXTRACTION OF KEY GREEN RESEARCH AREAS

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Purpose: Identification of key green research areas in scientific publications using bibliometric methods that simultaneously address logistics services and various green issues.

Design/methodology/approach: All scientific work was planned and conducted between November 2024 and March 2025. The study employed a bibliometric query, which enabled the extraction of 213 scientific publications from the Scopus database for analysis. The author's keywords assigned to the scientific publications were analysed.

Findings: As a result of the research assumptions and analyses carried out, 14 key green research areas were identified. Researchers most often referred to issues of green logistics, green supply chain management, green supply chains, or simply green innovation using the keyword 'green'.

Research limitations/implications: The study revealed two main limiting factors. Firstly, only publications from the Scopus database were analysed. Secondly, a proprietary bibliometric query (Q1) was used to define the search scope. It is worth emphasising that these limitations also enable future replication of the study for comparative purposes.

Originality/value: The study is unique compared to other bibliometric studies on logistics services due to the bibliometric query used. The presentation of results on the bibliometric map also differs from typical visualisations of this kind, showing only the key green research areas. In the subsequent discussion, attention was drawn to the effects of the ongoing greening of logistics services. For example, the need for future research to demonstrate the impact of this phenomenon on the creation of green jobs in the logistics sector was highlighted. The article is addressed to those interested in logistics services and green research topics within this context.

Keywords: green economy, green jobs, green logistics, green supply chain, logistics services.

Category of the paper: Literature review.

1. Introduction

Numerous scientific studies focus on the changes occurring in the socio-economic environment and their impact on the functioning of not only current but also future generations. In this context, the issue of the ongoing green transformation or green transition of the economy is increasingly being addressed. Regarding the green economy, it should be noted that this concept is linked, on the one hand, to the process of socio-economic progress and, on the other hand, to minimising the negative environmental impact of economic activity. In economic practice, the greening of the economy can be observed through green products and services (Armutcu et al., 2024; Tran, 2024), green public procurement (Szydłowski, 2024), green investments (Liu et al., 2023), and the implementation of various green technologies (Ahsan Iqbal et al., 2025; Wodnicka, Królikiewicz, 2024). An important element of this process is green jobs, which are increasingly being identified and researched (Han et al., 2025; Sulich, Kozar, 2024).

With the development of the green economy, many sectors are facing the challenges of transformation resulting from the need to meet the environmental challenges posed by various stakeholders. This aspect is visible, for example, through the prism of the logistics sector and the green innovations implemented in it (Sun et al., 2025). As a result, the issue of green logistics is increasingly being discussed in scientific publications (Kozar, Wodnicka et al., 2024; Nikseresht et al., 2024; Tetteh et al., 2024). Within the framework of this research problem, as the authors of this article recognise, the most frequently discussed are sustainable or green practices aimed at sustainable transport, reducing the carbon footprint, minimising waste generated by individual logistics processes, or the use of reusable materials.

Green and sustainable programmes and activities have become a major focus for the logistics industry to improve the provision of logistics services (Wang, Hu, 2021), which can be divided into two categories: resource-based services and management skills-related services. The first group includes physical services such as transport and warehousing, while the second group includes services related to organisation, planning, and supervision (Jarocka, Wang, 2018). Logistics also encompasses services related to inventory management, customer relationship management, and customer-specific services. Examples of green logistics services include activities related to the sustainable production, procurement, and distribution of goods. These include green transport, green warehousing, green packaging, green processing, and green recycling (Yu et al., 2018). Logistics service providers and freight forwarders play an important role in promoting and delivering green logistics services. They are key players in advancing the green economy and green logistics. Their activities, operations, and awareness of the importance of environmental issues ultimately influence the practices of providing logistics services that meet the challenges of the green economy. Given the growing importance of logistics services in the context of green issues, this topic has become the subject of further analysis.

The aim of the research is to use bibliometric methods to identify key green research areas addressed in scientific publications that simultaneously cover logistics services and various green issues. To achieve this objective, it was assumed that key green research areas would be identified based on proprietary keywords assigned to the individual scientific publications analysed from the Scopus database. It was also assumed that a green research area is simply a proprietary keyword that includes a reference to 'green'. The study employed both a systematic literature review and a classical literature review method, which allowed for broader conclusions. VOSviewer (version 1.6.20) was used to map the key green research areas.

The article is divided into four interrelated parts, which together present the research conducted and the conclusions drawn. The first part, the introduction, discusses the context of the analysis, defines the research purpose, and highlights the methods used. The second part elaborates on the methodological issues in detail and presents the schedule of the research activities undertaken. This detailed presentation of the methodological aspects was intended to ensure the study can be replicated in the future and enable other researchers to compare their results with those presented in this article. The third part focuses on the results and their interpretation, while emphasising the green directions for further research, which are considered important by the authors. In conclusion, it is noted that the growing interest in green issues in the context of logistics services will lead, among other things, to the emergence of new green research areas.

2. Research methodology

All research activities presented in this article were carried out from November 2024 to March 2025. The research process, as shown in the timeline in Figure 1, was divided into four key stages. The individual research steps were designed to ensure high-quality results. Additionally, the study was planned in such a way that it can be replicated in the future. This means that the data presented can be discussed in future studies on logistics services and green issues.

In the first phase of the research, the research problem was identified to isolate the research gap that would become the focus of the study. Initially, a review and analysis of randomly selected scientific publications related to logistics services were carried out from the Scopus database. The analysis focused on scientific articles, reviews, and conference papers. The review revealed an increased interest in various green issues in the context of logistics services. This research direction results from the gradual green transition of socio-economic life, including the greening of the logistics sector.

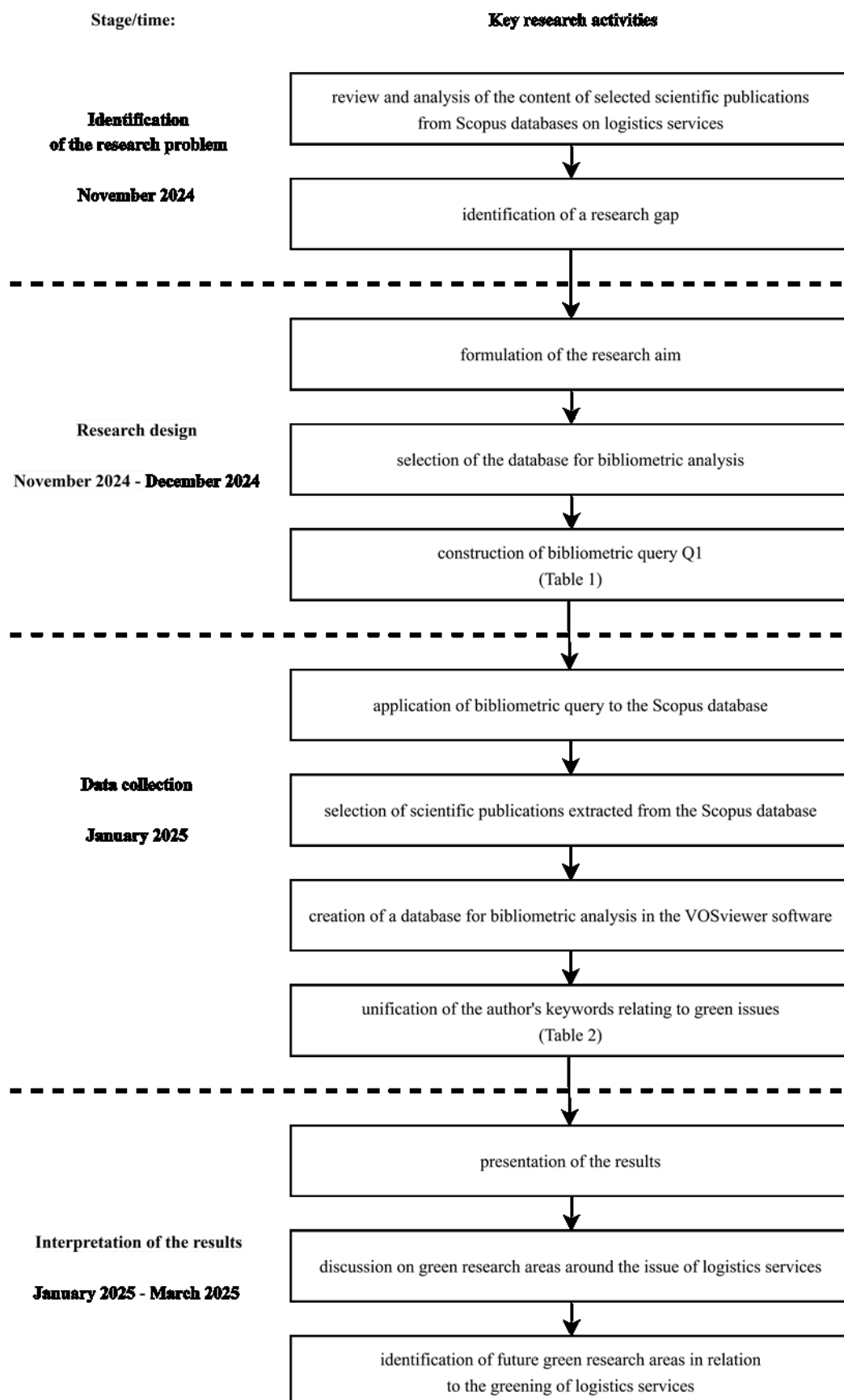


Figure 1. Research procedure stages and timeline.

Source: Authors' elaboration.

During these analyses, a notable diversity of green research areas mentioned in individual scientific publications was observed, which, in the opinion of the authors, requires scientific organization in the form of distinguishing key green research areas. Observations regarding green research directions became the basis for formulating the research objective. Therefore, it was assumed that the aim of the research would be to use bibliometric methods to identify key green research areas in scientific publications that simultaneously address logistics services and various green issues. As in the case of the research by Kozar & Wodnicka (2024), it was assumed that green research areas would simply be the author's keywords assigned to scientific publications referencing green issues. Thus, green research areas would be identified solely through the analysis of author keywords. The Scopus database was selected for the bibliometric analyses. It is widely used in bibliometric studies on logistics services, the identification of green research areas, and more broadly, in research related to sustainability issues. It is possible to construct a bibliometric query in this database by appropriately defining the search area, meaning that the study can be repeated in the future for comparative purposes. It is also worth noting that the Scopus database is highly regarded in the scientific community, and journals must meet strictly defined scientific standards to be indexed in it, further emphasizing the quality of the data source selected for the analyses undertaken.

In the final research activity, the bibliometric query Q1 was constructed during the research design phase, the syntax of which is shown in Table 1. The analysis covered scientific publications published up to 2025. Omitting publications from the year in which the bibliometric analysis is conducted is a common practice in this type of analysis. On the one hand, this makes it easier to compare studies in the future (especially in the context of citing bibliometric figures broken down by year). On the other hand, in the year the research is conducted, the publishing cycle is still ongoing, meaning there is a continuous process of adding new scientific publications to the Scopus database (including the possibility that some of these publications may meet the search parameters). As Table 1 shows, apart from the year of publication and reference to substantive issues (such as green issues and logistics services), scientific publications had to meet the following criteria: publication stage (final), source type (journal, conference proceedings), language (English), and document type (article, conference paper, review).

Table 1.
Details of search query syntax for Scopus databases

Database	Symbol	Query syntax	No. results
Scopus	Q1	TITLE-ABS-KEY (("green" OR "greener" OR "greening") AND "logistic* service*") AND PUBYEAR > 2005 AND PUBYEAR < 2025 AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SRCTYPE , "j") OR LIMIT-TO (SRCTYPE , "p")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (PUBSTAGE , "final"))	213

Source: Authors' elaboration 14.01.2025.

The third stage of the research began with the bibliometric query Q1 for the Scopus database. As Table 1 shows, 213 scientific publications met the criteria set in the bibliometric query (151 articles, 54 conference papers, and 8 reviews). In the interest of high-quality research, an automatic selection of scientific publications was carried out. As a result of the review, the following were removed from further analysis:

- 1 conference paper due to duplication of the same publication in the database,
- 2 conference papers with no authors assigned (labeled 'no authors found'),
- 7 conference papers and 4 articles without assigned author keywords (a necessary criterion for identifying key green research areas based on author keywords).

Hence, 14 scientific publications were eliminated after further analysis, resulting in 199 scientific publications being subjected to further analyses aimed at achieving the intended research objective. The final research activity at the data collection stage was the procedure of unifying author keywords referring to green issues. This activity improves the data quality on the bibliometric map. This procedure was necessary due to, among other things, language differences (British English, American English) or the use of singular and plural forms for the same green author keywords. The standardisations carried out are presented in Table 2.

Table 2.
Unified author keywords relating to green issues

Identified green author keyword (original record)	Green keyword after unification
a green warehouse	green warehouse
green supply chain (gsc)	green supply chain
green initiative	green initiatives
green innovations	green innovation
green logistic	green logistics
green logistics practice	green logistics practices
green supply chain management (gscm)	green supply chain management
green transportation (gt)	green transportation
gscm	green supply chain management
“green” logistics	green logistics

Source: Authors' elaboration.

The presentation of the results and their interpretation took place in the final stage of the research, as shown in Figure 1. This stage is described in the next part of this article. At this point, it should be emphasised that, due to the limitations of the research, the results should be interpreted with the presented methodology in mind. Thus, it should be noted that the first limitation of the research stems from the choice of the Scopus database. The selection of other bibliometric databases for analysis may result in a smaller or larger number of green research areas. Additionally, it is impossible to include all publications that meet the criteria set in the bibliometric query, as some scientific publications are not indexed in any online bibliometric database (making it impossible to obtain information about all publications in the discussed subject area published within a given period). Furthermore, the bibliometric query itself and its design limit the research area. Nevertheless, these limitations mean that the research can be repeated in the future, and the constructed proprietary bibliometric query, after adjusting its syntax, can be applied to other bibliometric databases (e.g., Web of Science).

3. Results and discussion

During the process of standardising green author keywords, the phrase ‘green research area’ was added to all publications containing such specific keywords. This was necessary to visualise the isolated key green research areas, which were considered to be those that appeared in at least two scientific publications. The identification and visualisation of key green research areas, as shown in Figure 2, was made possible by the VOSviewer software. This software is commonly used to visualise various types of bibliometric data. Each of the 14 key green research areas identified in Figure 2 is marked in green. No clustering was performed in this analysis due to the addition of the phrase ‘green research area’. The individual author keywords are represented on the bibliometric map not only by a word label but also by the size of the node in the form of a uniform green dot (the more often a particular author keyword appears in the analysed scientific publications, the larger the dot).

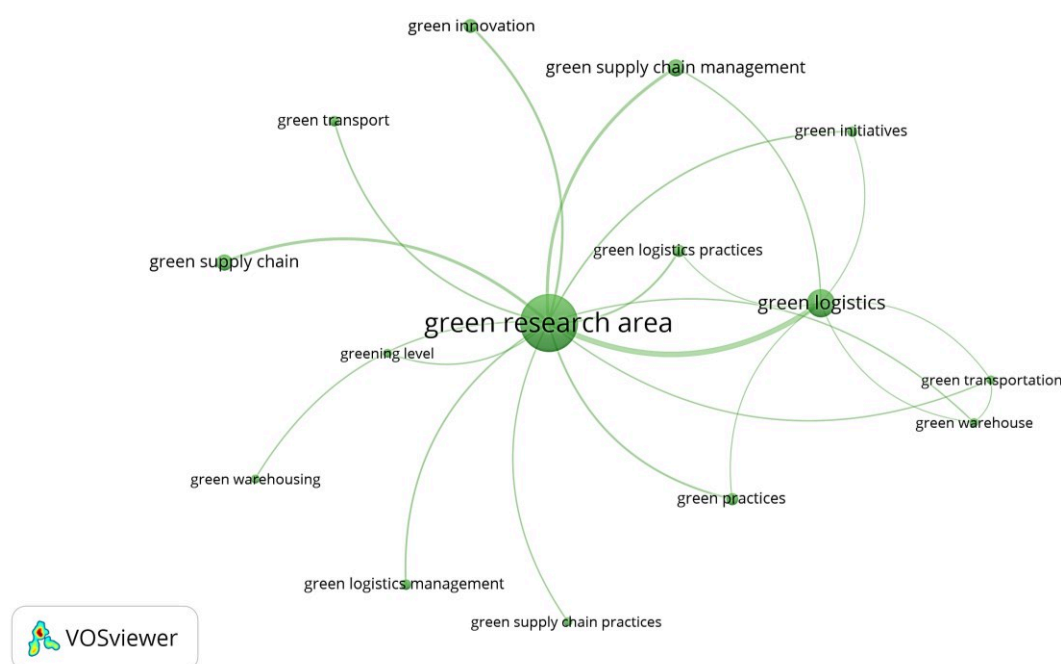


Figure 2. Bibliometric map of co-occurrence identifying key green research areas.

Source: Authors' elaboration in VOSviewer software (version 1.6.20).

On the bibliometric map in Figure 2, there are green lines between the individual words. If these lines connect the identified key green research areas, it means that these words appeared next to each other in at least one scientific study within the author keywords. As many as half of the identified green research areas did not appear with any other green author keyword in any of the analysed articles. The type of bibliometric analysis conducted primarily allowed for the identification of the number of scientific publications among those analysed in which the diagnosed key green research area was present, as shown in detail in Table 3.

Table 3.
Green keywords presented in Figure 2

Keywords	Number of occurrences	Articles (author/authors and year)
green initiatives*	3	(Evangelista et al., 2018; Froio, Bezerra, 2021; Ren et al., 2019)
green innovation*	6	(Chu et al., 2019; Karia, Asaari, 2013; Lin, Ho, 2008; L. Liu et al., 2023; D. Wang et al., 2024; Zailani et al., 2011)
green logistics*	33	(Abdullah et al., 2016; Alvarenga et al., 2023; Bahr, Sweeney, 2019; Celik et al., 2016; Cempirek et al., 2021; Čižiūnienė et al., 2024; Dong et al., 2023; Dudin et al., 2016; Dzwigol et al., 2021; Ehmke et al., 2018; Frehe, 2015; Froio, Bezerra, 2021; Hüge-Brodin et al., 2020; Jazairy, von Haartman, 2020; Liu et al., 2023; Liu et al., 2019; Martins et al., 2020; Martinsen, Björklund, 2012; Martinsen, Hüge-Brodin, 2014; Massaroni et al., 2016; Peng, 2010; Perotti et al., 2023; Philipp, Militaru, 2011; Rapp et al., 2021, 2024; Rüdiger et al., 2016; Sallnäs, Hüge-Brodin, 2018; Singh, Roy, 2022; Sureeyatanapas et al., 2018; Vienažindienė et al., 2021; Wang et al., 2019; Wehner et al., 2021; Yu, 2016)
green logistics management	3	(Aroonsrimorakot et al., 2022; Khan et al., 2019; Rehman Khan et al., 2018)
green logistics practices*	4	(Karia, 2016; Kim et al., 2024; Osman et al., 2023; Vienažindienė et al., 2021)
green practices	4	(Liu et al., 2023; Prataviera et al., 2024; Rapp et al., 2024; Shaharudin et al., 2018)
green supply chain*	9	(Bajec et al., 2015; Bilek et al., 2024; Centobelli et al., 2017a, 2017b; Centobelli, Cerchione, Esposito, 2020; Centobelli, Cerchione, Esposito et al., 2020; Elzarka, 2020; Lu et al., 2008; Xu et al., 2016)
green supply chain management*	10	(Abdullah et al., 2016; Aityassine et al., 2021; Bask et al., 2018; Jazairy, 2020; Jazairy et al., 2021; Jazairy, von Haartman, 2020; Laari et al., 2018; Lam, Dai, 2015; Meybodi, Delshad, 2023; Sallnäs, Björklund, 2020)
green supply chain practices	2	(Gupta, Singh, 2020; Nawurunnage et al., 2023)
green transport	3	(Beškovnik et al., 2020; Petljak et al., 2014, 2016)
green transportation*	2	(Liu et al., 2023; Orji, 2024)
green warehouse*	2	(Liu et al., 2023; Margareta et al., 2020)
green warehousing	2	(Cannava et al., 2023; Perotti, Colicchia, 2023)
greening level	2	(Wang, Hu, 2021, 2022)

* for these keywords, procedures were conducted to unify the author's keywords

Source: Authors' elaboration.

None of the 14 key green research areas identified was the subject of scientific consideration expressed through the author's keyword in all 199 scientific publications included in the research. Green logistics, green supply chain management, and green supply chain had the highest number of occurrences (Table 3).

It is worth noting that in the analysed research area, publications that simultaneously featured two green research areas most often included green logistics as one of these research areas, as shown in Figure 3. The issue of green logistics was addressed alongside such green key research areas as green supply chain management (Abdullah et al., 2016; Jazairy, von Haartman, 2020), green initiatives (Froio, Bezerra, 2021), green transportation (Liu et al., 2023), green warehouse (Liu et al., 2023), green practices (Rapp et al., 2024), and green logistics practices (Vienažindienė et al., 2021). Only one publication simultaneously identified

three key green research areas: green logistics, green transportation, and green warehouse (A. Liu et al., 2023).

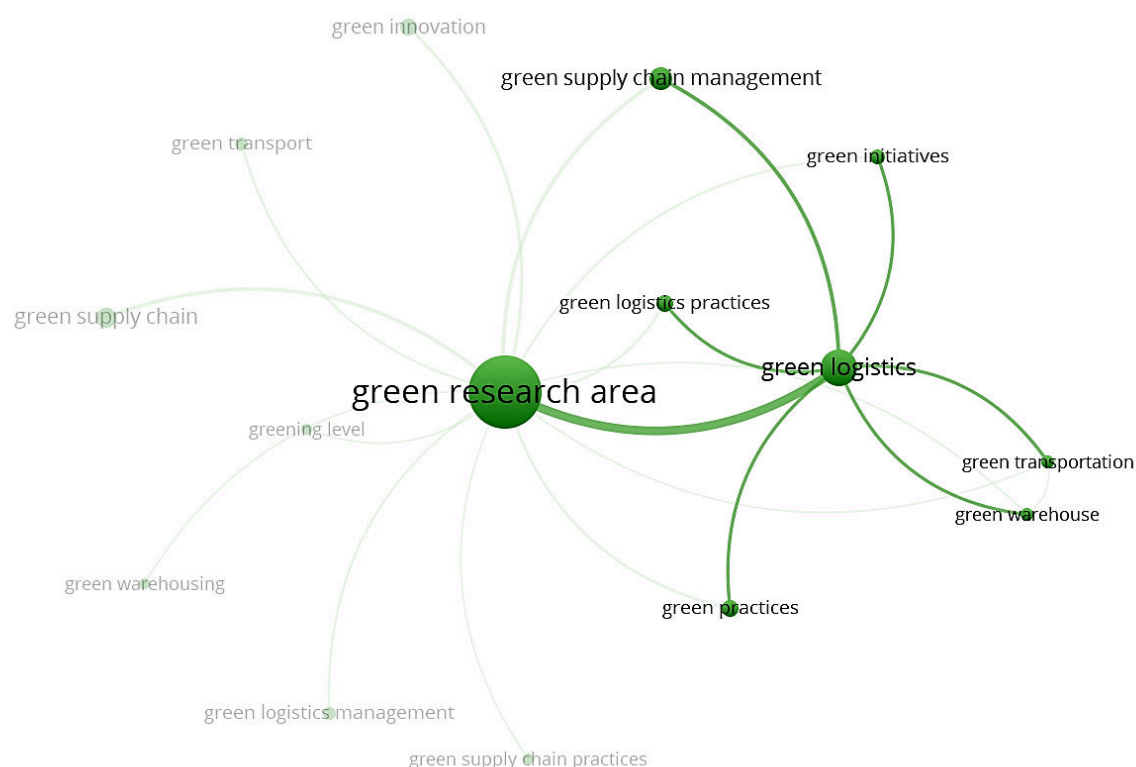


Figure 3. Visualization of connections with green logistics on a bibliometric map.

Source: Authors' elaboration in VOSviewer software (version 1.6.20).

During the analyses carried out, it was noticed that green issues are mainly raised in relation to logistics and the supply chain when the topic of logistics services is mentioned. This observation applies to both key green research areas and the totality of green keywords assigned to the 199 scientific publications analysed. Considering the increased interest of researchers in the green aspects of logistics services, the authors of this article believe that new green key research areas can be expected to emerge in the future. Even now, there is a slowly emerging interest in issues related to the management of human capital in individual logistics entities towards green practices. As a result, references to the green HRM concept or green competence management have been observed in the analysed set of scientific publications (Moczyłowska et al., 2024). In the opinion of the authors of this article, the gradual greening of logistics services in individual logistics entities will not only generate interest in green competencies among researchers but will also steer research towards the creation of green jobs (including green jobs of adequate quality and sustainability). The creation of these types of jobs in the logistics sector under the influence of the greening process is already slowly becoming noticeable to researchers (Kozar, Bednarski et al., 2024). Another area that the authors of this article believe will be further developed is the issue of green logistics services.

4. Summary

In contrast to previous bibliometric analyses that simultaneously focused on the topic of logistics services and various green issues, this study differs in both the content of the bibliometric query and the way the bibliometric map is generated by adding the term ‘green research area’. In previous studies, the issue of green was addressed in bibliometric queries alongside many other topics, such as sustainable development or eco-friendly practices, and was often framed in a much broader context referring to various issues related to logistics (Ren et al., 2019). This study thus fills a research gap in the context of logistics services.

The study identified 14 key green research areas addressed in scientific papers that simultaneously discuss logistics services and various green issues. These areas do not explicitly refer to green logistics services or even to green issues related to shaping a green labour market. Nevertheless, it has been observed that these issues are slowly emerging, although, as original keywords, they have so far been mentioned only in individual scientific studies. Based on the analyses carried out, it can be clearly stated that the increased interest of researchers in green issues in the context of logistics services will lead to both the further development of research on existing green research problems and the emergence of entirely new green research areas (especially those related to new innovative technologies).

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QUANTITATIVE ASSESSMENT OF SARS-COV-2 IN MUNICIPAL WASTEWATER IN COMPARISON TO DAILY EPIDEMIOLOGICAL REPORTS ON THE INCIDENCE OF COVID-19 IN THE REGION

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Purpose: in this article, virological analysis was used to detect SARS-Cov-2 RNA in municipal sewage. As part of the work obtained comparatively with current epidemiological data to assess, or in terms of the indicator of the impact of COVID-19, municipal sewage can be a representative medium for assessing the health status of residents, sewage catchment.

Methodology: The research used the physicochemical analysis method using a set of research techniques used in chemistry and related sciences, which allow for determining the physical and chemical properties of substances.

Result: based on the obtained results of physicochemical parameters of wastewater, it can be concluded that the quality of wastewater has a significant impact on virus RNA concentration, which directly affects the sensitivity, viability and reproducibility of the SARS-CoV-2 virus in the same volume of analyzed wastewater.

Originality: research groups around the world have begun analyzing wastewater for a new indicator that can estimate the total number of infections in a given community. Scientists have already shown that there is a correlation between the concentration of SARS-CoV-2 RNA in wastewater and the number of identified clinical cases of COVID-19. They also suggest that monitoring RNA concentrations can provide information about cases of infection 4-7 days in advance, and thus provide an early warning system or identify sources of serious infections.

Keywords: sars-cov-2, municipal sewage, region.

1. Introduction

The SARS-CoV-2 virus originally known as 2019-nCoV (novel coronavirus) was discovered in late 2019 in Wuhan, central China (Hubei Province). SARS-CoV-2 is the seventh identified human coronavirus that has proven to be extremely infectious and highly virulent. The rapid spread of the coronavirus resulted in January 2020 WHO's declaration of a public

health emergency and respectively a pandemic state in March 2021 (<https://www.who.int/...>, 2021). Currently (8.01.2022), there are over 298 915 721 confirmed cases of COVID-19 infection worldwide (Americas: 108 806 129; Europe: 108 040 601; South-East Asia: 45 406 695; Eastern Mediterranean: 17 277 716; Western Pacific: 11 841 165; Africa: 7 542 653). Since its beginning, the pandemic has caused more than 5,46 million deaths (<https://covid19.who.int/>, 2022). In Poland, according to information presented by the Ministry of Health from March 2020 (4.03.202) up to date (8.01.2022), more than 4,20 million infections have been reported in Poland, with over 99,727 cases resulting in death (<https://www.gov.pl/web/koronawirus>, 2022). Coronavirus infections occur mainly by droplet infection through direct contact with an infected person. However, because of the survival of the virus on various types of abiotic surfaces, infection by indirect transmission through touch from contaminated surfaces and materials (Tan, Chenshan, Zhou, Van Driel, Ye, Zhong, 2020; Chin, Chu, Perera, Hui, Yen, Chan, Peiris, Poon, 2020). Although the main mechanism of SARS-CoV-2 transmission is based on the airborne transmission of the so-called respiratory drop-lets and aerosols (Meselson, 2020) the presence of the virus in the faeces and urine of infected individuals is particularly important in terms of monitoring virus transmission by testing environmental samples.

Literature data confirm that the amount of SARS-CoV-2 virus RNA present in the sputum and feces of patients with mild disease symptoms are similar to those found in the upper respiratory tract of COVID-19 patients (Wölfer, Corman, Guggemos, Seilmaier, Zange, Müller, Niemeyer, Jones, Vollmar, Rothe, Hoelscher, Bleicker, Brunink, Schneider, Ehmann, Qu, Kuang; Yang, Li, Dai, Liu, Li, Jie, 2020). The presence of SARS-CoV-2 virus in the gastrointestinal tract, feces, and urine of COVID-19 infected individuals has also been confirmed in studies conducted by Wu and Singer (Wu, Xiao, Zhang, Gu, Lee, Kauffman, 2020; Singer, Wray, 2020). Thus, the presence of RNA virus in urine and feces at concentrations allowing its quantitative and qualitative identification allows to use WBE approach (Wastewater-Based Epidemiology) to assess the current course and predict the direction of the pandemic (Doughnton, 2020). Application of the WBE approach, based on virological analysis of municipal wastewater, allows assessing of the real scale of pandemic development including identification of new disease outbreaks. Moreover, the approach makes it possible to obtain the data and information necessary for decision-makers to take actions related to the allocation of resources during emergencies (prioritization of needs), to target response and prevention actions as well as to lift restrictions and bans in areas with low incidence (Doughnton, 2020; Ahmed, Angel, Edson, Bibby, Bivins, O'Brien, Choi, Kitajima, Simpson, Li, Tschärke, Vergahen, Smith, Zaugg, Dierens, Hugenholtz, Thomas, Mueller, 2020; Lorenzo, Picó, 2019). According to the assumption of the WBE model, when pathogenic organisms are excreted with the feces or urine of an infected person, this tool can be used to assess the concentration of pathogens in collective sewage systems.

The results obtained during analyses can be used to estimate the health status of the population living in the sewage catchment area. Thus, in times of a COVID-19 pandemic, the WEB model provides an alternative tool for predicting pandemic status in a region that can be used when analytical and diagnostic capabilities are limited or when there is no basis for testing so-called asymptomatic patients. A conceptual diagram of the application of the WBE model to a sewer catchment is shown in Fig. 1.

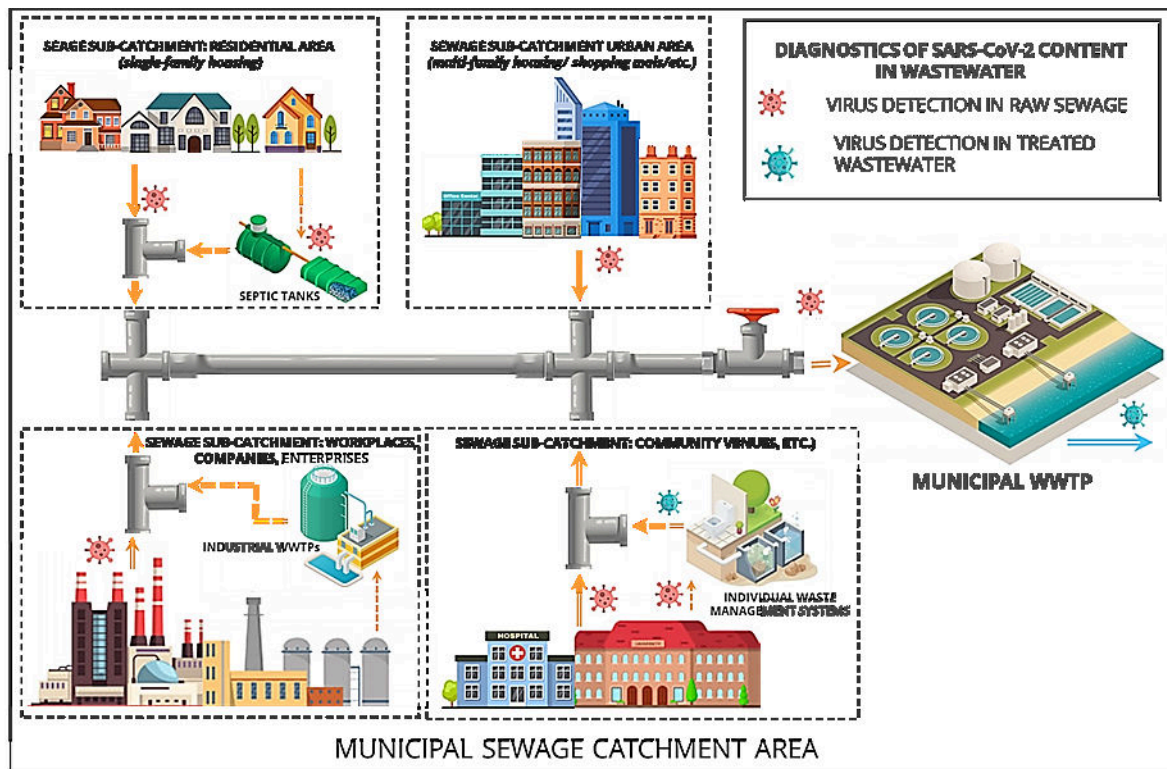


Figure 1. Municipal sewerage catchment area with delineated areas of potential sub-catchments.

The paper presents the results of microbiological analysis for the detection of SARS-CoV-2 carried out in the period of the observed increase in the number of new COVID-19 cases in the country and region. Due to the lack of possibility to obtain detailed data showing the actual number of sick inhabitants of the sewage catchment area (no available data at a local level), the results of virological analyses were compared with epidemiological data provided by sanitary services in the form of daily reports. Thus, the government data presented by the Ministry of Health and provincial sanitary and epidemiological units were used.

2. Materials and Methods

2.1. Sewerage catchment characteristics

The analyzed area is located in the south of Poland in Śląskie Voivodship. The WWP is located in the city which belongs to the Upper Silesian and Zagłębie Metropolis (GZM). According to hydrological data the WWTP is located in the Kłodnica river basin (Odra River tributary). The WWTP is one of 2 facilities serving a city with a population of 40 000 and has been designed as a mechanical-biological treatment plant with a target capacity of 8500 m³/day. The average volume of wastewater treated is 1 755 thousand m³ per year. The average inflow of wastewater on rainy and dry days is 5,05 m³ and 3,01 m³ per day respectively. The sewerage catchment area served by WWTP includes the city center and adjacent residential areas. Over 95% of the wastewater delivered to the facility by the combined sewer system is municipal wastewater.

The research process was designed in such a way which would facilitate to assess the possibility of applying the SEM/EDS technique to qualitatively identify the silica marker as well as to assess the applicability of this method in the case of different types of abiotic surfaces of various structure, porosity and shape. The possibility of applying the silica marker as a potential marker of virus pathogens, along with the option of its further identification on different types of carriers, constitutes a significant issue concerning simulation tests under laboratory and real conditions in terms of the pathogen spread as well as its presence on different types of surfaces. Considering the above, the idea of this research study was based on the assumption that the examined solutions would be sprayed by means of an atomizer on different types of carriers in a manner simulating the direct transmission route of the coronavirus (i.e., cough and sneezing) and next the carriers with the sedimented material would be subject to microscopic analyses using the SEM/EDS technique.

Two types of solutions were used in this study as research material; namely, the control solution (physiological saline solution constituting the equivalent of human saliva) and the silica marker solution (constituting the surrogate of the SARS-CoV-2 virus). The following three types of abiotic carriers were employed in the research: a membrane filter SKC, a sponge filter CIP and a graphite disc. The solutions were sprayed onto the carriers under laboratory conditions in the form of aerosols produced by means of a Turn'n'Spray atomizer (Bürkle, GmbH). The experiment was conducted within the framework of two research cycles for each type of the carrier. Each cycle consisted of three series during which the two solutions were applied on each of the carriers; the control solution (cycle 1) and the silica marker (cycle 2). In the next step, the carriers were subject to the SEM/EDS microscopic analysis.

2.2. Sampling

2.2.1. Wastewater sampling site characteristics

Municipal wastewater samples were taken directly from the raw inflow to the WWTP. The sewage sampling point was located in the mechanical part of the technological WWTP system (Fig. 2).



Figure 2. Urban waste water sampling location (a)(b) Mechanical grating station and wastewater inlet to biological reactors; (c)(d) Grating stand - mechanical part of the treatment plant.

Each time sampling was carried out after the grating station, directly before the equalization tank and the wastewater inlet to the biological reactor. The locations of the wastewater collection point are shown in the figures below.

2.2.2. Frequency and method of sampling

Municipal wastewater samples were collected by employees of the Department of Water Protection and Department of Underground Research and Surface Maintenance of the Central Mining Institute. The samplers have undergone training and have knowledge and experience in environmental sampling, confirmed by an appropriate certificate. In order to minimize the risk of samples contamination including pathogens such as SARS-CoV-2, wastewater sampling was

conducted under sanitary regime conditions. A total of 6 effluent samples were collected for analysis for the presence of SARS-CoV-2 in municipal wastewater. The collected samples were subjected to quantitative and qualitative analysis including evaluation of the concentration of isolated RNA of SARS-CoV-2 virus. Sampling was conducted during the period of increased incidence of COVID-19 in the region where the catchment is located. The sampling campaign was conducted from 6th to 17th December, 2021 (6.12.2021; 0.12.2021; 10.12.2021; 13.12.2021; 15.12.2021; 17.12.2021). Samples were taken at the treatment plant during the observed so-called morning peak. Sewage in the amount of 3x500 mL was collected with a hand scoop according to the method EN ISO 5667-10:2020 (ENISO5667-10:2020. Water quality...). Immediately after collection, wastewater samples were placed in a thermal transporter. Samples in volumes of 2x500 ml were transported to the microbiological laboratory for SARS-CoV-2 analysis. Samples delivered to the laboratory were frozen at -80°C. Virological analyses were performed simultaneously for all tested batches. At the same time, a batch of wastewater in value of 500 mL was transported to the Laboratory of Environmental Analysis of Central Mining Institute and was subjected to physicochemical analysis for selected contaminant indices.

2.3. Physicochemical analysis

2.3.1. Scope of analysis

The range of physical and chemical analyses included determination of the following parameters: temperature, pH, concentration of total suspended solids (TSS), phosphate phosphorus concentration (P-PO₄), concentration of ammoniacal nitrogen (N-NH₄), concentration of nitrate nitrogen (N-NO₃), concentration of nitric nitrogen (N-NO₂), chemical oxygen demand (COD).

2.3.2. Methodology

All selected physicochemical parameters were analyzed immediately after sampling. All tests were performed following the EN, or ISO standard protocols. If this wasn't possible, the wastewater samples were chemically stabilized and then measured within the approved timeline of appropriate standard protocols. The pH, temperature and conductivity were measured using an automatic field meter WTW MultiLine® IDS instrument (EN ISO 10523; EN 27888: 1993-11). For other physicochemical and chemical parameter, the following test procedures were used: phosphate phosphorus concentration (P-PO₄) - Analytical Method Spectroquant® Test Kits of Merck KGaA, № 1.114848; ammoniacal nitrogen (N-NH₄) - Analytical Method Spectroquant® Test Kits of Merck KGaA, № 1.4739, 1.1475 EN ISO 10523 2, № 1.14544, № 1.00683, № 1.14559; nitrate nitrogen (N-NO₃) - Analytical Method Spectroquant® Test Kits of Merck KGaA, № 1. 109713, nitric nitrogen (N-NO₂) - Analytical Method Spectroquant® Test Kits of Merck KGaA, № 1.14547, № 1.14776, № 1.00609; chemical oxygen demand (COD) - Analytical Method Spectroquant® Test Kits of Merck KGaA, № 1.114691.

2.4. Microbiological (virological) analysis

2.4.1. Sample processing for isolation and quantification of viral RNA

Previously frozen municipal wastewater samples were thawed at 4°C. For each batch of wastewater, three samples with a total value of 150 ml were further processed (3 x 50 ml). First, wastewater samples were centrifuged at 4°C, for 10 min at 600×g without break (Eppendorf® centrifuge 5801R), and the clear supernatant was harvested. In the next step, the samples were filtrated using a sterile syringe filter with a diameter 0,22 µm (PES/sterile). Preliminarily purified wastewater samples were then concentrated using Amicon® centrifugal ultrafiltration system (Amicon® Ultra-15 Centrifugal Filter Unit, Sigma). Each time during concentration, 15 mL of wastewater was added to the filter unit and centrifuged at 4°C for 10 min, at 6000×g, and the concentrated supernatant was harvested. The process was repeated until 45 ml of wastewater samples were completely concentrated (final volume of concentrated supernatant approximately 450 µl) and used for further RNA extraction, and the mass was determined (approx. 150 mg in influent and 5-10 mg in effluent). Contaminated equipment (e.g., filter units, tubes, reaction tubes) were stored in special waste containers and autoclaved according to the daily cleaning program in the microbiology laboratory.

2.4.2 RNA of SARS-CoV-2 virus extraction

RNA was isolated using the Viral DNA/RNA Virus kit A&A Biotechnology (34-200). According to the RNA isolation protocol included in the kit, 150 µl supernatant was mixed with lysis buffer supplemented with carrier RNA. After binding on silica membranes, samples were washed several times and eluted in total value of 50 µl RNase-free water. Isolated RNA was subjected to an RT-qPCR reaction.

2.4.3 SARS-CoV-2 specific quantitative RT-qPCR

RNA was analysed by One-step RT-qPCR using Luna Universal Probe One-Step RT-qPCR Kit (New England Biolabs) or LightCycler® Multiplex RNA Virus Master (Roche) and the CFX96 Real-Time System, with a C1000 Touch Thermal Cycler (Bio-Rad). Initial denaturation was performed for 1 min at 95°C followed by 45 cycles of denaturation for 10 s and combined annealing and extension for 30 s at 60°C. Reverse transcription was performed at 55°C for 10 min. Initial denaturation was allowed for 30 s at 95°C followed by 45 cycles of denaturation for 5 s, extension for 30 s at 60°C and final cool-down to 40°C for 30 s. The PCR runs were analysed with Bio-Rad CFX Manager software version 3.1 (Bio-Rad Laboratories). For quantifications, standard curves using plasmid DNA (RdRP) or in vitro transcribed RNA (M-gene) were used as described previously. To calculate from gene equivalents per reaction back to copies per mL, a PCR correction factor (cf) was determined with Luna Universal Probe One-Step RT-qPCR Kit (cf = 0.0037) and LightCycler® Multi-plex RNA Virus Master (cf = 0.0015), respectively. To control PCR, viral RNA of SARS-CoV-2 (isolate SARS-CoV-2-FFM1) was used as a positive control and water as a negative control.

3. Results & Discussion

During the analyzed period, the COD value in raw wastewater was in the range from 279,7 mgO₂/L to 298,6 mgO₂/L. The pH of the wastewater ranged from 6,56 to 6,89 with an average of 6,69. The maximum concentrations of ammonium nitrogen and nitrate nitrogen in the wastewater samples were 37,2 mg N-NH₄/L and respectively 22,1 mg N-NO₃/L. The maximum recorded phosphorus concentration was 4,4 mgP-PO₄/L. Detailed data on the physicochemical parameters of wastewater are presented in Table 1.

Table 1.

Physical and chemical parameters of raw municipal wastewater

Sampling date	Samples ID	Physical and chemical parameters						
		Temp. [°C]	pH [-]	COD [mg/L]	N-NH ₄ [mg/L]	N-NO ₃ [mg/L]	N-NO ₂ [mg/L]	P-PO ₄ [mg/L]
06.12.2021	0071309/21	11	6,78	314,2	31,2	19,4	1,3	2,3
08.12.2021	0071508/21	12,5	6,56	310,2	29,4	15,4	1,4	2,2
10.12.2021	0072043/21	10,4	6,89	279,7	26,7	16,1	1	1,8
13.12.2021	0072365/21	10,2	6,44	384,5	35,8	17,5	2,1	4,3
15.12.2021	0073621/21	11,3	6,68	390,6	33,3	22,1	1,8	3,7
17.12.2021	0073315/21	9,6	6,79	398,6	37,2	17,4	1,5	4,4

Qualitative analysis confirmed the presence of the SARS-CoV-2 virions in each in each analysed sample. On the basis of the RT-qPCR analyses (Table 2), it was found that the content of the genetic material of the virus SARS-CoV-2 (ex-pressed as a number of copies of the gene coding nucleotide) in the raw wastewater inflow ranged from 5,4 cp/mL (5400 cp/L) to 168,90 cp/mL (168 900 cp/L). The lowest SARS-CoV-2 virus concentration was recorded on December 10th, while the highest amount of genetic material in the raw wastewater was preserved on 17th December, after the growth of SARS-CoV-2 virions observed in earlier samples (table 2).

Table 2.

Results of microbiological analysis for SARS detection in wastewater

Sampling date	Samples ID	Parameter	Unit	Results
06.12.2021	0071309/21	Presence of SarS-CoV-2 viruses	-	<i>Possitive¹</i>
		RdRP gene copy number	[cp/mL]	16,50
		RdRP gene copy number	[cp/L]	16 500
08.12.2021	0071508/21	Presence of SarS-CoV-2 viruses	-	<i>Possitive¹</i>
		RdRP gene copy number	[cp/mL]	16,90
		RdRP gene copy number	[cp/L]	16 900
10.12.2021	0072043/21	Presence of SarS-CoV-2 viruses	-	<i>Possitive¹</i>
		RdRP gene copy number	[cp/mL]	5,4
		RdRP gene copy number	[cp/L]	5400
13.12.2021	0072365/21	Presence of SarS-CoV-2 viruses	-	<i>Possitive¹</i>
		RdRP gene copy number	[cp/mL]	53,5
		RdRP gene copy number	[cp/L]	53 500

Cont. table 2.

15.12.2021	0073621/21	Presence of SarS-CoV-2 viruses	-	<i>Possitive¹</i>
		RdRP gene copy number	[cp/mL]	53,5
		RdRP gene copy number	[cp/L]	53 500
17.12.2021	0073315/21	Presence of SarS-CoV-2 viruses	-	<i>Possitive¹</i>
		RdRP gene copy number	[cp/mL]	168,90
		RdRP gene copy number	[cp/L]	168 900

¹RNA of SARS-CoV-2 virus detected.

The presence of coronavirus in municipal wastewater samples has been confirmed by numerous scientific studies. So far, the presence of virus SARS-CoV-2 RNA in municipal wastewater has been confirmed by researches from Australia (Ahmed, Tschärke, Bertsch, Bibby, Bivins, Choi, Clark, Dwyer, Edison, Nguyen, Simpson, Sherman, Thomas, Verhagen, Zaugg, Muller, 2021), Brazil (Fangaro, Stoco, Souza, Grisard, Magri, Rogovski, 2019; Prado, Fumian, Mannario, Maranhão, Siqueira, Miagostovich, 2020), China (Cai, Xu, Lin, Young, Xu, Qu, 2020), the Czech Republic (Mlejnkova, Sovova, Vasickova, Ocenaskova, Jasikova, Juranova, 2020), Chile (Ampuero, Valenzuela, Valiente-Echeverria, Soto-Rifo, Barriga, Chnaiderman, 2020), France (Wurtzer, Marechal, Mouchel, Moulin, 2020), the Netherlands (Medema, Heijnen, Elsinga, Italiaander, Brouwer, 2020), India (Arora, Nag, Sethi, Rajvanshi, Saxena, Shrivastava, Gupta, 2020), Israel (Bar-On, Weil, Indenbaum, Bucrid, Bar-Illan, Elul, Levi, Aguvaeu, Cohen, Shirazi, Erster, Brown, Sofer, Mor, Mendelson, Zuckerman, 2021), Italy (La Rosa, Iaconelli, Mancini, Bonanno, Venerci, Bonadonna, Lucentini, Suffredini, 2020), United States (Wu, Xiao, Zhang, Gu, Lee, Kauffman, et.al, 2020) and Turkey (Kocamemi, Kurt, Haciogul, Yarali, Saatci, Pakdemirli, 2020). Similar results for the number of virus copies in municipal wastewater samples were obtained by Castiglioni et.al (Castiglioni, Schiarea, Pekkilegrinelli, Primache, Galli, Bubba, Manicelli, Marinelli, Ammoni, Pariani, Zuccato, Binda, 2020). In samples collected from the Milan WWTP and analyzed during March-June 2021 the concentration of virus copies per litre remained in the range from 13 900 cp/L to 147 000 cp/L. During the same period (March-June 2020), the detection of SARS-CoV-2 in municipal wastewater from WWTP in Lombardia confirmed the presence of the virus in the concentration range 1060-10 200 cp/L (Castiglioni, Schiarea, Pekkilegrinelli, Primache, Galli, Bubba, Manicelli, Marinelli, Ammoni, Pariani, Zuccato, Binda, 2022).

The relationship between the pollutant load entered into the treatment plants and the virus concentration is shown in Figure 3. The presented data show that for wastewater samples with one of the highest COD values, the highest number of SARS-CoV-2 copies were observed. The maximum virus concentration (168,9 cp/mL) was recorded at the COD concentration of 398,6 mgO₂/l. Taking into account the fact that samples were taken at the same time with uniform wastewater flow, the higher COD value proves higher organic and inorganic pollutant load delivered to the sewage treatment plant by the sewer system. The higher contaminant load proves a higher concentration of fecal (faecal) and urine samples, which are the carrier of coronavirus. Presented data show that for less concentrated wastewater samples (with lower pollutant loads), lower viral RNA concentrations were obtained.

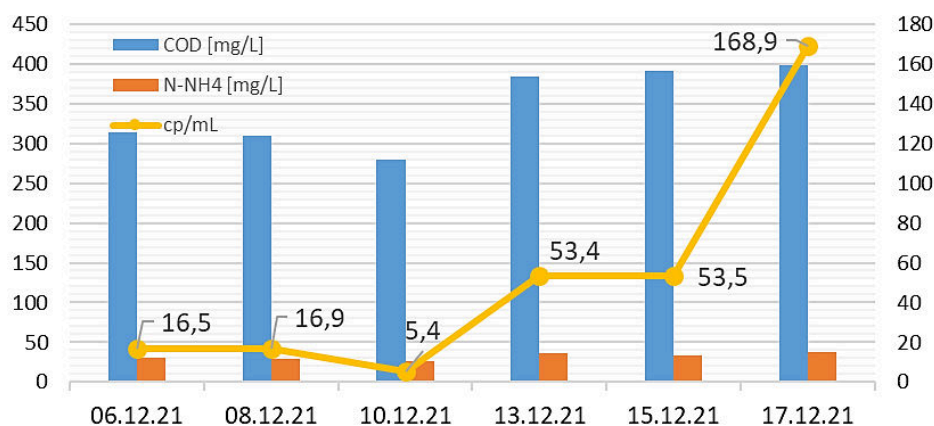


Figure 3. Number of COVID-19 infections – case study for Poland.

Based on the obtained results of physicochemical parameters of wastewater, it can be concluded that the quality of wastewater has a significant impact on virus RNA concentration, which directly affects the sensitivity, viability and reproducibility of the SARS-CoV-2 virus in the same volume of analyzed wastewater.

As part of the research, the relationship between the concentration of coronavirus in municipal wastewater and the recorded number of new COVID-19 cases in the local district in which the WWTP is located was assessed. It should be noted that epidemiological data are collected in relation to territorial units. Data from the sanitary inspection as well as medical data (number of hospitalized people), are collected and presented in reference to districts. Thus, it is not possible to obtain epidemic data on the daily number of cases in the sewage catchment area. The study referred to epidemiological data illustrating the daily number of new COVID-19 cases in the district. The table (Table 3) and graphs (Figure 5-7) show that during the 4th pandemic wave in Poland (Figure 4), the disease curve in terms of national, voivodeship and local level has a similar course. A visible increase in the number of cases is recorded in days, respectively 8-9th December; 15th December; 22nd December and 29th December.

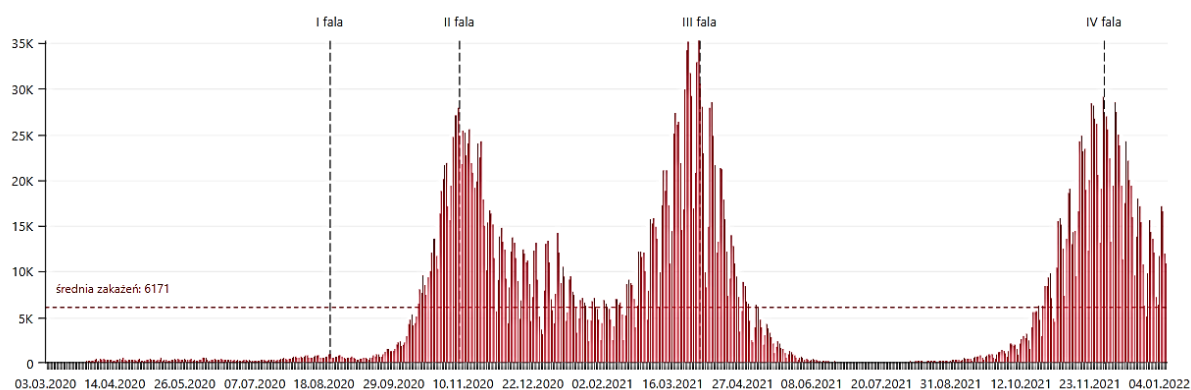
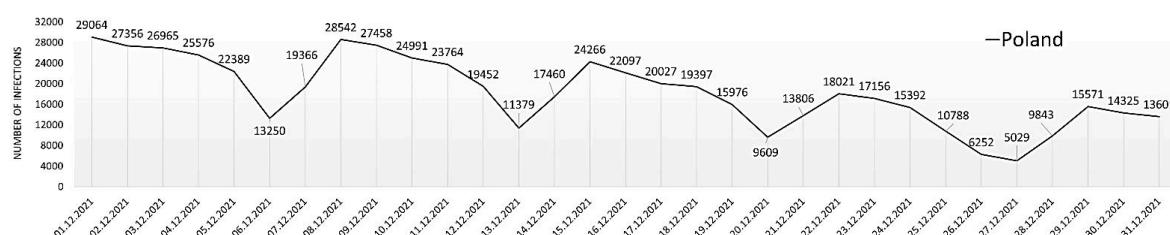
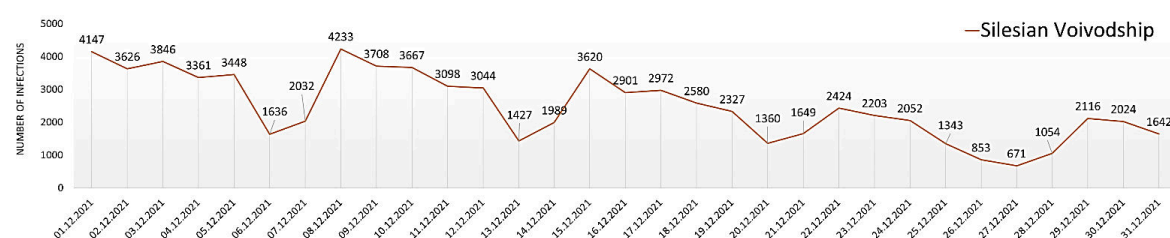


Figure 4. Number of COVID-19 infections – case study for Poland.

Table 3.

Number of new COVID-19 cases, deaths and recoveries reported in Poland, Śląskie Voivodship and ana-lysed district during December 2021

Date	Poland*			Śląskie Voivodship*		Local district*		
	Infections	Deaths	Recoveries	Infections	Deaths	Infections	Deaths	Recoveries
2021-12-01	29064	570	10077	4147	52	131	2	33
2021-12-02	27356	502	17690	3626	53	121	0	30
2021-12-03	26965	470	25041	3846	52	120	0	117
2021-12-04	25576	502	25616	3361	45	69	2	99
2021-12-05	22389	45	25390	3448	3	143	0	128
2021-12-06	13250	25	25489	1636	4	60	0	153
2021-12-07	19366	504	16922	2032	81	52	1	71
2021-12-08	28542	592	10055	4233	56	119	1	63
2021-12-09	27458	562	16827	3708	46	123	0	32
2021-12-10	24991	571	25459	3667	51	78	0	134
2021-12-11	23764	486	26546	3098	50	84	0	118
2021-12-12	19452	65	25554	3044	3	125	0	152
2021-12-13	11379	29	25126	1427	0	65	0	40
2021-12-14	17460	537	19070	1989	101	30	2	143
2021-12-15	24266	669	10909	3620	79	156	0	81
2021-12-16	22097	582	17306	2901	67	94	0	75
2021-12-17	20027	566	24693	2972	88	83	6	115
2021-12-18	19397	543	26092	2580	58	77	7	108
2021-12-19	15976	70	23670	2327	6	111	0	109
2021-12-20	9609	29	22887	1360	0	43	0	47
2021-12-21	13806	538	16527	1649	104	44	2	161
2021-12-22	18021	775	8955	2424	82	74	0	27
2021-12-23	17156	616	16218	2203	84	65	9	78
2021-12-24	15392	596	22246	2052	87	42	0	113
2021-12-25	10788	269	21012	1343	37	32	1	112
2021-12-26	6252	16	19606	853	0	14	0	85
2021-12-27	5029	38	18862	671	0	21	0	57
2021-12-28	9843	549	13618	1054	70	31	0	135
2021-12-29	15571	794	6788	2116	88	55	1	40
2021-12-30	14325	709	11588	2024	75	52	1	36
2021-12-31	13601	638	15829	1642	99	62	0	116

**Figure 5.** COVID-19 incidence curve for country during December 2021.**Figure 6.** COVID-19 incidence curve for Śląskie Voivodship during December 2021.

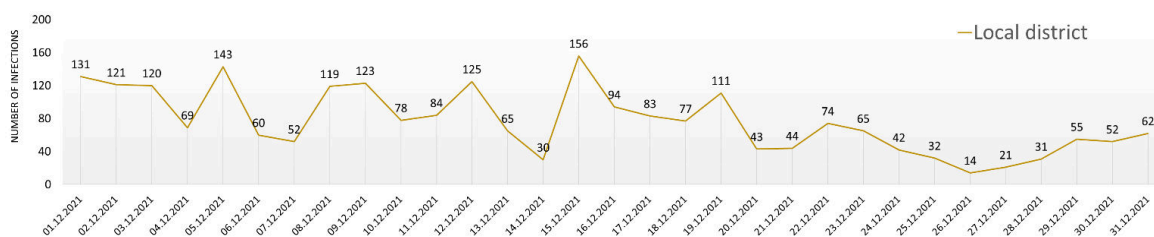


Figure 7. COVID-19 incidence curve for analysed district during December 2021.

Despite the fact that it is not possible to directly compare the results obtained in the virological analysis with epidemiological data for analyzed sewage catchment, positive results in the field of SARS-CoV-2 detection confirm the fact that the sewage reflects the health condition of the population living in the analyzed area. The results of the study indicate that raw wastewater may be an important tool for predicting COVID-19 epidemics. However, it should be noted, that the obtained data are based on a small number of repetitions and were carried out in a short time horizon. Thus, in order to obtain a full picture of the relationship, it would be necessary to extend the period of conducted analyzes and obtain more detailed epidemic data. Additionally, virus detection methods based on the RT-qPCR have shown that, depending on numerous environmental factors SARS-CoV-2 can exist in different forms: active virus, inactive virions or even inactive RNA fragments (Wurtzer, Marechal, Mouchel, Moulin, 2020). Thus, SARS-CoV-2 detection should take into account not only quantitative but also qualitative analysis of the pathogen.

4. Conclusions

Over the decades the Wastewater Based Epidemiology has become a viable and frequently used by the professional community as an alternative tool for assessing the population's consumption of chemical and pharmacological agents such as drugs, alcohol, nicotine, or caffeine. However, because of the need to rapidly assess population exposure to an-other harmful agent of microbial origin, the WEB-based methodology has found a new application in pandemic times. Although numerous studies prove its effectiveness, it should be kept in mind that the correlation between the amount of SARS-CoV-2 RNA in raw sewage and the number of new infections in the analyzed catchment allows predicting the course of the pandemic only when based on reliable data showing the actual health status of the population. The studies cited in the paper confirming the applicability of the WEB methodology for assessing the degree of pandemic development, each time were conducted for a specific and well-identified catchment for which the authors had reliable epidemiological reports of daily incidence. However, for many sewer catchments, it is not possible to obtain such detailed data showing the real incidence of COVID-19 in the population. The paper cites actual results for the amount of

SARs-CoV-2 in municipal wastewater for an urban catchment for which it is not possible to obtain such detailed epidemiological data. Obtaining detailed population morbidity data down to the city or district level is in many cases impossible. The data presented by the relevant services usually refer to the area of the voivodeship or the district, thus illustrating the health status of the community in somewhat broader terms. However, often despite the impossibility of establishing a correlation between the number of virus copies in wastewater and the number of new COVID-19 cases recorded, it must be borne in mind that microbiological characteristics of wastewater are a reflection of the health situation of the inhabitants of the catchment. However detailed data are a necessary element of the model which can be success-fully used not only to confirm the epidemiological situation but, also to track the directions of the pandemic development.

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THE INTERNATIONALIZATION OF ENTERPRISES IN THE FACE OF GLOBALIZATION – IDENTIFICATION OF KEY ISSUES AND MODELS

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Purpose: The purpose of this paper is to conduct a bibliometric analysis of research on business internationalization, with a focus on assessing the level of scholarly interest in the topic over time, identifying key thematic areas within the literature, and determining the relative popularity of different internationalization models.

Design/methodology/approach: The study employs bibliometric analysis to achieve its research objectives. Data extracted from the Web of Science database were analyzed using VOSviewer software, allowing for the identification of publication trends, key thematic areas, and the relative prevalence of various internationalization models in academic literature. The study provides a quantitative overview of the field, mapping research interests and conceptual developments within the domain of business internationalization.

Findings: The study reveals a growing academic interest in business internationalization, with publication activity peaking in 2019. Bibliometric analysis identified key thematic areas, including internationalization processes, performance outcomes, strategies, knowledge transfer, and the role of SMEs. The analysis also mapped the prevalence of internationalization models, with Foreign Direct Investment being the most frequently referenced, followed by the Network Approach, Born Global, Resource-Based View, and the Uppsala Model.

Research limitations/implications: This study is limited to Web of Science data, excluding other sources. The bibliometric approach lacks qualitative assessment and does not verify keyword co-occurrence, potentially overestimating references to internationalization models. Future research should integrate multiple databases, qualitative analysis, and temporal trends.

Originality/value: The study maps research trends in business internationalization, highlighting key themes and dominant models. It offers valuable insights for researchers, policymakers, and practitioners exploring international business dynamics.

Keywords: internationalization, internationalization theories, bibliometric analysis.

Category of the paper: Research paper.

1. Introduction

The contemporary market is dominated by global brands, posing challenges for domestic enterprises. The process of business internationalization, understood as the expansion of a company into foreign markets, is a key aspect of an organization's development strategy, thereby increasing its competitiveness. In the literature, internationalization is seen as a complex phenomenon that requires a multifaceted approach and consideration of various factors – from organizational structure to the specific resources of the company (Xie, Sun, 2014).

Internationalization not only provides access to new markets and customers but also fosters the transfer of knowledge, technology, and innovation, which further strengthens their competitive position (Almahendra, Rosari, 2014). A key factor in this process is the ability to adapt to local cultural, legal, and economic conditions, which often presents a significant challenge for companies. An important area in this context is also the selection of the appropriate internationalization strategy, which is determined by factors such as resources, business scope, and legal aspects. Contemporary research also highlights the growing role of digitization and technology in facilitating internationalization processes, particularly in the context of small and medium-sized enterprises (Hervé et al., 2020).

The article addresses the issue of key theories and models aimed at identifying critical issues and assessing the popularity of various internationalization models and theories. The bibliometric analysis conducted holistically covers both classic concepts of internationalization, such as the Uppsala model, as well as modern models that take into account the dynamics of contemporary markets. Despite the existence of articles containing review studies and bibliometric analyses on the area of internationalization, they focus on different aspects, narrowing the analysis either geographically or thematically (Papanastassiou et al., 2020; Chelliah et al., 2024).

The originality of this article stems from a comprehensive approach to the bibliometric analysis of internationalization theories, encompassing both classical and modern models in the context of dynamic changes occurring in global markets. As a result, the article makes a unique contribution to the literature, offering a deeper understanding of the evolution of internationalization concepts and their significance in contemporary business strategies.

This article presents the results of research conducted using quantitative data analysis and bibliometric analysis of works related to internationalization. This will help answer questions regarding the popularity of the internationalization field in academic research, researchers' interest in specific models, and highlight thematic areas addressed during the study of individual models. This paper will fill the research gap concerning the lack of a comprehensive bibliometric analysis that simultaneously identifies key research areas and determines the popularity of various internationalization models. The article will provide new value by

delivering a comprehensive overview of the state of research on internationalization, which can serve as a basis for further analyses.

2. Models of Enterprise Internationalization

The internationalization of enterprises is a complex process that requires an analysis of both the internal resources of the company and external market conditions. Early studies on the internationalization of enterprises focused on exploring issues related to the flow of goods and services in international business (Heckscher, 1919). The analysis of foreign trade concentrated on determining the role of factors such as land, labor, and capital, which influenced the benefits of export and import, based on the principle that countries export goods that intensively utilize abundant and cheap production factors, while importing those in which they are lacking (Ohlin, 1933).

A significant next step in research was the area of foreign direct investment, which was extensively analyzed by John H. Dunning in 1958. His studies focused on the factors influencing firms' decisions regarding the location of foreign operations. Dunning emphasized that this choice depends on elements such as market structure, resource availability, labor costs, and economic regulations (Dunning, 1958). In this early work, Dunning examined the motivations of firms choosing foreign investments over exports, which laid the foundation for the later development of the well-known eclectic paradigm (OLI1) (Dunning, 1981).

The end of the 20th century brought numerous studies exploring issues related to foreign expansion, focusing on the transformation of local businesses into international corporations, often dominating the market (Hymer, 1976). As a result of the work of scholars, theories such as the oligopolistic reaction theory (Knickerbocker, 1973), the internalization theory (Buckley, Casson, 1976; Hennart, 1982), and the resource-based view (Barney, 1991) emerged, emphasizing the role of a company's unique resources in the internationalization process. Related theories, such as the competitive advantage theory (Peteraf, 1993) and the transaction cost theory (Williamson, 1975), further explain the mechanisms of expansion into foreign markets. An important approach is also the network approach (Hägg, Johanson, 1982), which highlights the significance of networks of contacts in the internationalization process.

Research on the competitiveness and internationalization of enterprises has laid the foundation for the internationally recognized models of internationalization (Gorynia, Jankowska, 2007), which are the main focus of this paper. The literature has developed a range of models offering various perspectives on the mechanisms and determinants of international expansion (Jędralska et al., 2013). A comparison of internationalization models allows for a better understanding of the diverse theoretical approaches and practical strategies employed by companies in the process of entering foreign markets. The table below presents the key

characteristics, assumptions, and differences between selected internationalization models, enabling their comprehensive analysis (Table 1).

Table 1.
Selected Models of Enterprise Internationalization

Classification	Internationalization Model/Theory	Author	Key Assumptions
Resource-Based Approach	Foreign direct investment (FDI)	Hymer (1971)	It is a capital investment in a foreign company aimed at gaining long-term influence over its operations and deriving profits from it (Patora, Piasecki, 2001).
	Transaction cost theory (TCT)	Coase (1937), Williamson (1998)	In this perspective, the enterprise's activity is viewed as a contractual issue. It involves making a choice between purchasing specific goods and services from external, specialized market entities and producing them internally within the company. The exchange of goods and services, referred to as a transaction in this concept, is the key unit of organizational analysis (Williamson, 1998).
	OLI Model	Dunning (1980)	It is a combination of different approaches, according to which internationalization occurs if the company possesses a competitive advantage, has specific ownership characteristics, and its operations in a particular location can lead to increased profits (Dunning, 1980).
	Resource-based view (RBV)	Barney (1991)	It is assumed that an organization is a collection of resources and competencies. According to this theory, the company's knowledge and skill resources are more important in strategy creation than the conditions prevailing in the environment. The strategy is first developed for the entire organization and only later for individual divisions or business units (Barney, 1991).
Stage Approach	The Uppsala Model	Johanson, Wiedersheim-Paul (1975)	The stage model of internationalization assumes the gradual internationalization of a company, distinguishing stages such as: irregular exports, exports through intermediaries, establishment of sales subsidiaries, and the commencement of production abroad (Johanson, Wiedersheim-Paul, 1975).
	Innovation-Related Internationalization Model	Bilkey, Tesar (1977)	The stage model of internationalization refers not to the entire process of internationalization, but to the stages in which the dominant form of foreign expansion for the company is export (Bilkey, Tesar, 1977).
Network Approach	The Network Approach	Johanson, Mattsson (1988)	The network approach focuses on the networks created by the company, which connect it with various business partners. According to this approach to internationalization, the process involves establishing, maintaining, and developing relationships with other entities operating in foreign markets (Johanson, Mattsson, 1988).

Cont. table 1.

Contemporary Internationalization Models	Born Global (International New Venture)	McDougall, Shane, Oviatt (1994, 2000)	The approach assumes the internationalization of the company in the early years of operation. In this model, the company does not treat global operations as an addition to its domestic activities but instead focuses on operating in the global market from the very beginning of its existence (McDougall, Shane, Oviatt, 1994; McDougall, Oviatt, 2000).
	International Entrepreneurial Orientation (IEO)	Jones, Coviello (2005)	In this model, international entrepreneurship encompasses behavioral processes focused on creating value by developing unique resources and fully exploiting available opportunities by the firm (Jones, Coviello, 2005).
	Born-again global	Bell (2001)	The presented model refers to a phenomenon in which companies that were already well-established in domestic markets and had shown no prior interest in international expansion suddenly begin to enter global markets dynamically and decisively (Bell, McNaughton, Young, 2001).

Source: own elaboration based on Barłożewski, 2017, pp. 15-32; Milovanovic, Cvjetkovic, 2021, pp. 34-57; Wach, 2012, p. 99.

In the literature, the classification of internationalization models is quite consistent, considering the assignment of specific models to groups. Not all researchers use the aforementioned classification and terminology, as its shape depends on many factors, such as the research objective, perspective, or researcher preferences. Nevertheless, in numerous studies, the classification of approaches appears as resource-based, process-based, network-based, and other – alternative – approaches (Wach, 2012).

The presentation and classification of models aim to systematize knowledge in the field of enterprise internationalization. This serves as a starting point for the next section of the article, i.e., the research part, in which a bibliometric analysis of works describing the processes of enterprise internationalization will be conducted. This analysis will provide answers to the research questions presented. The study will address the research gap identified as the lack of a comprehensive bibliometric analysis, which, considering a wide range of scientific papers, identifies key research areas and determines the popularity of individual models of enterprise internationalization.

3. Research Methodology

Based on the planned activities, a research procedure was developed, beginning with the definition of the research problem, which focuses on analyzing researchers' interest in enterprise internationalization, identifying key issues addressed in the literature, and determining the popularity of individual internationalization models.

The article aims to analyze the current state of knowledge on the internationalization of enterprises, considering the most important thematic areas that dominate in the subject literature. The conducted analysis will fill the identified research gap by defining key research issues and the main directions for the development of this field. The analysis aims to provide answers to the following research questions:

1. How has researchers' interest in internationalization evolved over the years?
2. What key issues and areas are discussed in studies devoted to internationalization?
3. What internationalization models dominate in scientific literature?

In the context of this study, issues will be understood as keywords appearing in the works subjected to bibliometric analysis, which is the research method used to achieve the research objective.

For the purposes of the analysis, it was decided to use data from Web of Science due to its high indexing quality and consistent metadata, which enables a reliable bibliometric analysis. Although relying on a single data source may have certain limitations, including the possibility of omitting publications indexed exclusively in other databases such as Scopus, the choice to use a single database was deliberately made to enhance the clarity of the study. The data for the study was obtained on January 1, 2025. Initially, it was decided to use quantitative data cataloged by year to examine how researchers' interest in internationalization has evolved over time. The search was narrowed to the topic "internationalization" and the Web of Science Categories: Business, Management, Economics, Business Finance, International Relations, as these areas were considered to align with the research topic. This allowed the exclusion of works unrelated to the internationalization of enterprises. The topic was understood as a phrase appearing in at least one of the following fields: title, abstract, keyword plus, and author keywords. The Web of Science database contained 13,361 works that met the selected criteria. Data from these works were used to construct a chart depicting the number of publications on the selected topic in relation to the years of publication. The chart serves to illustrate how researchers' interest in internationalization has developed and to determine the dynamics of changes in the number of publications over the years, which will help answer the first research question.

The data export from the Web of Science database was performed using the "Record Content: Full Record" setting. The data was then analyzed using VOSviewer software, based on the following settings. The "Type of analysis" was set to "Co-occurrence", the unit of analysis was set to "All Keywords", and the counting method was selected as "full counting". Subsequently, to answer the second research question, a table was created containing the 50 most frequently occurring keywords in the analyzed papers. The identified keywords were grouped based on shared themes. These groups were considered key thematic areas found in the literature on internationalization.

Next, keyword maps for the topic "internationalization" were created to visualize the relationships between the 50 most frequently occurring keywords listed in the table. This allowed for confirming the connections between keywords and visualizing the complexity of these relationships. The visualization of the map also confirmed the accuracy of keyword grouping in certain thematic areas, where it was expected that such connections would exist. At the same time, it was explained that some thematic groups may contain concepts that do not necessarily co-occur in the papers due to their specific nature. This stage of the study provided an answer to the second research question.

The goal of the next stage of the research was to provide an answer to the third research question. To this end, bibliometric analysis of the collected data was once again conducted using VOSviewer software. The objective of this part of the study was to create a table of keywords related to specific theories and models of internationalization. For this purpose, a list of the 200 most frequently occurring keywords in the analyzed papers was created, based on which a table was constructed containing only those keywords associated with internationalization models and theories. The identification of keywords directly related to theories and models of internationalization considered the occurrence of the full, partial, or abbreviated form of the theory's name within the keyword. This approach allowed for obtaining results based on quantitative data without the need for qualitative analysis.

The resulting table served as a starting point for inferring the popularity of specific models in the literature. In the next step, the number of papers corresponding to the identified keywords was grouped based on their affiliation with specific theories and models. This allowed for the determination of the possible number of papers in which references to these models and theories appeared, thereby providing an answer to the third research question.

4. Research Results and Discussion

The first stage of the research involved processing the data obtained from the Web of Science database using Microsoft Excel. The results of the quantitative data analysis were visually presented in a bar chart (Figure 1).

The analysis revealed trends in academic interest in internationalization. Although the first theories and models of internationalization emerged in the 1970s and 1980s, the number of publications on the topic remained relatively low.

The earliest works mentioning "internationalization" appeared in the 1950s, but until the 1990s, the annual number of publications did not exceed a few dozen. It was only in the 1990s that the number of publications grew significantly, rising from 7 in 1991 to 56 in 1996.

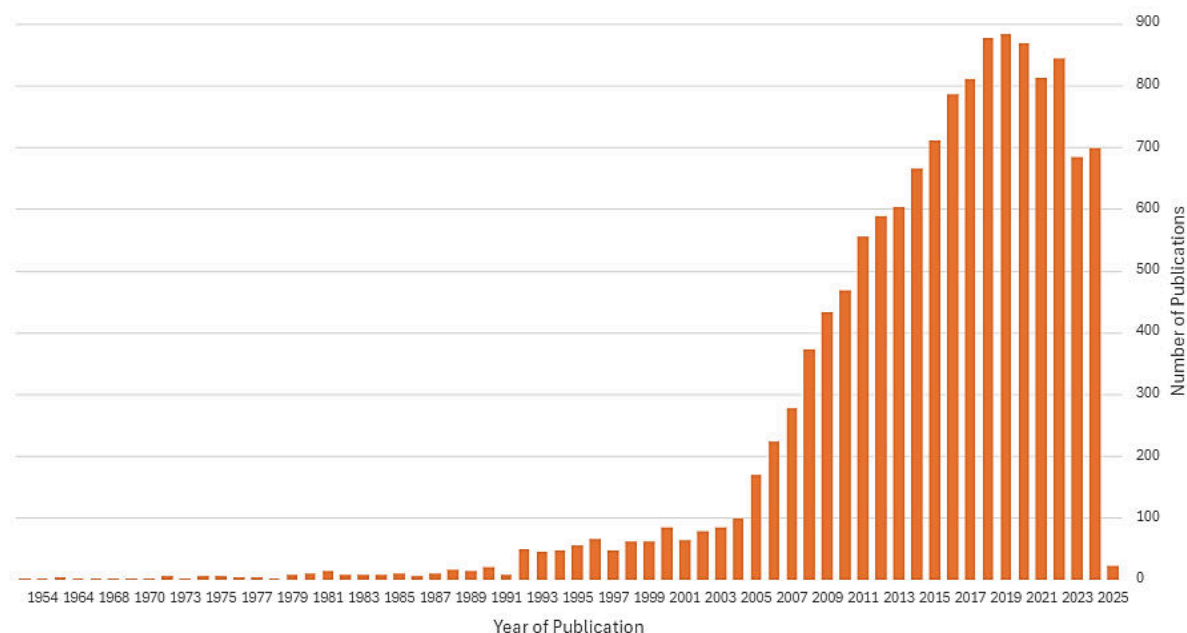


Figure 1. Trend Analysis of the Popularity of the Topic of Internationalization Based on Web of Science Data.

Source: own elaboration.

The annual number of publications surpassed 100 for the first time in 2005, reaching 169. This upward trend continued, peaking in 2019 with 883 publications. In the following three years, publication numbers remained stable, but 2023 and 2024 saw a noticeable decline. However, without further research, this decrease should not be interpreted as waning academic interest in internationalization, as it may result from data acquisition delays in the Web of Science database or other factors. Similar trends, with a decline in recent years, have been observed in other research areas (Zygosz, 2024).

Despite yearly fluctuations, the 2010s and 2020s represent the period of greatest scholarly interest in internationalization. The number of annual publications underscores the significance of this research area in the contemporary business landscape.

In summary, the analyzed data indicates a steady increase in scholarly interest in internationalization, measured by the number of publications since the 1950s. The peak was reached in 2019, though the 2010s and 2020s should be recognized as the most prolific period for research in this field.

The next stage of the study involved a bibliometric analysis of the collected research material. Using data from 13,361 publications, VOSviewer software was employed to generate a list of keywords appearing in the studies. Out of 24,474 keywords, the 50 most frequently occurring ones were selected for further analysis. Based on these, a table was created, ranking the keywords by frequency of occurrence (Table 2).

Table 1.*List of Keywords by Occurrences*

No.	Keyword	Occurrences	No.	Keyword	Occurrences
1	internationalization	5173	26	ownership	539
2	performance	2967	27	perspective	531
3	innovation	1792	28	technology	528
4	knowledge	1555	29	diversification	524
5	firms	1316	30	dynamic capabilities	514
6	firm	1259	31	growth	500
7	strategy	1185	32	emerging markets	473
8	model	1113	33	market	462
9	impact	1057	34	competitive advantage	434
10	management	948	35	export performance	425
11	entrepreneurship	903	36	expansion	400
12	smes	881	37	enterprises	399
13	determinants	881	38	governance	390
14	capabilities	876	39	international entrepreneurship	378
15	foreign direct-investment	848	40	resource-based view	373
16	firm performance	777	41	investment	371
17	globalization	764	42	multinationals	365
18	strategies	735	43	trade	356
19	internationalisation	700	44	entrepreneurial orientation	355
20	business	685	45	behavior	353
21	china	679	46	corporate governance	349
22	research-and-development	660	47	absorptive-capacity	345
23	internationalization process	619	48	choice	336
24	networks	617	49	international business	333
25	entry	606	50	ventures	332

Source: own elaboration.

The resulting table (Table 2) enables the identification of key areas addressed in studies on internationalization. The keywords from the table were grouped into the most homogeneous categories possible, which were then described based on their common features (Table 3).

Table 3.*Identified Key Thematic Areas*

No.	Key Area	Included Keywords	Description
1	Process of Business Internationalization	internationalization, internationalisation, entry, ventures	Research focuses on the processes of firms entering foreign markets, analyzing entry strategies, internationalization dynamics, and the role of networks in international expansion (Naudé, 2009; Sui, Baum, 2014).
2	The results and effectiveness of the actions of internationalized enterprises	performance, firm performance, export performance, growth	Issues related to the impact of internationalization on the financial, operational, and other aspects of enterprise efficiency (Thornton, 2024).
3	Models and theories of internationalization	model, resource-based view, networks, foreign direct investment	Development of theoretical models describing internationalization, including the resource-based view and dynamic capabilities perspectives (Kazlauskaitė et al., 2015; Kowalewski, Radio, 2014).

Cont. table 3.

4	Strategies and management in the context of internationalization	strategy, management, competitive advantage, governance, multinationals, corporate governance	Analysis of strategies adopted by enterprises in the process of internationalization and management mechanisms in different international contexts (Graves, Thomas, 2006).
5	The importance of knowledge and innovation in internationalization	knowledge, innovation, research-and-development, technology	The role of knowledge, technology transfer, and research and development activities in the effective internationalization of enterprises (Jaw, Chen, 2006).
6	Emerging markets and the global context of internationalization	emerging markets, globalization, international business, china	The specifics of internationalization in the context of emerging markets and the impact of globalization on business strategies (Ho, Nguyen, 2024).
7	Small and medium-sized enterprises (SMEs) in the process of internationalization	smes, entrepreneurship, entrepreneurial orientation, enterprises, international entrepreneurship	Internationalization of SMEs, entrepreneurship in the international context, and entry strategies for smaller firms in foreign markets (Wasowska, 2016).
8	International expansion	investment, expansion, trade	International expansion and the associated activities, such as investments and trade (Tatoglu et al., 2003).
9	Determinants of internationalization	determinants, capabilities, absorptive capacity, dynamic capabilities	Identification of factors influencing the effectiveness of internationalization, including the adaptive and absorptive capacities of enterprises (Mun, 2019).

Source: own elaboration.

The keywords that were omitted did not contribute directly to the discussion of key research areas on internationalization, as a result of the repetition and significance of selected keywords in this context.

To deepen the analysis of key areas discussed in works dedicated to internationalization, a map of the 50 most frequently occurring keywords was constructed using VOSviewer software (Figure 2).

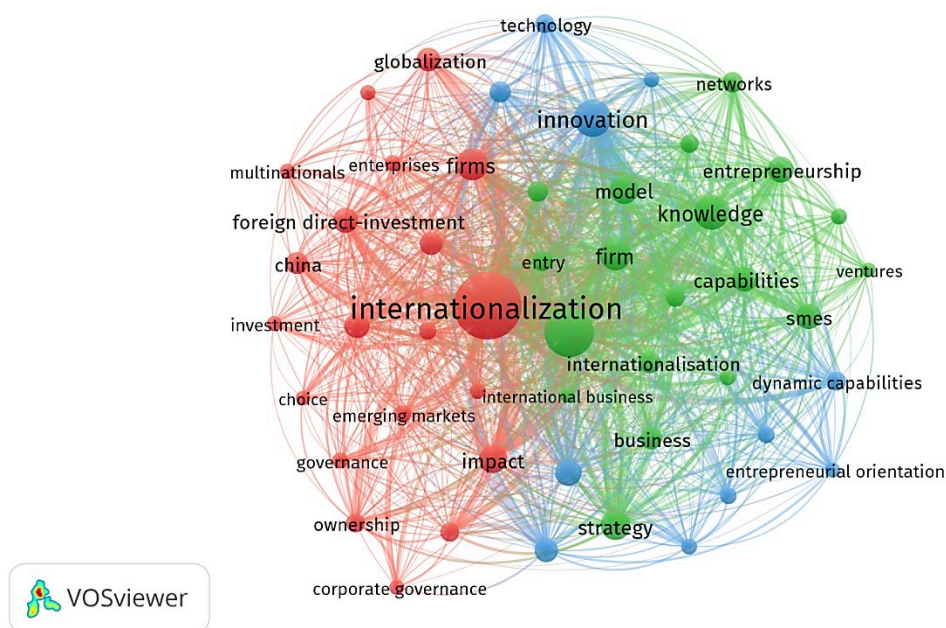


Figure 2. Map of 50 keywords related to the topic of internationalization.

Source: own elaboration.

The map divides the keywords into three areas marked by red, green, and blue colors. These colors separate the groups of keywords formed in this way, while the lines connecting the terms reflect the associations found in the works, i.e., the co-occurrence of keywords in the studies. The separation of the groups by color resulted from the analysis of keyword co-occurrence, with terms from the same-colored groups appearing together more frequently than those from two different groups.

The grouping of areas shown in Figure 2. should not be interpreted as contradicting the grouping from Table 3, as both were based on different assumptions. Referring to the selected areas that are the core of the studies from Table 3, it is important to note that some areas include keywords marked mainly by one color from Fig. 2. For example, the group "5. The importance of knowledge and innovation in internationalization" contains three terms from the blue area, i.e., innovation, research-and-development, technology, and one term from the green area, i.e., knowledge. At the same time, in Table 3, there are areas that contain terms marked by all three colors. For instance, group 3, "Models and theories of internationalization", includes terms such as model, resource-based view, networks, and foreign direct investment, which refer to different models of internationalization, but they rarely co-occur in the same paper. This results from the way the groups in Table 3 were selected, based on thematic consistency, and therefore, group 3 contains terms that relate to various internationalization models.

The next stage of the study was to identify how researchers' interest in specific models of internationalization is shaped. For this purpose, the 50 most frequently occurring keywords from Table 2 were reanalyzed. Keywords directly referring to specific internationalization theories/models were marked in light green. In the table, only three terms were directly related to models: no. 15 "foreign direct investment", appearing in 848 works; no. 24 "networks", appearing in 617 works; and no. 40 "resource-based view", appearing in 373 works.

While terms no. 15 and no. 40 are clearly associated with internationalization models, the term no. 24 "networks" is not necessarily directly linked to "the network approach" in all 617 works due to the potential for interpreting the term "network" in various ways depending on the context. Some of these studies indeed focus on the network approach to internationalization (Fletcher, 2008; Persson, Mattsson, Öberg, 2015), but many others focus on different network-related aspects, such as social networks (Han, Goxe, Freeman, 2024), Knowledge Network Capital (Wu, 2017), and interpersonal networks (Idris, Saridakis, 2018), among others.

The nature of this study and the quantitative character of the data make it difficult to precisely count the studies in order to verify the actual situation. Therefore, the current results can serve as a starting point for future research, which could conduct a qualitative literature review on internationalization models. Based on the presented results, it can be concluded that the most frequently analyzed approach in scientific papers is the FDI model, followed by the Networks Approach, and then the RBV. However, the results of this study in their current form are subject to high imprecision. For this reason, a decision was made to conduct another study.

Narrowing the search results to the 50 most frequently occurring keywords did not yield a satisfactory outcome in identifying the most frequently studied theories and models of internationalization, which is the main focus of this paper. Due to the low number of terms directly referring to these theories among the 50 most frequently occurring keywords, it was decided to create another table that would better illustrate the level of interest among researchers in specific theories. This table will be constructed based on the same data; however, the list of keywords will be expanded to the 200 most frequently occurring keywords. To improve the clarity of the work, the table will include only terms that directly reference specific theories and models of internationalization (Table 4).

Table 4.

List of keywords related to theories and models of internationalization

No.	Keyword	Occurrences
1	foreign direct-investment	848
2	networks	617
3	resource-based view	373
4	fdi	319
5	foreign direct investment	237
6	uppsala model	186
7	outward fdi	175
8	born globals	174
9	direct-investment	154
10	network	145
11	born global	124
12	born global firm	118
13	international new ventures	113
14	born-global firms	102

Source: own elaboration.

In the table, terms that refer to specific theories and models of internationalization can be distinguished. Among the 200 most frequently occurring keywords, phrases related to five internationalization models were identified: the Foreign Direct Investment (FDI) model, the Networks Approach, the Resource-Based View (RBV), the Uppsala model, and the Born Global model. These are the most frequently studied internationalization models and theories.

The FDI model is described by terms such as: foreign direct-investment, fdi, foreign direct investment, outward fdi, and direct-investment. The RBV model is described by the term: resource-based view. The Uppsala model is described by the term: uppsala model. The Born Global model is described by terms such as: born globals, born global, born global firm, international new ventures, and born-global firms. The Network Approach is described by terms such as: networks, network.

Often, one theory corresponds to more than one keyword, which makes it difficult to accurately determine the number of papers dedicated to a particular theory. Attempting to sum the number of papers in which keywords associated with a single theory appear is prone to a significant margin of error, as some papers contain more than one keyword from the list

(Bernat et al., 2024; Kapoor, Arora, 2023; Kaczmarek, 2017). On the other hand, some papers contain only one of the mentioned keywords (Brennan, Garvey, 2009; Szymczyk, 2020).

It was decided that for the purposes of this study, the indication of how researchers' interest in specific models of internationalization has developed would be constructed by summing the occurrences of grouped keywords, with the note that the number represents the maximum possible number of papers dedicated to a given theory, rather than the actual number. Indicating the actual number in this case would require a more in-depth analysis of the data using another tool that would allow for summing the number of papers while avoiding double-counting those that appear multiple times. The popularity of individual internationalization models is reflected in the table (Table 5).

Table 5.
Identified Models and Theories of Internationalization

No.	Model/Theory	The maximum number of academic works or articles in which it appears
1.	Foreign Direct Investment	1733
2.	Networks Approach	762
3.	Born Global	631
4.	Resource Based View	373
5.	Uppsala Model	186

Source: own elaboration.

The internationalization model that appears in the highest number of analyzed studies is the Foreign Direct Investment (FDI) model, representing the resource-based approach. Based on the conducted analysis, it can be determined that references to this model appear in a maximum of 1733 studies. The second most frequently occurring model in the analyzed papers is the Networks Approach, with up to 762 studies containing references to this perspective. The third model distinguished in the table is the Born Global approach, representing the school of international entrepreneurship. References to this model appear in a maximum of 631 studies. The fourth position is occupied by the Resource-Based View (RBV), another model representing the resource-based approach, with references appearing in up to 373 studies. In fifth place is the Uppsala Model, classified as a stage-based approach to internationalization, with a maximum of 186 studies dedicated to this theory among the analyzed works.

It is essential to highlight the remarkable dominance of the FDI concept over other models and theories. This concept is indeed one of the earliest described and represents a highly popular approach to internationalization applied in practice, which undoubtedly contributes to the substantial number of studies dedicated to it.

The number of studies focused on the Networks Approach is more than twice as low, indicating a particularly significant disparity. At the same time, it is crucial to reiterate that the keywords related to this concept may, in some cases, not specifically refer to the Networks Approach itself but rather be used in other contexts. The employed analytical tool did not allow for obtaining more precise results. Therefore, the Networks Approach was included in the table,

but attention is drawn to the potential ambiguities in the interpretation of the collected data. Consequently, the results of this analysis should be treated with caution, and any conclusions derived from them should be validated through additional sources or further analyses.

The next concept, Born Global, represents one of the more recent internationalization models, emerging at the turn of the 20th and 21st centuries. The high ranking of this model reflects significant scholarly interest. Undoubtedly, technological advancements and widespread Internet access have facilitated the development of this model, which assumes that firms operate in global markets from the very beginning of their existence.

Following in the table is the Resource-Based View (RBV) concept. RBV focuses on analyzing a firm's internal resources and capabilities as key determinants of its competitiveness in international markets. Although the number of studies dedicated to this theory (373) is significantly lower compared to leading models such as FDI or the Networks Approach, RBV remains a crucial framework in the literature on internationalization.

The final concept highlighted in the table is the Uppsala Model, which represents a stage-based approach to the internationalization of firms. Developed based on the research of Johanson and Vahlne in the 1970s, this model posits that the internationalization process occurs gradually as firms gain experience in foreign markets and reduce uncertainty stemming from cross-cultural differences. The analysis determined that a maximum of 186 studies reference this theory, placing it fifth in terms of popularity.

The lower number of publications compared to other models may stem from the fact that the Uppsala Model is one of the earliest approaches to internationalization, and its original assumptions have been subject to numerous revisions and modifications in response to rapidly changing market conditions. This model has been criticized, both historically and in contemporary research, primarily for its limited applicability to modern firms that often adopt more dynamic international market entry strategies and for its failure to account for the initial conditions of internationalization (Andersen, 1993). Nevertheless, the Uppsala Model continues to serve as a crucial reference point in internationalization research, particularly concerning small and medium-sized enterprises and markets characterized by high uncertainty.

The study demonstrated that firm internationalization is a subject with a long-standing research tradition. The conducted research confirms the growing interest of scholars in internationalization, as illustrated by the dynamic increase in the number of publications since the 1950s, with a particular intensification in the 21st century. Similar analyses have already appeared in scholarly works (Papanastassiou et al., 2020; Chelliah et al., 2024; Xie, Zeng, 2025), which also confirmed the occurrence of this phenomenon; however, those studies focused on specific groups of research papers. It was decided to repeat the study for a broader group of papers in order to verify the occurrence of this phenomenon for the entire body of research on firm internationalization. This approach may allow the results of this analysis to serve as a starting point for further studies focusing on the analysis of internationalization mechanisms, the identification of determinants of firm success in foreign markets,

and the development of new theoretical models that will enable a better understanding of the dynamics of global business strategies.

A novel aspect of this research is the detailed identification of the popularity of individual internationalization models, where the dominance of the FDI model is contrasted with a lower level of interest in the network approach, the Born Global model, RBV, and Uppsala. The analysis confirms the historical evolution of research in this field, but it also reveals new trends, including a strong increase in publications over the past decades and the dominance of the FDI model. Furthermore, the bibliometric analysis enabled the identification of less obvious relationships between the occurrence of specific keywords and the theoretical models under investigation.

Based on the analysis conducted, it can be stated that the literature on internationalization is developing dynamically, and researchers are increasingly undertaking analyses of complex theoretical models. The results indicate the need for more in-depth qualitative analyses, which would allow for a more accurate estimation of the actual number of papers devoted to individual theories and a better understanding of the specifics of the research methods employed.

In following stages, the plan is to apply tools that enable the elimination of duplicates and a more precise count of the papers, which will allow for the verification of the results obtained using quantitative analysis. Qualitative research is also intended to be conducted, which will allow for a deeper interpretative analysis of the data and the derivation of conclusions regarding the impact of individual models on the practice of managing firm internationalization. Future studies may focus on identifying the popularity of internationalization models in relation to publication time, in order to verify the current dynamics of research on specific internationalization models. Future studies may also verify the obtained results by conducting research using other databases, such as Scopus.

5. Summary

The first conclusion drawn from the study is the noticeable increase in academic interest in the topic of internationalization in recent years compared to the previous century. Although the main theories emerged between the 1970s and 1990s, the number of studies on internationalization during that period was relatively low. The annual number of publications on this subject increased steadily, reaching its peak in 2019.

Currently, a slight decline in the number of publications is observable, which may result either from a decrease in researchers' interest in internationalization or from delays in indexing new studies in the Web of Science database. Future research will be necessary to verify the actual trend. Despite this, the 2010s and 2020s represent the period of greatest scholarly attention to internationalization, with the annual number of publications being significantly

higher than in the previous century. The presented findings address the first research question: "How has researchers' interest in internationalization evolved over the years?"

The article presents the results of a bibliometric analysis of research on the internationalization of enterprises, based on 13,361 academic papers. Using VOSviewer software, the 50 most frequently occurring keywords were extracted from a total pool of 24,474 terms. The key concepts were categorized into nine thematic areas, including: the process of enterprise internationalization, performance and efficiency of internationalized firms, models and theories of internationalization, strategies and management in the context of internationalization, the role of knowledge and innovation in internationalization, emerging markets and the global context of internationalization, small and medium-sized enterprises (SMEs) in the internationalization process, international expansion, and determinants of internationalization.

Additionally, the bibliometric analysis led to the creation of a keyword map that grouped the key topics into three color-coded clusters, representing the relationships between keywords. The analysis indicated that the groups from the table and the keyword map partially overlap. However, complete alignment was not possible due to differences in the methodological assumptions used for categorizing keywords into thematic groups in the table. The presented findings provide an answer to the second research question: "What key issues and areas are discussed in studies devoted to internationalization?"

The next stage of the study involved identifying the popularity of specific internationalization models in academic research, understood as the occurrence of references to particular models and theories within the analyzed papers. To achieve this, the study initially examined a table containing the 50 most frequently occurring keywords in the reviewed studies. However, since this table included only three keywords directly referring to specific models and theories, it was decided to expand the analysis to the 200 most frequently occurring keywords and construct a new table containing only those terms that directly corresponded to particular internationalization models and theories.

The final table included 14 keywords, which were then assigned to five different models. For models associated with multiple keywords, the total number of publications in which these keywords appeared was summed. The results regarding the popularity of specific models and theories were subsequently presented by highlighting the maximum number of publications in which references to them were found. The maximum number of studies was used as a metric due to the inability to verify whether multiple keywords related to a given theory co-occurred within a single paper.

Based on the study results, the most frequently referenced theory was Foreign Direct Investment, with a maximum of 1733 publications. The next most frequently mentioned models were Networks Approach (762), Born Global (631), Resource-Based View (373), and Uppsala Model (186). These findings provide an answer to the final research question: "What internationalization models dominate in scientific literature?"

The article provides a summary of the current state of knowledge regarding the theories and models of firm internationalization. The study's results highlight key areas and theories in the literature on internationalization and may serve as a foundation for further analyses, including a qualitative literature review on internationalization models. Additionally, future research could focus on determining the popularity of specific internationalization models over time. Such studies would provide deeper insights into the changes and trends occurring in internationalization research.

The conducted bibliometric analysis, in addition to providing a comprehensive overview of the state of research on internationalization, also carries significant practical implications. The presented findings can serve as a reference point for businesses and policymakers in selecting internationalization strategies. Understanding dominant models and identifying key research areas can help companies adjust their international expansion strategies to evolving market conditions.

The research results highlight the growing role of digitalization and innovation in internationalization processes, which may be particularly relevant for companies planning to expand into foreign markets. Models such as Born Global and Network Approach can be especially useful for small and medium-sized enterprises (SMEs) aiming for rapid entry into international markets without the traditional, gradual internationalization process. On the other hand, companies with greater capital and resources may benefit more from the Foreign Direct Investment theory, enabling them to manage global operations more effectively.

Furthermore, the analysis results can be utilized by policymakers to shape support policies for companies planning internationalization. Understanding the most applied models and strategies can aid in developing effective instruments to support firms' expansion, such as funding programs, regulatory facilitation, or initiatives promoting the development of internationalization-related competencies.

It should be noted that this work has significant limitations. The results of the study on the popularity of internationalization models are subject to the risk of error due to the research tool used, which prevented the verification of the co-occurrence of terms within a single article. As a result, cases where two or more concepts related to different internationalization models were discussed within the same paper were treated as separate publications for each of these terms. This may lead to an overestimation of the number of papers assigned to specific models and distort the analysis results. Furthermore, in some cases, the attempt to verify the association of certain keywords with specific models revealed that not all instances of the term directly relate to the model, which also impacts the accuracy of the results. It is also worth mentioning that the data for the analysis was drawn from a single database, which limited the amount of research material. However, this was done deliberately to avoid issues related to differences in metadata structure and indexing standards.

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