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FOREWORD

Presented number of Silesian University of Technology. Scientific Papers. Organization and Management Series. Presented papers contain result of researches conducted by various universities. The number consists of 32 papers.

The papers presented in the number concentrate on many topics connected with organization and management. There are in the number papers about: human resource management; marketing; production management; environmental management; human-machines collaboration; financial management; public management; logistics; digital awareness; services management; quality management; tourism management; artificial intelligence in management; brand management; sustainability; social responsibility and innovativeness.

Bożena Skotnicka-Zasadzień

Radosław Wolniak

CHEATING JOB APPLICANTS. ETHICAL DILEMMAS OF HR

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Purpose: The purpose of this article is to identify manifestations of cheating by HR departments/employees during the hiring process.

Design/methodology/approach: The main research method used by the author was a literature review. The empirical study used a qualitative approach. Interviews were conducted in 2025. They were young people (aged 19-35), students of studies for working people who had already completed training in HR (methods, processes, functions). They were management students, participants in training in organizational behaviour. A total of 83 employees participated in the study on a voluntary basis.

Findings: During the interview, false information is given about the salary, and the scope of responsibilities. In a few cases, unethical methods are used during the selection process. These mainly consist of humiliating candidates. There are a few reasons for cheating, but the survey respondents indicated the need to represent the interests of management, lack of attention to the needs and expectations of employees.

Research limitations/implications: In the case of interviews, we may have to deal with different experiences and emotions of employees. We interpret opinions, but not always facts. There are also limitations related to the socio-demographic characteristics of the respondents.

Practical implications: The content of the article allows for the improvement of the work of HR departments, especially in the hiring process.

Originality/value: While there are articles showing the white lies formulated by job applicants, there is a dearth of publications showing the problem of cheating by HR departments/employees.

Keywords: HRM, cheating, hiring, ethics.

Category of the paper: research paper.

1. Introduction

Organizations often claim that the full potential of employees can be developed and utilized to the benefit of both them and the organization (Storey, 1996) – read its owners. In fact, all interventions aim to increase productivity. Coaching, motivational schemes, development sessions, telling employees that they are the most important resource, etc., all serve this purpose.

There is no doubt that failure to adhere to ethical principles and values can result in several detrimental effects in the workplace, including poor performance, conflict among employees and lack of moral conduct (Tadesse Bogale, Ayenew Birbirs, 2023).

The literature on the ethical behaviour of job applicants is prolific. Thousands of articles have been published on how employees cheat and how to protect themselves from dishonest practices. The literature to date tends to concern how to prevent lies formulated by employees themselves (Burns, Kintz, 1976; Marella, Vijayan, 2020). One of the solutions used is CV certification (Teixeira da Silva et al., 2020; Marella, Vijayan, 2020; Weiss, Feldman, 2006). Currently, various multinational companies are investing heavily to verify the personal data of job applicants. However, according to research, the personal data verification process implemented by these companies is extremely costly, time-consuming and inefficient (Marella, Vijayan, 2020). One solution being used is CV certification (Teixeira da Silva et al., 2020).

New technological solutions are also being sought to determine how much of the information provided by a candidate is true. One such solution is the use of blockchains. It is claimed that a job candidate's data can be verified during the recruitment process by comparing the hash value of a given document with the hash value of a document present on a blockchain. This process is extremely efficient, less time-consuming and very cheap to implement for all types of companies (Marella, Vijayan, 2020).

Therefore, the literature review conducted indicates that there are more publications regarding employee deception (Burns et al., 1976; Weiss, Feldman, 2006; Teixeira da Silva et al., 2020; Marella, Vijayan, 2020; Stevens, Bernstein, 2023). On the other hand, however, little is said about the ethical behaviour of employees/HR departments.

The first amendments on this topic were published in the 1990s. Researchers highlighted unethical HR practices. These included: recruitment and promotion based on favouritism, leading to unfair pay gaps, career development based on friendships with senior management, gender discrimination in promotions, inconsistent application of disciplinary norms and attention to external factors in performance appraisals (Simões et al., 2019). Results from other studies indicated that employee selection, performance management and appraisal, recruitment were the areas most susceptible to unethical HR practices (Erasmus, 2018). In many companies, HR focuses on distancing, depersonalizing and hiding the truth. Thus, HR acts on the “moral” demands of the business rather than the people (de Gama et al., 2012). Much less has been written about the lies committed by HR professionals. Data on this most often appears on online portals (e.g., <https://www.resumebuilder.com/4-in-10-hiring-managers-admit-they-lie-to-candidates-in-the-hiring-process/>, December 11, 2024).

The literature review clearly indicates a research gap. There is a lack of articles addressing deception (motives and manifestations) by HR departments themselves. Therefore, after the review, qualitative research was conducted interviews with individuals who had encountered various manifestations of employee/HR department misrepresentation. The aim of the research is to identify manifestations of cheating by HR departments/employees

during the hiring process. The significance of this article lies in its ability to serve as a starting point for further, more in-depth analyses. This article will discuss selected practices of unethical behaviour by HR departments in the hiring process. This article discusses the results of quantitative research. It is part of a broader study on unfair HR practices. It presents employee opinions regarding the provision of false information during job interviews, manipulation related to salary negotiations, and various identified lies.

2. Method

The aim of this article is to identify the manifestations of cheating by HR departments/employees during the hiring process. The main research method used by the author was a literature review. Literature on the subject was reviewed in the course of the following stages: selecting key words for each problem, topics, searching for works containing the identified key words in the databases: (f.e. Academic Search Ultimate, Google Scholar), becoming familiar with the returned publications, reviewing the publications, summarizing the selected publications, and arranging the collected research material. The applied procedure is consistent with the general methodology of conducting research (Creswell, 2013; Easterby-Smith et al., 2015) and the methodology of research in management sciences (Easterby-Smith et al., 2015). The empirical study used a qualitative approach. Interviews were conducted in 2025. The qualitative procedure (Creswell, 2013) comprised the following stages: choosing a research strategy, selecting participants, identifying data sources and preparing an interview protocol, performing data analysis and interpretation (including: organising, preparing, reviewing and coding data, describing situations, determining methods of data presentation and interpretation). The qualitative method was selected because the research problem had not been earlier examined thoroughly. At that stage, it was difficult to isolate variables (Creswell, 2013, p. 66).

Considering the literature review conducted, the researchers formulated the following questions:

1. What areas of HR activity are affected by false information given during interviews?
2. What are some extreme examples of unethical employee selection?
3. What is the opinion of employees regarding deception by HR departments?

This main problems were assigned specific questions. The questions concerned practices involving providing false information during hiring, unfair compensation, and training. Participants were given the opportunity to provide examples of behaviour they considered to constitute cheating. For example, one question asked whether information provided during the interview proved to be confirmed in practice – during the hiring process.

Based on the literature review, a questionnaire consisting of 20 questions was prepared. They were adapted to the structure of the work, which means that individual open-ended questions were assigned to the content discussed in the work. Considered that open questions can avoid bias (despite their limitations) (Easterby-Smith et al., 2015). They referred to individual HR processes (recruitment, training, assessment, remuneration, dismissals). Thematic coding was used, which involved assigning codes to interview excerpts that represented specific themes. After coding, the researcher identified the main themes present in the interviews, allowing for a deeper understanding of the opinions expressed by the interviewees.

About 750 employees were asked to participate in the study. They were young people (aged 19-35), students of studies for working people who had already completed training in HR (methods, processes, functions). They were management students, participants in training in organizational behaviour. However, only 83 employees responded.

I wanted answers from people who know how HR departments should function. In this sense, it was a purposeful selection. It is not representative. The results of the interviews are only illustrations of the problems that are discussed (these are only selected representative statements, opinions of employees).

The research was voluntary. The entire interview was conducted in such a way that the obtained data was credible. For this purpose, I did not exert time pressure and made every effort to obtain trust. When analysing the data, the recommendations contained in the work *Conducting qualitative research* by D. Silverman (2004) were used. This means that the data was analysed on an ongoing basis. Quantitative and qualitative analysis was performed (positive and negative opinions), and examples were selected referring to both positive and negative assessments. The aim was to maintain objectivity, so that the reader would have at their disposal both cases referring to good practice and examples illustrating improper actions taken by HR. In some cases (e.g., when avoiding errors related to the organization of training), knowledge gathered during quality audits was additionally used (following ISO 19011, while maintaining confidentiality). The audit uses three techniques: observations, targeted interviews, and document analysis. I used the exemplification method, which aims to additionally illustrate formulated assumptions and to justify them with certain properly selected examples (Kazmierska, 2018). This method is not a complete case study but rather a deliberately and selectively applied approach serving to enrich the explanation of the studied reality.

3. Results

Recruitment itself is already fraught with lies – after all, the aim is to attract as many candidates as possible. This is why companies use two strategies – concealment or embellishment. In the first strategy, companies withhold information on salary ranges, working

conditions and entitlements. Instead, they embellish information about development conditions, promotion opportunities, additional bonuses, etc. Recruitment advertisements – in the section on working conditions and pay – are designed to arouse interest and therefore by their nature do not contain truthful information.

3.1. The interview

When writing about irregularities, it is also important to refer to the interview itself. During the interview, the job applicant is asked to provide additional information, to elaborate on the data contained in the CV. Sometimes additional tests are carried out, even the assessment center method is used. A common mistake is to conduct interviews/interviews only with the recruiter himself. Consequently, the people with whom someone is to work do not have the opportunity to get to know the job candidate. It is also a mistake to believe that at this stage it is possible to fully assess competences-especially soft ones.

Unfortunately, it happens that during the interview they try to assess the candidates by asking them questions – Are you able to work in a team. Are you resistant to stressful situations?

3.1.1. Remuneration information

Corporations employ external recruiters (sometimes second year university students with no practical experience). They are taught to ask the question – How much do you want to earn? This is how candidates' negotiation skills are supposed to be learnt.

A frightened candidate who wants to be hired usually gives an understated amount. In this way, he falls into the motivation trap. Every year he receives a small increase until he becomes unprofitable for the company – because he earns too much. Of course, throughout this period, the increases made are only to keep him engaged.

The reality is that corporations are keen to hire workers at the cheapest possible cost. When there is an employer labour market the amounts quoted by candidates are almost always understated.

From the interviews, it appears that some people receive information in advance about what the salary is.

"I was offered a salary straight away. I was not asked about my financial requirements" (k.u.p.500), states one person.

Sometimes it is the employees themselves who give the minimum amount they can agree to, or who try to find out what the additional elements of remuneration are – when the rate given is, in their opinion, too low. Below is one statement:

"I was asked about financial expectations. I gave an amount based on my experience and the market standards for the position. When I heard that the company did not have such a budget, I initially felt distaste but quickly moved on to action: I asked about non-wage benefits (e.g. training) or the possibility of a salary review after a trial period" (k.u.51-250). In extreme cases, only the lowest hourly rates are given during the interview, and the expectation is then created that these lowest rates can be negotiated in the future. Candidates agree to the lowest

salary just to get any work experience or to get a living wage: Yes, I was just starting my career path at the time, and I thought I had to give as low as possible to at least get some work experience' (k.u.p.500).

"Before a job interview, I try to find out what the median salary is for a similar position and based on that I determine for myself the minimum amount with which I go to the interview. Unfortunately, in Poland it is still very hard to find out about salaries (salaries are still a taboo subject). At every interview I've been to, I've been asked how much I want to earn. Once, being forced by the situation (covid times) I was forced to employ a company whose wages only allowed me to survive" (m.u.11-50).

As one might have guessed, sometimes the proposed salary is higher than this. 'I was asked, I felt apprehensive that it was too much due to my lack of experience, but in the end the amount that was presented to me was higher than my requirements (k.u.51-250), the worker states.

3.1.2. Terms of reference

Yet another misconduct is the misrepresentation of responsibilities. The interviewees stated that after starting work it turned out that some promises and information given during the interview did not work out in reality. These mainly concerned interpersonal relationships, the amount and pace of work, promotions, raises, forms of employment.

"Terms of reference for the position (difference in offer and presentation of duties at interview), requirements (knowledge of software not previously mentioned)" (m., p.500, u, spec.).

"My recruiter asked if I liked to read books, because in the company the employees read books, and they do employee training from them and they are voluntary. It turned out that they are not voluntary" (k.p.500.u, spec.).

"The information provided in the advertisement regarding the duties of the position I applied for was in fact completely different" (k. p.500.u).

"The requirements stated during the interview (knowledge of software, which had not been previously mentioned) turned out to be completely different" (m. p.500.u).

"Additionally, the scope of responsibilities often turned out to be much broader than indicated in the job offer" (k.p. 500.p).

"There were situations where the scope of responsibilities was presented in a more attractive way than in reality. There were instances where the scope of responsibilities presented during the interview differed significantly from reality – there were more operational tasks than strategic ones" (m.p.500.u).

The reason for providing false information is that external recruiters are unfamiliar with the specifics of the organization. Interestingly, some interviewees justify such behavior. Below is one such statement:

"It's difficult to convey such a scope of responsibilities in a few sentences" (k.u.p.500).

3.1.3. *Catalogue of lies.*

Respondents would list all the lies formulated by HR departments. Some individuals stated:

"During the recruitment process, I encountered deceptions and concealment of relevant information, such as:

- salaries (the salary offered for this position and the average salary for this position in this company),
- the exact duties of the position, how and with what tools the work will be done, how overtime is accounted for,
- withholding information about PPKs (receiving a sign-off sheet without explaining what you are signing and, when questioned, being told that there are no Employee Capital Plans in place at this workplace),
- being required to sign a statement that I will not share earnings information with co-workers" (m.u.11-50).

"The most common lies were about salary. In the advertisement, the company guaranteed a basic salary + commission. As a result, not even the base was paid, expecting availability and above-normal working hours" (k.do.10, u. spec.).

Candidates were also given false information regarding promotion or career development opportunities.

"Yes, lies about opportunities for development within the company and the possibility of getting a permanent contract, writing a thesis based on company data. Nothing like that was possible afterwards" (k., p.500, u, spec.).na podstawie danych firmowych. Nic takiego później nie było możliwe" (k., p.500, u, spec.).

3.2. **Reasons for cheating**

The question arises as to why recruiters lie. Maybe it gives them pleasure, maybe it is because, according to popular belief, everyone lies. According to the report already quoted, recruiters act dishonestly in order to: hide negative information about the company, make the offer sound better than it really is, and attract more qualified candidates. Some of them deliberately try to say things that will satisfy the candidate (<https://www.resumebuilder.com/4-in-10-hiring-managers-admit-they-lie-to-candidates-in-the-hiring-process/>).

Lies occur for economic reasons (but the primary source is a poorly designed recruitment program). In some companies, employees are told that if they refer to someone and that person is hired, the referrer will receive some amount of extra compensation. Unfortunately, when HRs no longer have the financial means then, despite the recommended candidate being the best, their application is rejected. Employees pointed out the reasons for HR's inappropriate behaviour.

They stated that there is a 'fear of losing their jobs' (c. u. p. 500) and HR employees act under pressure from owners and managers. Below are a few selected statements. These are formulated only by those who also gave manifestations of fraudulent, unethical behaviour.

"In my opinion, it is mainly the great need to find someone quickly to replace a person in a position. This may be due to pressure from management or owners" (k. u.p.500).

"I think HR often operates under a lot of pressure from the board - their aim is to "sell" the position and not necessarily present a fully realistic picture. There is also a lack of accountability for the promises made" (k. manager, p.p.500).

"They cheat because it is due to a 'top-down order' from the CEO" (k.u.p.500), but also due to a 'sense of superiority' (k.sp.51-250).

"The reasons for this behavior are primarily due to the function the HR department plays in the organizational structure. If the company's priority is the interests of management and the achievement of business objectives, HR is often reduced to the role of enforcer of internal policies, which may be at the expense of individual employee needs. In such cases, instead of fulfilling a support function, it becomes a tool for implementing organizational strategy, often at the expense of the atmosphere and the commitment of the team" (k. u.p.51-250). If you don't know what it's all about, it's all about the money, as one proverb says. Employees thus recognize the primary problem, namely the desire for profit or – ethically – to guarantee business continuity. Interviewees stated:

"Prejudices caused by bad previous experiences. In my experience, it is also the financial problems of the business owners that cause this behavior, and the recruitment process seems to be very often a shame in smaller and medium-sized companies" (k.u.do10).

"This can be due to pressure from management or supervisors who tell them to "keep costs down" and minimize employee claims. Sometimes it is also a matter of poor organizational culture – where the interests of the company are more important than the welfare of the employee. A lack of proper ethical standards in the HR department itself or simply insufficient training in labor law and communication cannot be ruled out either" (k.u.11-50).

4. Discussion and further research

In making even a valid criticism of the activities undertaken by HR, it must be considered that HR employees are not given complete freedom to undertake various activities. They are contractors. They must implement many unpopular and difficult matters, for example, such as dismissals, restructuring, transferring employees to another less attractive job, maintaining discipline. Some researchers believe that in contemporary organizations, institutional structures – particularly the structures of Anglo-American market capitalism – threaten and limit the ability of human resource managers to exercise moral agency

and therefore engage in ethical behavior (Wilcox, 2012). T Wilcox, citing the work of M Greenwood (2002), argues that the barriers to ethical HRM practice may seem insurmountable, yet, as the fieldwork suggests, some HR managers remain aware of the negative impact of “market opportunism” and other contextual “bullshit” on decisions that ultimately change the lives of others in their organization (Wilcox, 2012, p. 2). Although there is sometimes a clear understanding of the expectations of ethical management, HR practitioners often find it difficult to fulfil this role due to conflicting tensions and perceptions of their role in their organizations (Parkes, Davis, 2013). HR practitioners and managers are often confronted with and conflicted by the actions and decisions they are required to make (de Gamaet et al., 2012). HR professionals may think that they are competent in ethics management and that they should be involved in ethics management (Van Vuuren, Eiselen, 2006). In practice, however, much depends on other factors, such as the extent to which other managers are involved in dealing with ethical issues, who may feel relational obligations towards subordinate employees - thus introducing a more humanistic approach to people management (cf. e.g. Au et al., 2024).

C. Rozuel writes that people at work are encouraged to embody certain values that fit the corporate trend, to wear the mask or uniform of the company. We rarely see human faces, but all too often we see “salesmen”, “customer service managers” or “bankers” (Rozuel, 2009, p. 2).

HR professionals also regularly face ethical issues in their daily lives, as many do. HR plays a role in quite significant decisions such as hiring, training, development, promotion, job definition, discipline, dismissal (Tonus, Oruç, 2012). The different roles played by HR professionals and the fact that they are something intermediate between employees and employers means that they may experience ethical dilemmas (Wooten, 2001). For example, when, on the explicit instruction of top management, they are obliged to change employee appraisals so that lower appraisals ensure that employees do not need to be paid extra. Much then depends not only on their moral attitudes, but also on the internal context (cf. e.g. Simões et al., 2019).

The assessment of HR ethical activities is difficult not only on the place of HR departments, not so much in the organizational structure, but in the structure of ethical values and their compliance. It is also important to remember that the individual ethical orientation of employees may influence perceptions of various HR programs and, after all, may be perceived as intrusive. Research findings indicate that ethical orientation has a direct effect on the perceived intrusiveness of programs and has both direct and indirect effects on the perceived appropriateness of programs (Alder et al., 2007). Thus, a great many factors influence how HR professionals act, and not only of an ethical nature. These factors require classification and the search for interdependencies.

Ethical issues increasingly include the applicability of AI to HR activities (cf. e.g. Andreas, 2024). Organizations may be aware of AI ethical issues, their responses vary and depend on various governance and self-regulatory mechanisms that may have influenced their ability to proactively engage with ethical issues (Bar-Gil et al., 2024).

Considering only the above formulations, as well as the research findings discussed above, it can be concluded that new research needs to increasingly consider the impact of AI tools on deception of both candidates and job applicants themselves. The extent to which the actions taken by HR departments are autonomous and the extent to which their identification with the organization may be a source of unethical behavior remains a serious issue.

The pathologies that occur during the candidate selection process deserve further investigation. Audit notes indicate that such disturbing phenomena are occurring.

One of the silliest ideas is the use of the chair test or, as HR specialists write, the wobbly chair test. This involves job candidates being asked to take a seat on a chair that is wobbly. The aim of this 'experiment' is to find out how the candidate will cope in difficult situations?" The chair on which the candidate sits has one leg shorter. This supposedly tests assertiveness and resistance to stress. Recruiters want to know how such a candidate will behave, will they ask for a change of chair? Such a supposed assertiveness test is the most boorish behaviour on the part of the recruiters. It is not in line with health and safety principles.

In the 1990s, canvassing became a popular profession. Unfortunately, most cars at the time did not have air conditioning fitted and there was a dress code – the need to dress in a white shirt and suit. Someone from HR came up with the idea of locking candidates in a car without air conditioning during the selection process and checking how fast they sweated.

Another idea was to test patience. Which was to stand on a chair on one leg – for as long as possible, but no less than 15 minutes.

These issues, presented in a highly simplified form, require further research.

5. Limitation

It is important to remember the limitations associated with qualitative research. The interpretation of data obtained through interviews depends on the knowledge and skills of the researchers, the structure of interviews, and the ability to avoid bias (Easterby-Smith et al, 2015). There are also limitations related to the socio-demographic characteristics of the respondents. Of course, it should be remembered that the potential distortion of opinions could have occurred due to the participation of students with HR education in the research.

6. Completion

During the interview, false information is given about salary and responsibilities. In a few cases, unethical methods are used during selection. These mainly consist of humiliating candidates. There are many reasons for cheating, but those surveyed pointed to the need to represent the interests of management, a lack of concern for employees' needs and expectations.

In summary, it is wrong in recruitment and selection to:

- giving false information about working conditions and pay, and opportunities for training and professional development,
- creating expectations about the future,
- making assessments based on gender, age, ethnicity, etc.,
- competence testing based only on motivation letters and CVs,
- asking questions that supposedly assess soft competences,
- attaching particular importance to the results of psychological tests,
- asking questions about salary (negotiation is allowed after a salary range is given),
- admission without taking into account the principles of the management systems in place and only on the basis of the job description (without organization-wide competences),
- not allowing future co-workers to participate in the process,
- allowing a lack of opportunity to get to know the nature of the work even before the hiring decision is taken.

To prevent errors in practice, it is important to: provide information about the annual salary in advance (e.g., in job advertisements), limit the involvement of external recruiters to the absolute minimum, create opportunities for job candidates to participate in the life of the organization before the hiring decision is made, avoid using recruiter evaluations based solely on quantitative criteria.

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PURCHASING STYLES OF CONSUMERS IN POLAND: CONDITIONS, PREFERENCES AND MARKETING IMPLICATIONS

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Purpose: The purpose of this article is threefold: (1) to determine the prevalence of consumer purchasing styles among Polish consumers, (2) to identify the influence of economic, social, marketing, while also technological factors on the formation of these purchasing styles, and (3) to explore their implications for marketing strategies and market segmentation.

Design/methodology/approach: The study was conducted using a quantitative survey method. Empirical research was carried out in 2024 using a standardized questionnaire and the Computer-Assisted Telephone Interviewing technique. The sample was representative of the adult population of Poland, in which a total of 1080 respondents participated in the study.

Findings: The results indicate a clear dominance of rational purchasing styles among Polish consumers, especially the rational-pragmatic, economic, and balanced styles, which are characterized by price sensitivity, resistance to external social influences, while also a focus on functionality and quality. In contrast, socially dependent and imitative styles show a high susceptibility to trends, advertising, and the opinions of reference groups. The study also confirms a strong correlation between purchasing styles and preferred sales channels while socially-oriented consumers gravitate towards modern digital solutions (e.g., online and mobile commerce) and rational buyers prioritize efficient and functional channels. These distinctions have significant implications for market segmentation and the personalization of marketing communication.

Research limitations/implications: The study is limited to the Polish market and reflects consumer attitudes at a specific point in time. Future research could expand the geographic scope and include qualitative methods to explore motivations in greater depth.

Practical implications: The findings can support marketers in tailoring omnichannel strategies, adjusting promotional messages to dominant purchasing styles, while also creating behaviour-based personas for digital advertising and customer relationship management.

Social implications: Understanding consumer purchasing styles contributes to more responsible and inclusive marketing aligning with ethical and sustainable consumption trends and reducing manipulation in advertising targeted at socially dependent consumers.

Originality/value: This article contributes to literature on consumer behaviour by offering a comprehensive, data-driven classification of purchasing styles in the Polish market and linking them to specific marketing implications.

Keywords: purchasing styles, consumer behaviour, consumer, marketing.

Category of the paper: research article.

1. Introduction

The contemporary consumer market is characterized by the growing intricacy of purchasing behaviour which arises from dynamic economic, technological and social change. Consumers more and more frequently make purchasing decisions in a differentiated manner, which in turn constitutes significant challenges for marketers, market researchers and the creators of sales and communication strategies. A key issue is becoming the perception of the so-called consumer purchasing styles (CPS), or in other words, well-established patterns of consumer behaviour that determine the way of making purchasing decisions, while also the selection of sales channels, as well as susceptibility to the influence of marketing stimulants. CPS, similarly to lifestyles, constitute important areas of interest in research on consumer behaviour. Not only do they reflect individual preferences of a person, but also their attitudes towards prices, quality, functionality of products or opinions of the social environment. Styles have an impact on the way in which they go through a decision-making process; for instance, how they approach searching for, evaluation and choice of information, while also shaping their own purchasing behaviour (Nayeem, Marie-IpSooching, 2022). Consumers usually have more than one style, while their usefulness depends on the analysed product and context). One or more defined dimensions of purchasing styles may have an impact on the purchasing choices of consumers, while these influences are relatively long-lasting (Sproles, Kendall, 1986).

CPS are significant for marketing as they determine the behaviour of consumers, while are also relatively stable over time and simultaneously significant for market segmentation. The identification of purchasing styles is useful in order for advertisers and marketers to be able to avail of profiles for the segmentation of consumers in profitable clusters (Nayeem, Cassidy, 2015). The creators of promotional strategies use their knowledge of purchasing styles for the creation of segments of clients, which they subsequently adjust their marketing message, distribution channels and product offer to.

In times of intensive development of electronic trade, while also the transformation of sales models, recognising the prevalent purchasing styles in a particular community may provide valuable indicators for the designing of the omnichannel strategies, as well as effective management of customer experience. The increasingly widespread personalization of marketing communication is based on the analysis of purchasing styles with the aid of behavioural data (Wedel, Kamakura, 2012). The perception of CPS facilitates the personalization of advertising and offers in real time. Algorithms of machine learning analyse the behaviour of consumers and attribute them to the specified purchasing styles. On this basis the adjusted advertisements are displayed (e.g. dynamic remarketing). Firms are increasingly using integration of advanced analytics and artificial intelligence (AI) with the aim of acquiring more precise strategies of segmentation and positioning (Tokhtasinovna, 2025).

In spite of the fact that many researchers have analysed the styles of CPS, there is a lack of research on the impact of differentiated economic, social and marketing factors in the shape of purchasing styles. With relation to this, there is a research gap relating to the identification of ties between CPS and economic, social and marketing factors.

The aim of this paper is the 3-D analysis of the CPS of Polish consumers. Firstly, their dispersion in the population was defined. Secondly, key factors were identified, namely economic, social, marketing and technological factors, which all have an impact on their formation. Thirdly, the implications of the results of market segmentation and the personalization of marketing have been presented. This paper is based on the results of quantitative research conducted in 2024 on a nationwide representative sample of adult consumers with the application of the CATI technique.

In order to realize these aims, the following research questions were put forward: What CPS do Polish consumers prefer? To what extent does the frequency of using these forms of sales have an impact on CPS? To what extent do economic, social and marketing factors have an impact on CPS? To what extent do groups of influence that provide patterns to imitate have an impact on purchasing styles? The answers to these questions will make it possible to identify the patterns of consumer purchasing styles occurring among Polish consumers.

2. Purchasing styles of consumers – theoretical background

The issue of the purchasing styles of consumers constitutes a significant area of research in literature in the sphere of consumer behaviour. These styles are defined as exemplary, mental and cognitive orientation towards purchases and acquisitions, which continue to dominate in the choices of a consumer, which in turn results in the relatively constant personality of the consumer (Sproles, Kendall, 1986). Some claim that it is the drilled habitual pattern of reactions presented by an individual in confrontation with a decision-making situation (Scott, Bruce, 1995). Nevertheless, Schiffman and Kanuk (2010) feel that CPS constitutes a relatively constant orientation of the individual in terms of the purchasing process, as it has an impact on the way of searching for information, evaluating alternatives and the ultimate choice. A similar perspective is presented by Hoyer et al. (2013), in which they define this construct as a set of cognitive and behavioural features that determine the reactions of a consumer to the market offer. Solomon (2018) emphasizes that CPS is the way in which an individual interprets and organizes information referring to products, brands and purchasing decisions based on his/her own values, experiences and social context. This signifies that consumer decisions are embedded not only in a national sphere, but also emotional and cultural spheres. In turn, Kotler and Keller (2021) perceive CPS in a more practical marketing context, by describing it as a typical way of reaction on the part of the consumer to the fundamental instruments

of the marketing-mix as follows: product, price, distribution channels and promotion, which are all shaped by psychological, social and cultural factors. However, Helmi et al. (2023) perceive the styles of CPS as a mental orientation that has an impact on choices that consumers intend to make, the manner in which they make that choice, the place of purchasing, while even for whom they make that choice. This mental orientation may be conscious or not conscious.

Purchasing styles may be perceived within the framework of three principal approaches as follows: psychographic (concentration on defining lifestyle), descriptive (characterizing the behaviour of the consumer), while also aimed at the general typology of consumers (selecting a group of buyers (Budzanowska-Drzewiecka, 2014)). In each of these approaches, the involvement of the consumer is emphasized in terms of the purchasing decisions, assuming rational purchases, awareness of the existence of brands, while also price differentiation and quality of product.

In subject-related literature, purchasing styles are frequently perceived as consumer decision-making style (CDMS), which is understood as the basic orientation of a consumer towards purchases. It is a relatively constant pattern of behaviour, attitudes and preferences that determine the way of undertaking purchasing decisions. It also includes cognitive elements, as well as affective elements. Karimi et al. (2015), who analysed purchasing behaviour online, suggested that the style of taking decisions may be defined as the tendency of the individual to maximize or placate (or satisfy) his/her decisions. The maximizers seek alternatives and devote their time to their evaluation and search for the best possible options, whereas the people striving towards satisfaction aim for “sufficiently good” and satisfy themselves with a lower number of options and invest less time and effort.

A significant impact on purchasing decisions is that of access to information relating to alternative products. Processing information is a necessary task that faces consumers, who differ from each other in terms of the level of involvement in this task (Ayal, Hochman, 2009). It is possible to distinguish two basic styles of undertaking purchasing decisions on the part of consumers with regard to access to information: expanding and info-mising (Ngcamu et al., 2023). Expanding is the habit of processing information relating to the desire to make a greater effort in the processing of information. However, info-mising relates to the style of processing information in which the particular person does not like processing information and simultaneously puts in less effort (Mittal, 2017). Each product choice out of necessity is associated with becoming familiarized with information about alternative products, therefore processing information is a necessary task for consumers.

The differentiation of consumer attitudes and behaviour means that in subject-related literature multiple types of CPS have been distinguished. These classifications are aimed at capturing the specific decision-making patterns that facilitate the most accurate market segmentation and adjustment of marketing activities to the needs of various groups of consumers. One of the first researchers to identify CPS was Stone (1954), who identified four separate purchasing types on the basis of their purchasing orientation: (1) economic client,

(2) personalizing client, (3) ethical client and (4) apathetic client. On the basis of this concept of CPS, Westbrook and Black (1985) identified four categories, namely economic consumer, personalizing consumer, ethical consumer and apathetic consumer. Sproles and Kendall (1986) prepared an inventory of consumer styles (CSI) based on the assumption that the decision-making behaviour of consumers may be clarified with the aid of eight central decision-making dimensions, which have an impact on the decision-making behaviour of a consumer. In the subsequent decades, numerous empirical research projects adapted the scale of CSI to various cultural and market contexts, by illustrating its high level of accuracy and usefulness in market segmentation (Bakewell, Mitchell, 2003). Another direction of research is based on the psychographics and sociology of consumption that classify styles according to the following: orientation towards “Me” vs the local environs (individualism vs conformism), the level of involvement in making purchases (active vs passive consumers), sensitivity to social and media impact (Solomon, 2018; Kotler, Keller, 2021).

The formation of CPS is influenced by a multitude of factors. Research indicates that the purchasing style is influenced by demographic factors (age, sex type, education), psychographics (values, attitudes, lifestyle), while also contextual variables, such as economic situation, development of technology or intensity of marketing stimulants (Lyonski et al., 1996; Wesley et al., 2006; Brunello, 2018). In analysing the style of taking decisions amongst young consumers from India and Germany, Mehta and Dixit (2016) identified multiple common factors that exert an impact on purchasing decisions, namely, perfectionism, brand awareness, mixed with excessive choice, habitual loyalty/brand loyalty, while also price-quality awareness. Research conducted by Hu et al. (2023) illustrates that purchasing experience, price, logistics, customer service, product quality and access to information have a significant impact on the choice of purchasing style on the part of consumers. Simultaneously, the most important influencing factors are product quality and price.

In contemporary times, particular attention is paid to the impact of digitization of trade, while also the personalization of information and the growing role of references and social recommendations in the online community (Verhoef et al., 2021).

In the context of the Polish market, analysis of CPS is conducted relatively seldom and the findings are sparse. The hitherto analysis mainly focused on chosen aspects, e.g. generational gaps, brand loyalty or the role of social media (Baruk, 2019). However, there is a lack of a comprehensive notion that would combine the typology of styles with the sales channels and marketing strategies.

In sum, the purchasing style consists of an intricate cognitive-behavioural structure that reflects individual preferences and reactions of consumers with regard to the market. Hence, CPS is not only a way of purchasing, but also a projection of the personalities of a consumer, including his/her values, competences and relations with the local environs. Its identification facilitates a more accurate segmentation of the consumer, while also a more precise adjustment of marketing activities to the needs of various groups of clients.

3. Methods

Empirical research conducted in 2024 with the aid of quantitative analysis survey. The CAVI technique was applied (Computer-Assisted Telephone Interviewing), which facilitates getting to wide and differentiated groups of respondents in a relatively short amount of time. The research tool constituted a standardized questionnaire that contains questions relating to purchasing styles, preferred sales channels, while also factors influencing purchasing decisions.

The sample selection was of a random nature and was executed in such a way as to ensure the representativeness with regard to the basic demographics of the adult population of Poland (age, sex type, place of abode, education). The selection of people for research was conducted with the application of the stratified sample and took account of the magnitude of the place of abode, sex type and age. The numbers in the particular layers were selected in accordance with the structures of GUS (Narodowy Spis Powszechny, 2021). On the basis of the method of random selection, a research sample was created, which consisted of 1080 adult inhabitants of Poland. The research was participated in by 50% women and 50% men aged between 18-24 (7%), 25-34 (17%), 35-44 (20%), 45-54 (18%), 55 years or more (38%), having basic education (2%), vocational education (7%), secondary school education (43%) and higher level education (48%), with place of abode in a village (40%), in a small town up to 20,000 inhabitants (12%), medium-sized town between 21,000 and 99,000 inhabitants (20%), large cities between 100,000 and 499,000 inhabitants (16%) and great cities of 500,000 or more inhabitants (12%), with a professional activity of directors, chairmen, managerial staff of workplaces and public institutions (2%), creative professions and independent specialists with higher levels of education, medium-level department heads (11%), administrative-office employees, lower-level heads (21%), physical-white collar workers, shop workers, service point workers (10%), qualified workers and foremen employed outside of agriculture and forestry (8%), workers performing simple tasks (5%), farmers (2%), owners of private firms, shops, points of sale (4%), retirees and those on disability allowance (26%), professionally inactive (7%), while also pupils, students (4%).

In the analysis of data the technique of descriptive statistics was applied, as well as cluster analysis, which facilitated the identification of the typical patterns of purchasing behaviour. Additionally, analysis of correlations was availed of with the aim of defining strength and direction of dependency between variables relating to purchasing styles and the preferred sales channels. The statistical significance of the results was evaluated at the level of significance of $\alpha = 0.01$.

The methodological approach accepted facilitated the acquisition of data which enabled the distinction of the prevalent CPS, their determinant, while also their potential implications for marketing strategies and market segmentation.

4. Results

During the course of research, seven purchasing styles were accepted, namely, rational-pragmatic style (CPS1) (79%), which represents the classic rational consumer that is resistant to external influences, e.g. fashion, advertising and impact of local surroundings (Table1). He/She is characterized by the statement “I try to maintain my own style, regardless of the trends currently in fashion”. The emotional-evaluative purchasing style (CPS2) (44%), is associated with acquiring products that are distinctive by their original and attractive appearance and who is characterized by the statement “I buy goods that are distinctive by their original attractive appearance”. He/She places emphasis on appearance, fashion and social acceptance, while also sensitive to trends and advertising. A balanced style (CPS3) (59%) is characterized by the statement “I try to buy products that are tailor-made and adjusted to my needs and profile”. This is based on a moderate and national approach to purchasing consumer goods. The socially dependent style (CPS4) (31%), is featured by the response “I buy products of well-known brands”, and strongly reacts to fashion, prestige, the opinions of others and advertising. The economic style (CPS5) (69%), is characterized by the statement “I buy standard articles that are available on the market” and is concentrated on the price and functionality, while being indifferent towards trends and the local surroundings. The consumption-imitative style (CPS6) (51%), is characterized by the statement “I search for goods produced in small series by unknown producers” and is characteristic of consumers who are individualists who want to be distinguishable in social spheres. The moderate style (CPS7) (41%), is characterized by the statement “I buy nice clothes and shoes in used clothing shops”. This is an indirect style, which may be altered depending on the context and situation. Consumers who present this style are susceptible to social influences, but are without strong preferences.

Table 1.
Consumer Purchasing Styles (CPS) in percentage form

Type of Purchasing Style	Frequency assessment						
	1	2	3	4	5	6	7
CPS1 Rational-pragmatic	1	1	4	15	34	29	16
CPS2 Emotional-evaluative	5	8	14	28	27	12	5
CPS3 Balanced	4	5	9	21	37	18	4
CPS4 Socially dependent	7	12	22	29	21	7	3
CPS5 Economic	0	1	5	24	45	19	5
CPS6 Consumption imitative	11	13	21	32	14	6	31
CPS7 Balanced	14	10	13	22	23	12	6

Scale: 1 – definitely unimportant, 2 – unimportant, 3 – rather unimportant, 4 – I don't have an opinion, 5 – rather important, 6 – important, 7 – definitely important.

Source: author's own study.

In the analysis of CPS, it is important to analyse the relations between them and the independent variables, e.g. sex type, age, education, place of abode and professional activity, which facilitates building a profile of the consumers that prefer a specific style.

For the purposes of identifying the relations between CPS and sex type, the Mann-Whitney test was applied (Table 2). Analysis of the test results indicates that there are significant differences between men and women in the case of the majority of styles ($p < 0.05$), namely, CPS1, CPS3, CPS4, CPS5, CPS7, whereas a lack of significant differences ($p > 0.05$) occurred in the following styles: CPS2 and CPS6. A detailed analysis of values (rank sums) indicates that the greater values (rank sums) amongst women occurred in the cases of CPS1, CPS2, CPS3, CPS5, CPS6, CPS7. However, with regard to men in the case of SN4. Hence, sex type significantly differs with relation to purchasing styles.

Table 2.
Results of Mann-Whitney Test $N=1080$

Type of Purchasing Style	Total ranks men	Total ranks women	U	Z	p	Z	p
CPS1	265429,0	318311,0	119359.00	-5.15	0.00	-5.35	0.00
CPS2	282333,5	301406,5	136263.50	-1.86	0.06	-1.91	0.06
CPS3	280023,5	303716,5	133953.50	-2.31	0.02	-2.39	0,02
CPS4	316955,5	266784,5	120714.50	4.89	0.00	5.01	0.00
CPS5	281052,5	302687,5	134982.50	-2.11	0.03	-2.24	0.03
CPS6	285599,0	298141,0	139529.00	-1.22	0.22	-1.25	0.21
CPS7	259558,0	324182,0	113488.00	-6.30	0.00	-6.40	0.00

Note: $p < 0,05$.

For the purposes of identifying ties between CPS and age, education, place of abode and professional status, the Kruskal-Wallis test was applied (Table 3). The research findings indicate the significant differences between the variables. The most numerous statistically significant differences occurred in the case of the age variable (CPS1, CPS3, CPS5, CPS7) and professional activity (CPS1, CPS3, CPS6, CPS7). The less numerous statistically significant relations occurred in the case of education and place of abode (CPS3). Thus, the age variable and professional activity variable are significantly associated with the level of all dependent variables analysed.

Table 3.
Results of Kruskal-Wallis Test $N = 1080$

Type of Purchasing Style	Age		Place of residence		Education		Professional activity	
	H(4)	p	H(5)	P	H(4)	p	H(14)	p
CPS1	12.56	0.01					23.81	0.05
CPS2								
CPS3	35.12	0.00	13.59	0.02			41.07	0.00
CPS4							41.54	0.00
CPS5	11.96	0.02						
CPS6							28.18	0.01
CPS7	15.32	0,00					31.87	0.00

Note: $p < 0,05$.

Analysis of the relations between CPS and the socio-demographic variables facilitated the definition of the profile of consumers for particular styles. The rational-pragmatic style is most frequently preferred by women (85%), consumers aged 45-54 (81%) and 55 years of age or older (82%), with higher level education (79%), while living in a large city (from 100,000 to 500,000 inhabitants (83%) and professional activity – creative professions, specialists with higher level education (86%). The emotional-evaluative style is chosen by women (74%), people aged 55 or more (72%), with basic level of education (69%) and basic vocational level (70%), while living in a village (71%) and professional activity - individual farmers (91%). The balanced style is first and foremost the choice of women (64%), people aged 55 or more (72%), with medium level of education (76%), while living in a medium-sized city (between 20,000 and 99,000 inhabitants and professional activity – retirees (72%). The socially dependent style is featured by women (25%), consumers aged 25-34 (30%), with a higher level of education (27%), while living in a great city (over 500,000 inhabitants) (27%), and professional activity - directors, chairmen, managerial staff of firms and public institutions (43%). The economic style is usually characterized by women (47%), consumers aged 45-54 (43%), with a higher level of education (45%), while living in a large city (from 100,000 to 500,000 inhabitants) (49%), and professional activity–owners of private firms, shops, points of sale (48%). The consumption-imitative style is declared by men (35%), consumers aged 45-54 (32%), with a higher level of education (33%), while living in a great city (over 500,000 inhabitants) (31%), and professional activity – directors, chairmen and managerial staff of firms and public institutions (56%). The balanced style is featured by women (51%), people aged 18-24 and 25-34 (48%), with medium-level of education (51%), while living in a large city (from 100,000 to 500,000 inhabitants (47%), and professional activity – workers performing physical work (56%).

CPS is the result of the impact of various factors. The most important of these include sales channels that may be divided into the following: forms that are physically located in points of sale of shopping chains, in general stores, specialized stores, supermarkets, shopping malls, exclusive shops, e.g. mail order shops and forms of sales online.

The choice of location of purchase is influenced by many factors. One of the principal ones include the type of shop where purchases are made. In Table 4, the research findings have been laid out relating to the most frequently chosen places of making purchases by consumers. Amongst the sales channels presented, namely, small shops, supermarkets, wholesale shops, discount stores, street markets, online shops and mail order shops, consumers most frequently do their shopping in discount stores of specific brands (Biedronka, Lidl, Netto, Polomarket, Dino, etc.) (83%), whereas subsequently in large supermarkets (54%) and online shops (53%). They more seldom purchase consumer goods in hypermarkets (45%) and in small self-service shops (42%). Consumers most seldom do their shopping in wholesale shops or in shops where products are sold in bulk (8%).

To conclude, in Poland there is a noticeable trend of withdrawal of consumers from small shops, bazaars and street markets, while also wholesale shops for the benefit of large supermarkets, discount stores and online shops. The hypermarkets and medium-sized discount stores in large cities constitute significant competition for small shops and bazaars. In villages and small towns a large role is still played by small shops and street markets.

Table 4.

Frequency of making purchases in various sales channels (SC) in percentage form

Sales channels	Frequency assessment						
	1	2	3	4	5	6	7
SC1. In a small shop where goods are served by shop assistants (or in a kiosk)	7	28	24	21	14	5	1
SC2. In a small self-service shop (up to 3 checkouts)	4	11	20	24	30	10	2
SC3. In a large supermarket or grocery shop	2	4	10	19	38	22	4
SC4. In a hypermarket	4	10	18	22	25	17	3
SC5. In a shopping mall	6	21	29	24	15	5	1
SC6. In a wholesale shop or in a shop where products are sold in bulk	33	28	18	13	5	3	0
SC7. In a shop of a specific brand (e.g. Biedronka, Lidl, Netto, Polomarket, Dino)	1	1	4	11	30	38	15
SC8. At a bazaar, street market, in stalls	6	18	24	23	22	6	1
SC9. In an online shop	4	7	13	24	32	18	3
SC10. In a mail order store	13	14	19	26	20	9	1

Scale: 1 – means never, 2 – very rarely, 3 – rarely, 4 – neither rarely nor often, 5 – often, 6 – very often, 7 – always).

Source: author's own study.

With the aim of identifying statistical ties between sales channels and purchasing styles, analysis was conducted with the aid of Spearman's Coefficient Correlation of ties between sales channels (SC1-SC10) and purchasing styles (CPS1-CPS7) (Table 5). It was accepted that for the level of significance $\alpha = 0.01$, the threshold value amounts to approximately $r_s \geq 0.08$, or in other words, all the correlations exceeding this value are deemed to be significant. A range of statistically significant correlations were identified, albeit the majority of them are featured by low strength. Particular attention should be paid to the style of CPS4, which indicated the most significant ties with various forms of sales (a combined total of 8), including the most powerful correlation in the entire set of SC5 ($r_s = 0.333$). This may suggest that people representing this style are more open or active in terms of purchasing in various sales channels. The style of CPS2 also significantly correlates with multiple forms of sales, particularly with SC5 ($r_s = 0.301$) and SC4 ($r_s = 0.212$), which indicates a clear preference for these channels amongst this group of purchasers. Other significant correlations, albeit weaker, occur for instance between the following: CPS6 – SC1 ($r_s = 0.231$), CPS7 – SC8 ($r_s = 0.140$), CPS1 – SC7 ($r_s = 0.174$).

Hence, shopping malls (SC5) are distinguishable the most often and are the most strongly correlated with various purchasing styles, which may be testament to their great sense of attractiveness and availability.

To conclude, despite the numerous significant dependencies, none of the correlations reach the level of moderate strength ($r_s \geq 0.40$). This signifies the fact that although the dependencies are statistically significant, their practical importance may be limited. The results suggest rather weak tendencies than strong preferences or unequivocal behaviour.

Table 5.

Spearman's Rank Correlation Coefficient between sales channels (SC) and consumer purchasing styles (CPS)

	SC1	SC2	SC3	SC4	SC5	SC6	SC7	FSC8	SC9	SC10
CPS1	0.006	0.053	0.089*	0.005	0.004	0.120*	0.174*	0.012	0.100*	0.017
CPS2	0.100*	0.038	0.185	0.212*	0.301*	0.147*	0.073	0.155*	0.098*	0.137*
CPS3	0.030	0.065	0.132*	0.095*	0.148*	0.051	0.085*	0.136*	0.026	0.032
CPS4	0.097*	0.060	0.146*	0.200*	0.333*	0.225*	0.071	0.106*	0.110*	0.183*
CPS5	0.057	0.017	0.113*	0.045	0.021	0.048	0.169*	0.010	0.060	0.005
CPS6	0.231*	0.116*	0.045	0.021	0.049	0.169*	0.010	0.061	0.005	0.101*
CPS7	0.094*	0.070	0.087*	0.113*	0.082*	0.120*	0.097*	0.140*	0.054	0.119*

Note: * $p < 0.01$.

In the research on purchasing styles, an important place is held in terms of analysis on the impact of varied factors on purchasing decisions (Table 6). Amongst the factors analysed, the greatest impact was exerted by the economic factor, namely, price (92%) and the features of the product, namely, its functionality, quality and attractive appearance (87%). A rather less important impact was exerted by social factors, or in other words, the opinions of other consumers (family members, acquaintances), the impression that a product can exert on others and possession of a particular product by people from the closest environs (35%), while also marketing factors, namely, advertising and fashion (28%).

Table 6.

Importance of factors influencing purchasing decisions (IPD) in percentage form

Type of factor	Frequency assessment						
	1	2	3	4	5	6	7
IPD1. Functionality of product	0	0	2	9	31	33	25
IPD2. High quality	0	0	2	10	31	36	21
IPD3. Reasonable price	0	0	1	6	24	35	33
IPD4. Attractive look	0	1	4	11	32	33	19
IPD5. Opinions of family members, acquaintances	5	6	13	24	29	18	6
IPD6. Conformity with fashion trends	13	11	20	22	21	9	3
IPD7. Fact of possessing a particular product by a person from your environment	17	15	20	24	15	6	2
IPD8. Impression which the product may make on others	16	15	20	21	17	8	3
IPD9 Attractive and convincing advertisement of particular product	21	16	17	22	15	6	2

Scale: 1 – definitely unimportant, 2 – unimportant, 3 – rather unimportant, 4 – I don't have an opinion, 5 – rather important, 6 – important, 7 – definitely important.

Source: author's own study.

Analysis was conducted of the dependency between purchasing styles (CPS1-CPS7) and the factors influencing purchasing decisions (IPD1-IPD9) (Table 7). Correlations were calculated with the aid of the Spearman method on a sample of 1080 respondents. It was accepted that for a level of significance of $\alpha = 0.01$, the threshold value amounts to

approximately $r_s \geq 0.08$, or in other words, all correlations exceeding this value are deemed to be significant.

Particular attention must be paid to the style of CPS1, which indicates strongly positive correlations with IPD1, IPD2, IPD3, IPD4. Simultaneously, significant negative correlations are observed with socio-image factors such as the following: fashion, impact of local surroundings and advertising. This style represents consumers who are first and foremost geared towards practical and useful features of a product and are resistant to external factors. The style of CPS2 is featured by significant positive dependencies with image factors such as IPD6, IPD8, IPD9. People representing this style are more susceptible to the impact of the environs, aesthetics and marketing message. The style of CPS3 indicates moderate, yet significant correlations with IPD1, IPD2, IPD4. This symbolizes a balanced purchasing style, without the domination of social factors. The style of CPS4 strongly correlates with IPD6, IPD7, IPD8 and IPD9. This signifies strong socio-image orientation and great susceptibility to pressure from the environs, while also trends. This is one of the most susceptible styles in marketing activity. The style of CPS5 mainly focuses on IPD1 and IPD3. The remaining factors have a negligible impact. This style may be defined as frugal-pragmatic. The style of CPS6 indicates strong correlation with certain factors, particularly IPD6–IPD9. This means a high level of susceptibility to the influence of the environs, trends and advertising. This style represents a modern conformist consumer. The style of CPS7 is featured by weaker, yet significant correlations with IPD7–IPD9, which suggests a moderate social orientation. This profile may be defined as indirectly between national and image.

Table 7.

Spearman's Rank Correlation Coefficient between factors influencing purchasing decisions (IPD) and purchasing styles (CPS)

	IPD1	IPD2	IPD3	IPD4	IPD5	IPD6	IPD7	IPD8	IPD9
CPS1	0.533*	0.471*	0.396*	0.370*	0.042	-0.144*	-0.212*	-0.145*	-0.204*
CPS2	0.118*	0.250*	0.054	0.373*	0.176*	0.376*	0.248*	0.394*	0.304*
CPS3	0.292*	0.381*	0.209*	0.327*	0.188*	0.182*	0.077	0.107*	0.079
CPS4	0.013	0.173*	-0.089*	0.178*	0.274*	0.451*	0.391*	0.447*	0.434*
CPS5	0.321*	0.215*	0.325*	0.182*	0.144*	0.009	0.023	0.008	0.012
CPS6	-0.088*	0.021	-0.107*	0.125*	0.269*	0.425*	0.405*	0.431*	0.449*
CPS7	0.055	0.008	0.080	0.151	0.160*	0.165*	0.194*	0.168*	0.178*

Note: * $p < 0.01$.

One of the significant determinants of purchasing styles are groups of social influence (Table 8). Analysis of the research findings reveals that in the opinions of the respondents, the greatest impact on purchasing decisions is exerted by people who they are close to, namely family members (59%) and friends, acquaintances (51%). This is followed by respondents imitating acquaintances when in the process of making purchases (43%). It is more seldom in the process of making purchases to be influenced by the opinions of celebrities, namely, people generally well-known, frequently shown on TV and in colourful magazines (17%), influencers, YouTubers (14%), while also opinions of people found in the financial elite (13%).

The least important for consumers are politicians (7%). Hence, the most significant groups of influence for Polish consumers are the primary groups, which they are members of.

Table 8.

Groups of social influence (GSN) providing patterns to follow in purchasing process in percentage form

Type of factor	Frequency assessment						
	1	2	3	4	5	6	7
GSN1 People generally known, frequently show on television and in colourful magazines	29	17	19	18	12	3	2
GSN2 Influencers, YouTubers online	38	16	16	16	10	3	1
GSN3 Acquaintances	9	7	16	26	32	8	3
GSN4 Friends/colleagues	7	6	13	23	36	11	4
GSN5 Family	6	4	11	21	35	17	7
GSN6 Neighbours	15	11	18	29	21	5	2
GSN7 Politicians	41	18	16	18	5	1	1
GWS8 Intellectual elite (professors, artists, writers, etc.)	30	16	16	20	11	4	2
GSN9 Financial elite	34	19	16	20	9	3	1

Scale: 1 – definitely unimportant, 2 – unimportant, 3 – rather unimportant, 4 – I don't have an opinion, 5 – rather important, 6 – important, 7 – definitely important.

In the subsequent stage of research, analysis was conducted of the dependencies between various social groups that provide patterns to imitate in the sphere of purchasing and consuming products (GSN1-GSN9) and purchasing styles (CPS1-CPS7) (Table 9). It was accepted that for the level of significance $\alpha = 0.01$, while the threshold value amounts to approximately $r_s \geq 0.08$, or in other words, all the correlations exceeding this value are deemed to be significant.

Research shows that the style of CPS1 indicates negative correlations with media and elite groups (GSN1, GSN2, GSN7, GSN8, GSN9). This signifies the fact that people who are guided by national and practical approaches to purchases are less susceptible to the influence of celebrities, politicians and intellectual or financial elites. The purchasing decisions of these groups are based on independent evaluation and rational criteria. In turn, CPS2 illustrates moderately positive correlations with the majority of groups, e.g. GSN1, GSN3 and GSN8. Consumers are moderately susceptible to the influence of varied groups, particularly media figures, acquaintances and intellectual elites. This style represents consumers who appreciate fashion, aesthetics and social trends, while their purchasing choices are partly formed by their local surroundings. In the case of the style of CPS3, correlations are generally low and ambiguous, in which the greatest positive is from GSN4 and GSN5, which signifies the moderate openness to influence, with the simultaneous maintenance of independence. The style of CPS4 indicates strong positive correlations with all the groups of social influence, particularly with GSN1, GSN8, GSN9. This style is intensively imitated by famous people, elite and authorities and is strongly social and sensitive to trends. The style of CPS5 indicates correlations without clear tendencies, e.g. slightly positive with GSN5 (0.175). This style is rather independent of the groups of influence and is focused on pragmatism (price, functionality). The style of CPS6 illustrates strongly positive correlations with all groups, particularly GSN1, GSN7, GSN9. Consumers strongly adjust to social role models, particularly authorities and elites. This style is very susceptible to social influences and trends.

The style of CPS7 indicates slightly positive correlations with all groups (0.086-0.167), which indicates a moderate, yet not dominant susceptibility to social influence.

Table 9.

Spearman's Rank Correlation Coefficient between groups of social influence providing patterns to follow in sphere of purchasing various products, ways of consumption (GSN) and purchasing styles (CPS)

	GSN1	GSN2	GSN3	GSN4	GSN5	GSN6	GSN7	GSN8	GSN9
CPS1	-0.224*	-0.255*	0.013	0.029	0.052	-0.102*	-0.264*	-0.165*	-0.227*
CPS2	0.248*	0.154*	0.187*	0.174*	0.154*	0.164*	0.172*	0.191*	0.177*
CPS3	0.018	-0.078*	0.118*	0.138*	0.122*	0.053	0.044	0.055	0.022*
CPS4	0.358*	0.301*	0.247*	0.227*	0.183*	0.288*	0.354*	0.376*	0.387*
CPS5	0.058	-0.097*	0.094*	0.112*	0.175*	0.050	-0.106*	0.023	-0.101*
CPS6	0.406*	0.321*	0.213*	0.175*	0.156*	0.303*	0.387*	0.360*	0.371*
CPS7	0.167*	0.155*	0.134*	0.125*	0.149*	0.148*	0.103*	0.100*	0.086*

Note: * $p < 0.01$.

On the basis of the analysis of differentiated degree of susceptibility to social influence, the features of a product and the forms of sale are characterized as seven purchasing styles (CPS1-CPS7) (table 10). The results indicate clear differentiation between rational, emotional, economic, and socially driven decision-making patterns. Rational-pragmatic consumers focus on functionality and resist external influences, while emotional-evaluative and socially dependent types show greater sensitivity to fashion, advertising, and opinions of others. Economic and balanced consumers emphasize price and transparency, whereas the consumption-imitative group aspires to prestige and elite lifestyles. The moderate style reflects routine, stable purchasing behavior.

Table 10.

Analysis of collective purchasing styles of Polish people

Purchasing Style	Features	Correlations	Market Segment	Marketing Strategy
CPS1. Rational-pragmatic	Low susceptibility to external influences (e.g. advertisements, celebrities), low correlation with emotional features of decisions.	Lack of significant ties with IPD5-IPD9; negative with GSN1, GSN2, GSN7 (e.g. celebrities, influencers, politicians).	Consumers who are resistant to trends and loyal towards their own standards	Communiqués based on specific detail: technical parameters, durability, profitability
CPS2. Emotional-evaluative	Average susceptibility to social environment that is strengthened by family values and emotional values.	Positive with IPD4 (appearance), IPD6-IPD9 (fashion, advertising), moderate ties with family and acquaintances (GSN3-GSN5). Significantly correlates with multiple forms of sales, particularly with SC4 and SC5.	Consumers who are susceptible to fashion and image, yet maintain a certain selectivity	Balanced communication: quality + style + social acceptance.
CPS3. Economic	High susceptibility to reasonable pricing and functionality.	High correlation with IPD3 (reasonable price), moderate with IPD1 (functionality).	Pragmatic and rational consumers, who are oriented towards economic benefit	Promotions, discounts, price comparison portals

Cont. table 10.

CPS4. Socially dependent	High susceptibility to impact of opinions of group of influence, fashion and advertising.	Greatest ties with known people, influencers, family and elite (GSN1-GSN9). Strong correlation with IPD5-IPD9 (opinions, fashion, advertising). Positive relations with all social groups in GSN. The most power correlation of SC5 (shopping mall).	Consumers who are susceptible to pressure from their environs, whereby fashion and opinions are principal determinants of decisions.	Influencer marketing, aesthetic visual communication, storytelling.
CPS5. Balanced	Moderately positive relation to quality, price and opinions of close ones.	Weak, yet positive ties with IPD1-IPD4; Lack of strong ties with social groups.	Reflective consumers, yet not necessarily loyal or active	Promotions and clear pricing information. Avoidance of unnecessary “decorations” – they prefer transparency and effectiveness.
CPS6. Consumption imitative	Purchases serve imitation of elite styles – aspirational model of consumption.	Strong positive correlations with IPD6-IPD9 (fashion, possessions, advertising), very high correlations with GSN1, GSN2, GSN7-GSN9.	Consumers who are strongly susceptible to trends, advertisements and pressure from their environs, while also identify with prestige	Social events and activity (events, cooperation with celebrities). Campaign building aspirational image of brand.
CPS7. Moderate	Lack of extreme behaviour, relatively loyal with regard to purchasing routine.	Low, yet cohesive correlations with majority of decision-making features and social influences.	Consumers who are not distinguishable by their extreme behaviour and are relatively loyal with regard to purchasing routines.	Careful campaign, loyalty.

Table 10 summarizes the key characteristics, correlations, and marketing implications of seven purchasing styles identified among Polish consumers. Overall, the findings highlight the heterogeneity of Polish consumers and suggest that marketing strategies should be tailored to match the dominant motivations and social influences of each purchasing style.

5. Discussion and summary

Purchasing styles constitute a key tool for modern-day marketing as they facilitate a profound understanding of the needs and behaviour of consumers, while also more effective targeting, personalization of the message, as well as optimization of the promotional activities. Familiarity with them is necessary in terms of building marketing strategies, especially in the context of a dynamically changing market and the growing expectations of clients.

The research findings acquired in terms of the occurrence of CPS indicate the clear domination of rational purchasing styles amongst Polish consumers. Three types were most represented as follows: rational-pragmatic style, economic style and balanced style. Consumers who indicated these styles were characterized by a high price sensitivity, low level of susceptibility to social influences, while also a strong orientation towards functionality and quality of products. This indicates conscious decision-making in terms of purchases that is based on the analysis of information available, while also comparison of offers and evaluation of usefulness. As opposed to the national approach, groups of consumers were also identified who represent socially dependent styles, as well as imitative styles. These people indicate a clear susceptibility to market trends, advertising, opinions from leaders of society, while also pressure from the local environs. In their case a key role in taking decisions is played by emotion, while also the need to belong, as well as the identification with a specific social group.

This data also indicates the differentiation of the styles of CPS in accordance with demographic features. Younger people (between 18-34 years of age) were more prone to represent socially dependent styles, whereas older people (over 50 years of age) indicated greater stability of preferences, while also a greater amount of rational styles. In turn, consumers with a higher level of education more frequently declared behaviour that is in conformance with economic and balanced styles.

The differentiation of CPS translates to preferences relating to the forms of sales. Consumers representing styles of a strong social orientation (e.g. CPS4 and CPS6) indicate greater tendencies to avail of the modern channels, such as e-commerce, mobile applications or social commerce. In turn, consumers of rational-pragmatic styles choose purchasing channels that are functional and effective, regardless of their form. Such a situation forces enterprises to develop multi-channel strategies, while integrating traditional forms of sales with digital channels (Ylilehto et al., 2021).

Analysis of the ties between purchasing styles and decision-making factors confirms the fact that rational styles are based on measureable criteria, such as price, quality and usefulness of the product. However, consumers who are guided by socially dependent and imitative styles pay greater attention to the meaning of recommendations, trends and social perception of products. An interesting case is that of the emotional-evaluative and balanced styles, which combine the rational approach with taking aesthetic and environmental aspects into account.

In turn, analysis of the influence of the opinion groups indicates that consumers representing the socially dependent and consumption-imitative styles are particularly susceptible to the influence of celebrities, financial elite, while also social authorities. As opposed to them, people guided by rational-pragmatic and economic styles indicate greater independence in terms of taking purchasing decisions.

The perception and identification of CPS may constitute a solid foundation to market segmentation, as well as creating differentiated marketing strategies adjusted to values and attitudes that are prevalent in a particular target group. Segmentation based on purchasing behaviour not only facilitates effective planning of a campaign (e.g. digital marketing, Google Ads, Meta Ads), but also the creation of precise purchasing profiles and long-term building of relations with clients. Furthermore, availing of knowledge of consumer styles favours the increase in the visibility of the electronic offer, while also conversion into channels online (Tabianan et al., 2022). With relation to this fact, CPS shall remain not only the subject of theoretical analysis, but also a practical tool that increases the effectiveness of marketing activities in a contemporary differentiated consumer environment.

The research conducted facilitates the formulation of several significant conclusions with regard to contemporary consumer behaviour in Poland, while also their significance for marketing practices. The clear domination of national purchasing styles was confirmed, which indicates the growing consumer awareness that is geared towards the analysis of the usage value of products, while also relation of price to quality, as well as avoidance of the excessive impact of the social environment.

Identification of the segmentation of CPS illustrates that consumers are not a uniform group, but indicate differentiated approaches to the purchasing process, which arises from their demographic features, attitudes and technological preferences. A particularly interesting issue is the connection of the socially dependent styles with the preferences for modern sales channel, such as e-commerce or mobile applications, which suggests that these groups are more susceptible to innovative forms of promotion, recommendations online, while also the activities of influencers.

From the perspective of marketing strategies, the results attained have significant implications. The perception of the prevalent CPS facilitates more effective creation of advertising campaigns, adjustment of the language and tone of communication, while also the personalization of the product offer. CPS may also constitute the basis for creating the so-called *buyer persona* availed of in target advertisements, while also managing relations with a client (CRM), as well as implementing the omnichannel strategy.

By way of conclusion, CPS is not only a descriptive category, but also a practical tool of analysis, segmentation and creation of marketing communication. In a time of personalization and behavioural data, its role will probably continue to rise, both in scientific research, as well as in business practices. In this way, knowledge of consumer styles not only enriches theory, but first and foremost translates to practical benefits in the areas of marketing and sales.

Future research on Consumer Purchasing Styles (CPS) could broaden the geographic scope and employ qualitative methodologies to gain deeper insights into consumer motivations. Particular emphasis should be placed on examining the impact of digitalization, e-commerce, and social media on the evolution of purchasing styles, capturing the subtle motivations and emotional drivers underlying consumer behaviour.

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MOTIVATION IN HUMAN RESOURCE MANAGEMENT ON THE EXAMPLE OF GENERATION Z

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Purpose: The theoretical aim of the paper is to present motivation and incentive as the area of human resource management, and to characterise the basic features of Generation Z, i.e. the youngest generation on the modern labour market. The practical goal is to identify and characterise the attitudes towards work and the incentives expected by Generation Z representatives, as well as to find the differences in this area between the generation individual groups, which for the purposes of this research are distinguished using the criterion of age and work experience.

Design/methodology/approach: The theoretical part uses the method of critical analysis of the literature, while the empirical part contains the results of own research using an online survey conducted among representatives of Generation Z.

Findings: Generation Z is not a homogeneous collectivity in terms of motivation for work. Depending on age and professional experience, a diversity of attitudes towards work was found among the members of Generation Z, concerning issues such as the career goal, gratification for work, work-life balance, teamwork, changing jobs, training and development. As regards the expected incentives, different assessments of the importance of their individual types were also found, including incentive, persuasion and coercion measures.

Research limitations/implications: The research results provide a valuable source of information on motivation in human resource management on the example of Generation Z, which proves to be very diverse. They also fill the research gap in this area. The limitations of the study are due to the use of the online survey method. The aim of the acquired knowledge, both methodological and empirical, is to improve the methodology of nationwide representative surveys planned in the future.

Practical implications: The research results provide the managerial staff with knowledge that forms the basis for creating strategies and incentive systems in the area of human resource management in generationally diversified organisations, including those employing representatives of Generation Z.

Social implications: Perceiving the status of an individual in terms of belonging to a specific generation as the main determinant of his/her characteristics, including the attitude to work, would be an example of erroneous stereotyping. Individual generations are not uniform. A single group can demonstrate a huge variety of views, attitudes and behaviours.

Originality/value: The research provides a new perspective on the management of motivation of the representatives of Generation Z, which turns out to be very diverse in terms of attitudes towards work and expected incentives. The paper originality results from the empirical research presenting motivation as an element of human resource management in the context of the Generation Z diversity.

Keywords: human resource management, motivation, incentives, motivation management, Generation Z.

Category of the paper: Research paper.

1. Introduction

Social and economic changes taking place in the modern world force organisations to modify their approaches to human resource management. Employers are looking for new solutions in the above area, which includes the element of motivating employees. This is becoming more and more difficult, as work-related priorities and expectations change dynamically and in many directions. They are diversified in the cross-section of a large number of factors differentiating labour resources, among which the differences between generations play a huge role. In this context, an important theoretical and practical problem is the issue of effective motivation of employees coming from different generations.

There are currently four main generations of employees on the labour market: BB, X, Y and Z. The relatively poorest description can be found of the representatives of the youngest and the least recognized Z Generation, which includes people born after 1995 (Barhate, Dirani, 2022; Barszcz, 2020; Lutyńska, Wasiluk, 2023; Seemiller, Grace, 2016; Seemiller, Grace, 2018; Szukalski, 2012; Wątroba, 2017). It should be emphasised that, in the context of management, the occurrence of these generations is not a problem because on the labour market there have always been employees of different ages. It is important, however, to differentiate the characteristics of individual groups in terms of, for example, presented attitudes towards and expectations of work, as well as their impact on human resource management. Therefore, in recent years, more and more attention has been devoted to the issues of generational diversity management in organisations (Dziopak-Strach, 2018; Godlewska-Majkowska, Lipiec, 2018; Hysa, 2016; Jagoda, 2016; Kordbacheh, Shultz, Olson, 2014; Lapoint, Liprie-Spence, 2017; Lewicka, 2017; Lipka, Król, 2017; Sidor-Rządkowska, 2018; Waligóra, 2018; Warwas, Wiktorowicz, Jawor-Joniewicz, 2018; Wiktorowicz et al., 2016). Particular importance should be given to the youngest and – as already mentioned – the least recognized Z Generation, which is just entering the labour market, but which – according to some forecasts – by 2028 will account for 58% of the global labour force (Borowska, Pietroń-Pyszczyk, 2025; Makolus, 2022).

The issue of motivation in the management literature has been taken up in a great number of studies which present the results of systemic analyses concerning the concept of motivation and incentive (Armstrong, 2010; Dhaliwal, 2016; Juchnowicz, 2012; Kamińska, Warzyński, 2011; Kozłowski, 2009, 2017; Król, Ludwiczynski, 2006; Krzakiewicz, 2006; Kumar et al., 2025; Lenik, 2012; Lipka, 2021; Masłyk-Musiał, 2011; Myjak, 2018; Penc, 2000; Pocztowski, 2008; Przybyła, 2003; Woźniak, 2012). Generational diversity and its impact on the selection of appropriate strategies, incentive systems and means, despite being the subject of a growing interest, have not so far been treated in a sufficiently detailed scope and in many cases they mainly take account of the older BB, X and Y generations (Bugaj, Budzanowska-Drzewiecka, Jędrzejczyk, 2022; Jankowiak, Czerwińska-Lubszczyk, 2024; Kobyłka, 2016; Lipka, 2019; Lutyńska, Wasiluk, 2023; Mazur-Wierzbicka, 2015; Murzyn, Nogiec, 2015; Nieżurawska-Zajac, 2020; Opalińska, 2018; Smolbik-Jęczmień, 2013). Works on Generation Z, and, in particular, comprehensive studies including empirical research results, are still rather scarce. Most of them are just a reason for further in-depth research.

Moreover, the results of the research have so far been quite divergent. Some authors emphasise that Generation Z representatives demonstrate a low level of internal motivation, which manifests itself in poor engagement in work (Dziopak-Strach, 2018). Additionally, it is pointed out that this issue is correlated with the years of work experience. Motivation and commitment increase in subsequent age groups with the length of service (Kordbacheh, Shultz, Olson, 2014; Lewicka, 2017). On the other hand, a survey conducted by Juchnowicz (2014) indicated that employees showed the greatest engagement in the first year of employment. Such results can be explained by the fact that respondents with the shortest period of service are in a phase of fascination with their first job. They show a high level of energy and a desire to present themselves to the employer in a good light, feeling no potential frustration caused by previous work experiences. At the same time, the prevailing view is that for all workers, regardless of age, the strongest factor affecting motivation and commitment at work is remuneration, together with financial rewards, followed among others by job security and stability, as well as work atmosphere (Dziopak-Strach, 2018; Jawor-Joniewicz, 2016; Sajkiewicz, 2016). Research results can also be found that indicate that for the youngest generation the most important are the job flexibility, in terms of the place, hours and form of work, and work-life balance, with the financial aspects just behind the above-mentioned factors (Gajda, 2017; Lutyńska, Wasiluk, 2023).

The importance of this research area results, among others, from the fact that – as it can be assumed – Generation Z, apart from being different from its predecessors, is also internally diverse, which affects the management of this youngest group of employees (Aggarwal et al., 2020; Barhate, Dirani, 2022; Borowska, Pietroń-Pyszczyk, 2025; Dobrowolski, Drozdowski, Pandit, 2022; Dwivedula, 2025; Fodor, Jaeckel, 2018; Gabrielova Buchko, 2021; Gajda, 2017; Lipiński, Koczy, 2023; Lutyńska, Wasiluk, 2023; Ławińska, Korombel, 2023; Mahmoud et al., 2021; Messyasz, 2021; Muster, 2020; Różańska-Bińczyk, 2022; Pietroń-Pyszczyk, Borowska, 2022; Tomaszuk, Wasiluk, 2023; Żarczyńska-Dobiesz, Chomętowska, 2014).

2. Motivation and incentive in human resource management in theoretical terms

The issue of motivation has for many years been the subject of interest from both the theory and practice of management, especially the management of human resources in organisations. The knowledge of the mechanisms of human motivation to work and the ability to use them is one of the factors of effective human resource management and organisational success on a competitive market. The issue of motivation is also relevant due to the continuous social and economic changes and generational differences between successive generations of employees.

The concept of “motivation” is understood differently and its universal definition has not been found yet. It is probably due to the fact that there are so many determinants that influence people and their active and conscious shaping of the life and work environment (Kozłowski, 2009, 2017; Krzakiewicz, 2006). Within the scope of the motivation-related issues in human resource management, there are internal and external determinants of people’s behaviours in the work process. From this point of view, two approaches to motivation are of fundamental importance: attributive and functional (Juchnowicz, 2012; Nieżurawska-Zajac, 2020; Pocztowski, 2008). In the attributive approach, motivation is defined as “the internal force and state regulating people's behaviours in the work environment, i.e. the state activating, directing and sustaining their behaviours aimed at achieving professional goals (internal motivation)” (Pocztowski, 2008, p. 203). Motivation in this case means an internal process regulating people’s behaviours in the work process, i.e. influencing decisions about taking up a job, engaging in doing it and giving a job up. In the functional approach, motivation is treated as “a configuration of external factors influencing people’s behaviours and determining their strength and durability (external motivation)” (Pocztowski, 2008, p. 203). In functional terms, motivation means incentive, i.e. conscious and purposeful influence on people’s behaviours in the work process, using knowledge about the factors that determine them. In this approach, motivation is one of the classic management functions, including planning, organising, motivating and controlling.

In the theory and practice of management, shaping people's motivation in an organisation is considered as one of the very important management methods, referred to as motivation management, requiring the formulation of an appropriate incentive strategy. There are interesting studies and considerations in this field, but also considerable areas of ignorance. The question is still open what really motivates people to act, how their motivation to work is influenced by such factors as: inspiring, stimulating, inducing and even forcing, and in what conditions they want to work efficiently, assuming that both people and conditions change (Juchnowicz, 2012).

The incentive strategy consists in setting long-term goals in the sphere of motivating employees, defining the directions of action, the corresponding tools, and allocating the means necessary to achieve the goals. This extends the time horizon of decisions and makes them more rational. The main argument for the need to have an incentive strategy is the fact that incentive solutions should support the global strategy of the organisation and the strategy of human resource management (Juchnowicz, 2010).

The task of the organisation managers is to connect the motivation of employees with the needs of the organisation. This may sometimes require, in addition to trying to strengthen the employees' motivation, a modification of the organisation goals and working methods. Motivation management is the process of identifying the needs of employees and taking them into account so that high-level results should be achieved. In the work environment this means taking into account the needs that people bring with them to the workplace. In the context of managing an organisation, it is extremely important to develop a proper motivation process and an incentive system.

The impact that people's needs have on their actions is used in the motivation process. Motivating is identifying the needs of subordinates and activating these needs consciously to stimulate subordinates to an action that is in line with the manager's will, but also leads to their needs being satisfied. The essence of the motivation process is therefore to put subordinates in a situation in which they can satisfy their needs, provided that the tasks set before them are carried out efficiently (Przybyła, 2003).

The development of a motivation strategy consists in shaping the motivation process and an appropriate incentive system. The motivation process is a broader concept than the incentive system, the latter being a part of the former. The incentive system is a system of logically coherent and mutually supportive means (tools) of motivation (Juchnowicz, 2010). Every manager has many opportunities to stimulate and consolidate motivation. He/she can operate using various means, and so motivate by creating higher wages, but also by getting the employees' interested in the work itself, by creating prospects for promotion, better social benefits, better working conditions, greater opportunities for participation in management, greater freedom of action by expanding the possibilities of choice, etc.

3. Characteristics of Generation Z

The term "generation" has been present in scientific discourse for many years and is characterized by ambiguity (McQueen, 2016). Today, a generation is defined as "a collectivity of individuals born and living in the same era. Belonging to a generation is determined not only by the year of birth, but also by shared experiences shaped by a particular society" (Giddens, Sutton, 2012, p. 1084). McCrindle and Wolfinger (2010, p. 19) regarded a generation as "a group of people born in the same era, shaped by the same times and influenced by

the same social markers – in other words, a cohort united by age and life stage, conditions and technology, events and experiences”. Generational belonging is a subject of interest and analysis in many scientific disciplines, including management, especially in the context of human resource management.

Modern generations are changing much faster than before. In the past, a generational change occurred every 25-30 years, and now new generations may appear even every decade. In the literature, the researchers studying this problem argue about the exact time frame to which a given generation belongs. It is assumed herein that currently on the labour market in Poland there are representatives of four basic generations (Barszcz, 2020; Lutyńska, Wasiluk, 2023; Sidor-Rządkowska, 2018; Wątroba, 2017; Żarczyńska-Dobiesz, Chomątowska, 2014):

1. Baby Boomers (BB) – born between 1946 and 1964.
2. Generation X (Post-Boomers) – born between 1965 and 1979.
3. Generation Y (Millennials, the Internet Generation, the Google Generation, the SMS Generation) – born between 1980 and 1994.
4. Generation Z (Generation C – from the words connected, communicating, content-centric, computerized, community-oriented, always clicking, the members of which are also referred to as Z’s, iGeneration, Gen Tech, Gen Wii, Net Gen, digital natives, Gen Next, Post Gen) – born in 1995 and later.

The oldest generation of the so-called “Traditionalists” (the Silent Generation) should also be mentioned. These are the people born in 1945 and earlier, who, although possibly still active on the labour market, already play a marginal role there, most often acting as mentors. In addition, there is the term “Millennials”, which is not clear. According to some authors, Millennials are the people born between 1980 and 1995, and in this case they would have to be classed as Generation Y. Others claim that this period should be extended to even the late-90’s, which means that Millennials would also include the oldest representatives of Generation Z (Barszcz, 2020; Żarczyńska-Dobiesz, Chomątowska, 2014). The term Generation “Alpha” has also appeared lately to refer to the youngest people born in 2010 and later (*Understanding Generation Alpha*).

The youngest generation entering, and to a large extent already functioning on the labour market, is Generation Z. According to the typology of generations presented earlier, these are people who are currently under 30. Assuming the existence of a separate generation: “Alpha”, the lower age limit of the representatives of Generation Z is now 15. This means a very large variety of Z’s in the age span of 15 to 30, who are people learning at different levels of education, as well as graduates of different types of schools, already having several years of work experience.

Trying to characterise Generation Z, it is noted that they have many features in common with the representatives of the earlier Generation Y. This applies to the oldest Z’s in particular. On the other hand, there is a consensus that apart from being only more advanced than their predecessors in the use of new technologies, they differ from them significantly in many respects (Żarczyńska-Dobiesz, Chomątowska, 2014).

The representatives of Generation Z grew up surrounded by devices created by new technologies (the computer, the Internet, mobile phones, mobile devices). They use them with great ease, treating their omnipresence as something normal. Using more and more technologically advanced solutions and applications, they have access to all kinds of data and information contained therein, and they can communicate with other people from any place and at any time. They are a global generation and therefore establish international and intercultural contacts easily, thus having a great opportunity to learn foreign languages quickly. Moreover, they can function in parallel in the real and virtual world and make a smooth transition from one to the other because in their opinion the two worlds complement each other.

On the other hand, it is often stressed that members of this cohort focus on new technologies excessively in their life, suffer from increasing addiction to technology and have problems with distinguishing the virtual world from the real one. Living constantly online, Generation Z members limit their verbal communication skills and lose the ability to make contacts in the real world. Among the weaknesses of Z's, problems are also mentioned such as poor concentration, distraction, lack of patience, superficiality in assessing information and making analyses, a materialistic and consumerist approach to life, together with great uncertainty about the future (Barszcz, 2020; Lutyńska, Wasiluk, 2023; Żarczyńska-Dobiesz, Chomątowska, 2014).

4. Results of empirical research

The aim of the quantitative primary research was to identify and characterise attitudes towards work and the means of motivation expected by Generation Z representatives. The research also aimed to identify the differences in this respect between individual groups of this cohort, which were distinguished according to the criterion of age and work experience. The research used an online survey method consisting of closed questions and a metric. The survey was carried out from March to May 2025 with the participation of 440 students and graduates of the University of the Commission for National Education in Krakow, representing Generation Z. The respondents were divided into three groups:

- Group Z1 – people aged 18-24 with no work experience, i.e. they had never worked before under any form of employment (this group accounted for 25.5% of the respondents).
- Group Z2 – people aged 18-24 with work experience, i.e. either they were working at the time or had worked before using any form of employment (39.3% of the respondents).
- Group Z3 – like Group Z2 but older – at the age of 25-30 (35.2% of the respondents).

Women accounted for 65.7% of all the respondents, while men accounted for 34.3%. Nearly half of the respondents described their financial situation as average (46.8%). 11.1% of them described their material situation as very good, 20.5% as good, 13.0% as bad, and 8.6% as very bad. Almost every fifth respondent came from a city with more than 500 thousand inhabitants (19.8%), or from a village (19.5%). The rest came from towns and cities of less than 10 thousand inhabitants (13.9%), 11-50 thousand inhabitants (15.0%), 51-100 thousand inhabitants (16.4%) and 101-500 thousand inhabitants (15.5%).

The subject scope of the research covered attitudes towards work and the means of motivation expected by the representatives of Generation Z.

The following research hypotheses were adopted:

1. There are differences in attitudes towards work depending on the age and professional experience of the members of Generation Z, including attitudes towards issues such as the career goal, gratification/pay for work, work-life balance, teamwork, change of jobs, training and development.
2. The most important in motivating the representatives of Generation Z to work are incentives (including mainly those of a material nature), then persuasion means (related to the formation of relationships, development and achievements), whereas coercive measures (orders, prohibitions, control, penalties) are by far the least important.
3. There are differences in the assessment of motivation means depending on the age and work experience of Generation Z representatives. The older they are and the more experience they have, the more important incentives and persuasion means are for them, while coercive means definitely lose their significance.

The research hypotheses were verified during empirical research, the results of which are presented below.

4.1. Attitudes towards work

“Attitude” is a fundamental concept in social sciences, which results, among others, from the importance it is given in the context of the impact on human behaviour. An attitude is crucial both for the action taken in various areas of one’s own activities, as well as for the activity of others. Attitudes can be used to predict human behaviour (Juchnowicz, 2014; Juchnowicz, Mazurek-Kucharska, Turek, 2018).

A particular type of attitudes that are important from the point of view of creating desired organisational behaviours are the attitudes towards work, i.e. “the tendency of a human to react in a certain way to the tasks and effects of his/her own work” (Juchnowicz, 2014, p. 103). The general attitude towards work consists of many partial attitudes towards different work-related elements (Juchnowicz, Mazurek-Kucharska, Turek, 2018). The elements adopted in this primary research are as follows: the career goal, gratification/pay, work-life balance, teamwork, changing jobs, and training and development (Table 1).

Table 1.*Attitudes of respondents towards work*

Item	Total	Groups of respondents			Change in importance with age and gained work experience
		18-24 years of age, no work experience (Z1)	18-24 years of age, with work experience (Z2)	25-30 years of age, with work experience (Z3)	
Career goal					
Waiting patiently for a raise or promotion in one workplace	43.9 %	31.3 %	38.2 %	59.4 %	↑
Expecting a fast career, parallel careers, an unlimited career	49.3 %	60.7 %	54.9 %	34.8 %	↓
Hard to say	6.8 %	8.0 %	6.9 %	5.8 %	-
Gratification for work					
Sense of pleasure and satisfaction derived from work, the importance of material factors is less important	17.7 %	21.4 %	17.3 %	15.5 %	↓
Quick pay, well-paid job as the most important factor	75.7 %	68.8 %	76.9 %	79.4 %	↑
Hard to say	6.6 %	9.8 %	5.8 %	5.2 %	-
Work-life balance					
Prioritizing work over personal life according to the “I live to work” principle	13.6 %	8.0 %	12.1 %	19.4 %	↑
A great need for flexibility and good work-life balance according to the “I work to live” principle	83.6 %	88.4 %	85.0 %	78.7 %	↓
Hard to say	2.7 %	3.6 %	2.9 %	1.9 %	-
Teamwork					
Great importance of teamwork, readiness to submit to the group with a view to achieving collectivity objectives	39.1 %	34.8 %	39.3 %	41.9 %	↑
Putting individualistic attitudes first, prioritising own needs over collectivity objectives	58.6 %	62.5 %	59.0 %	55.5 %	↓
Hard to say	2.3 %	2.7 %	1.7 %	2.6 %	-
Changing jobs					
Ultimate necessity, fear of losing the achieved position	24.3 %	17.0 %	23.7 %	30.3 %	↑
A normal and common phenomenon, the importance of a high openness to change, professional mobility and ease of adaptation	71.6 %	75.9 %	72.3 %	67.7 %	↓
Hard to say	4.1 %	7.1 %	4.0 %	1.9 %	-
Training & Development					
Training considered as an opportunity to connect with the current workplace (“anchor” of employment)	28.0 %	19.6 %	26.0 %	36.1 %	↑
Readiness for continuous education as a way of career development at various places.	70.5 %	76.8 %	72.3 %	63.9 %	↓
Hard to say	1.6 %	3.6 %	1.7 %	0.0 %	-

Source: own studies.

The surveyed representatives of Generation Z demonstrate quite a lot of impatience when it comes to achieving career goals. Nearly half of them expect a “fast career” (49.3%), slightly less declare “patient waiting for a raise or promotion in one workplace” (43.9%). Although the respondents are before or at the beginning of their professional career, their opinions in this area are clearly defined, only 6.8% do not have a firm opinion and answered “Hard to say”.

The members of Group Z1 (aged 18-24 and never employed) are the most impatient. As many as 60.7% of them expect a “fast career”, and only a third (31.3%) are ready to wait patiently for it to happen. It turns out that people who have already entered the labour market and have some work experience are much more cautious in such declarations. In Group Z2 (people aged 18-24 and with work experience), slightly more than a half (54.9%) expect a “fast career”, and in the oldest group (aged 25-30 with work experience) only a third of the respondents (34.8%) chose this answer. At the same time, the percentage of those waiting patiently for their career to develop increases to 38.2% (Z2) and 59.4% (Z3). The above data indicate that with age and gained work experience, the expectation of a “fast career” among the representatives of Generation Z decreases clearly.

When it comes to the attitudes of respondents towards gratification/pay, as many as 3/4 of them expect “quick pay” and treat “a well-paid job” as “the most important factor” (75.7%). Only 17.7% of the respondents rank high “the sense of pleasure and satisfaction from work”, adding that the importance of material factors is less important, while 6.6% have no opinion on this issue.

“The sense of pleasure and satisfaction from work” with the lesser importance of material factors was most often indicated by the representatives of Group Z1 (aged 18-24 and never employed) (21.4%). This was declared less frequently by members of Group Z2 (aged 18-24 and employed) (17.3%) and Group Z3 (aged 25-30 and employed) (15.5%). At the same time, the percentage of people declaring the expectation of “quick pay” and indicating “a well-paid job as the most important factor” increased in the surveyed groups – 68.8% (Z1), 76.9% (Z2) and 79.4% (Z3). The obtained results clearly show that the attitudes towards and expectations of gratification/pay of the respondents representing Generation Z materialise with age, their entry into the labour market and gained work experience,

The research results also indicate that the surveyed representatives of Generation Z are strong supporters of the work-life balance concept. As many as 83.6% of the respondents declare “a great need for flexibility and work-life balance” according to the “I work to live” principle. On the other hand, only 13.6% declare “prioritising work over personal life” according to the “I live to work” principle, while 2.7% did not have an opinion on this issue.

The highest percentage of people advocating flexibility and work-life balance was found among the people aged 18-24 and never employed, i.e. in Group Z1 (88.4%). It turns out that entering the labour market and first work experience reduce the importance of this attitude. Among those aged 18-24 and already having some work experience (Group Z2), the percentage

of people definitely supporting the work-life balance concept was 85.0%, while among the older representatives of Generation Z, i.e. people aged 25-30 and employed, it was 78.7% (Z3). At the same time, with age and increasing professional activity the percentage of people declaring “prioritising work over personal life” according to the “I live to work” principle gets higher, totalling 8.0% (Z1), 12.1% (Z2) and 19.4% (Z3). In Z3 the group of such people was almost 2.5 times bigger than in Z1. This proves that professional activity and the challenges related thereto, such as the need to care for the job to keep it, the desire for promotion and higher pay, which is of great importance at the beginning of the professional career, result in the readiness to devote oneself more to work, even at the expense of personal life.

Another issue under analysis was the attitude towards teamwork. The research results indicate that among the representatives of Generation Z there is clear domination of the individualistic approach. 58.6% of the respondents declared “an individualistic attitude” and “prioritising own needs over collectivity objectives”. The importance of “team work”, the “readiness to submit to the group with a view to achieving collectivity objectives” were indicated by 39.1% of those surveyed. Only 2.3% of the respondents did not have an opinion on this issue.

Individualistic attitudes are the most pronounced in Group Z1 (aged 18-24 and never employed) (62.5%). They are slightly less visible in Group Z2 (aged 18-24 and employed) (59.0%) and Group Z3 (aged 25-30 and employed) (55.5%). With age and gained work experience the importance of teamwork is indicated more and more often. Great importance of teamwork and the “readiness to submit to the group with a view to achieving collectivity objectives” was indicated by 34.82% of the people in Group Z1, as well as by 39.3% and 41.9% of the people in Group Z2 and Group Z3, respectively.

There is noticeable readiness to change jobs among the representatives of Generation Z if necessary. Nearly 3/4 of the respondents (71.6%) declared that “changing jobs is a normal and common phenomenon”, emphasising the “importance of a high openness to change, professional mobility and ease of adaptation”. Only one in four respondents said that “changing jobs is the ultimate necessity” accompanied by the “fear of losing the achieved position” (24.3%), while 4.1% had no opinion on this issue.

The highest number of those treating change as a “normal and common phenomenon” was among the people aged 18-24 and never employed (Group Z1) (75.9%). In Group Z2 (aged 18-24 and employed), the percentage was already smaller (72.3%), while the lowest was among the older and working representatives of Generation Z, i.e. people aged 25-30 and employed (Z3) (67.7%). At the same time, the perception of changing jobs as the “ultimate necessity” accompanied by the “fear of losing the achieved position” was the least common in Group Z1 (17.0%), while it was more frequent in Group Z2 (23.7%) and Group Z3 (30.3%). In the case of the older members of Generation Z (Group Z3), i.e. the people aged 25-30 and employed), such opinions were almost twice as common as in Group Z1 (aged 18-24 and never employed). Functioning on the labour market and achieving a certain professional position, although not at

all the highest in the case of even older members of Generation Z, weakens the readiness to change jobs and treat this as a “normal and common phenomenon”. Instead, a fear of the change and loss of the achieved position appears.

The last analysed issue concerning attitudes towards work was the importance of training in the context of professional development. A vast majority of the respondents pointed to the “readiness for continuous education as a way of career development at various places” (70.5%), while those who treated training as “an opportunity to connect with the current workplace”, thus perceiving it as a certain “anchor” (guarantee) of employment at their current workplace belonged to a minority (28.0%). Only 1.6% of those surveyed had no opinion on this issue.

The most active approach to training as a “way of career development at various places” was demonstrated by the members of Group Z1 (aged 18-24 and never employed) (76.8%). In Group Z2 (aged 18-24 and employed) and in Group Z3 (aged 25-30 and employed), the percentage was 72.3% and 63.9%, respectively. The passive approach, meaning that training is treated as “an opportunity to connect with the current workplace”, i.e. in terms of a guarantee of current employment, was most often demonstrated by the members of Group Z3 (36.1%), followed by Group Z2 (26.0%) and Group Z1 (19.6%). This attitude was indicated almost twice more often by the older representatives of Generation Z, who already had some work experience. The above indicates that with age and the achievement of a certain professional position, the tendency to engage in training as a means of acquiring new knowledge, skills and competences useful in potential new workplaces decreases.

All in all, the above data show that with age and gained work experience, the expectation of a “fast career” among the representatives of Generation Z decreases clearly. They become more patient in achieving their career goals. In addition, their attitudes and expectations towards gratification for work become more materialistic. Work activity and the challenges related to satisfying job requirements result in increased readiness for greater devotion to work, even at the expense of personal life. There is a growing awareness of the role and importance of team work. On the other hand, the willingness to change jobs and undertake training useful in possible new jobs decreases.

4.2. Means of motivation

The means used in the incentive system (also referred to as stimuli, motivators, instruments and forms of motivation) can be classified according to a number of criteria (Przybyła, 2003). According to the criterion of financial (material) measurability, material and non-material means are distinguished. Using the criterion of formal validity (recognising the means as binding and/or acceptable), formal and informal means can be considered. The criterion of the direction and manner of their impact on employees makes it possible to distinguish positive and negative means (rewards and penalties). In another approach, the means of motivation can be divided into three basic groups: incentive, persuasion, and coercion means (Juchnowicz,

2012; Penc, 2000). The incentive means are any promises made to a member of an organisation (employee) that if the organisation recommendation is followed, there will be consequences whose positive value (useful result) exceeds the cost of performance of/compliance with the recommendation. The persuasion means are motivation means referring to internal motivation, resulting from mutual relations between the motivating representative of the organisation and the motivated employee. The coercive means, on the other hand, include all dictates and prohibitions, orders and recommendations, as well as advice of the superior that force a certain behaviour and action within the organisation.

The research used the approach of the Kontekst HR International Group consultants, who proposed the so-called motivational mix consisting of five main interrelated areas of motivation instruments. These include “material values” (incentive means), “relationships”, “achievements”, “development” (persuasion means), and “pressure” (coercion means) (*Mix motywacyjny*). Twenty-three detailed means were analysed in each of the five areas of motivation. Generation Z representatives were asked to determine the weight of each of them on a scale from 1 to 3, where 1 meant that the means of motivation was not important for them, 2 meant that it was of average importance, and 3 meant that the motivation means was important.

In the total number of Generation Z respondents, in the five main areas of motivation means, the highest average ratings were given to “material values” (2.78), “relationships” (2.76) and “development” (2.73). “Achievements” ranked slightly lower (2.59), while “pressure” was assessed the lowest (1.67%) (Table 2). In other words, the research results show that the most important instruments for motivating Generation Z representatives are incentive means (“material values”), then the means of persuasion (“relationships”, “development”, “achievements”), and the means of coercion (“pressure”) are considered as the least important.

Table 2.

The importance of the main groups of motivation means (on a scale from 1 /not important/ to 3 /important/) and the change in the respondents' opinion

Item	Total		Groups of respondents						Change in importance with age and gained work experience
			18-24 years of age, no work experience (Z1)		18-24 years of age, with work experience (Z2)		25-30 years of age, with work experience (Z3)		
	Assessment	Place	Assessment	Place	Assessment	Place	Assessment	Place	
Material values	2.78	1	2.74	2	2.75	2-3	2.78	2	↑
Relationships	2.76	2	2.71	3	2.77	1	2.79	1	↑
Achievements	2.59	4	2.57	4	2.61	4	2.58	4	-
Development	2.73	3	2.79	1	2.75	2-3	2.65	3	↓
Pressure	1.67	5	1.56	5	1.70	5	1.72	5	↑

Source: own studies.

The hierarchy of the importance of the three most important areas was different in the three surveyed groups of respondents. Among the younger respondents aged 18-24 and never employed (Group Z1), “development” (2.79) ranked first, followed by “material values” (2.74) and “relationships” (2.71). The respondents aged 18-24 and employed (Group Z2) indicated “relationships” as the most important (2.77), followed by equally ranked “material values” (2.75) and “development” (2.75). A similar order of importance was observed among the older respondents aged 25-30 and employed (Group Z3), i.e. “relationships” (2.79), “material values” (2.78), “development” (2.65). Only the last two areas, “achievements” and “pressure” ranked the lowest in each group in the fourth and fifth place.

In addition to the above-mentioned hierarchy of the importance of the five main areas of motivation means, it is also worth noting that with age and gained work experience, the respondents rated higher “material values” (Z1: 2.74; Z2: 2.75; Z3: 2.78), “relationships” (Z1: 2.71; Z2: 2.77; Z3: 2.79) and “pressure” (Z1: 1.56; Z2: 1.70; Z3: 1.72), but the importance of “development” decreased (Z1: 2.79; Z2: 2.75; Z3: 2.65). In the case of “achievements”, no such clear-cut dependencies were found.

The overall assessments of the five main areas of motivation means presented above are based on a thorough analysis of the detailed means corresponding to them (Table 3). Of the twenty-three motivation means under analysis, the respondents ranked first in terms of importance: “pay” (incentive in the area of “material values” – ranked 2.94), “work atmosphere” (2.90) and “team relationships” (2.89) (means of persuasion in the area of “relationships”), “contact with modern technologies” (2.87, means of persuasion in the area of “development”), “relationships with the superior” (2.86, means of persuasion in the area of “relationships”). At the very end were two coercive means in the area of “pressure”, i.e. “the scope and intensity of control” (1.71) and “penalty hazard” (1.63).

Table 3.

The importance of individual motivation means in the respondents' opinion (on a scale from 1 /not important/ to 3 /important/)

Item	Importance				Assessment	Place
	Important (3)	Average importance (2)	Not important (1)	Hard to say		
Total						
Material values						
Pay	95.0 %	4.1 %	0.9 %	0.0 %	2.94	1
Safe working conditions	88.0 %	5.7 %	3.4 %	3.0 %	2.79	8-9
Job security	67.5 %	22.7 %	5.2 %	4.5 %	2.53	19
Material rewards	88.6 %	5.0 %	3.9 %	2.5 %	2.80	7
Bonuses and additional benefits	91.1 %	4.5 %	2.5 %	1.8 %	2.85	6
Relationships						
Organisational culture	74.1 %	15.9 %	6.8 %	3.2 %	2.61	14-15
Work atmosphere	93.2 %	4.3 %	1.4 %	1.1 %	2.90	2

Cont. Table 3.

Relationships in the team	92.5 %	5.0 %	1.4 %	1.1 %	2.89	3
Relationships with the superior	91.6 %	4.3 %	2.7 %	1.4 %	2.86	5
Organisational credibility	70.9 %	16.8 %	8.0 %	4.3 %	2.54	18
Achievements						
Status of the position held	69.1 %	17.7 %	8.9 %	4.3 %	2.52	20
Opportunity to succeed	71.6 %	19.1 %	6.6 %	2.7 %	2.60	16
Recognition, appreciation	76.6 %	17.5 %	3.4 %	2.5 %	2.68	12
Delegation of responsibility (powers)	71.1 %	17.0 %	7.0 %	4.8 %	2.55	17
Promotions	74.1 %	14.8 %	8.9 %	2.3 %	2.61	14-15
Development						
Work in a creative team	78.9 %	9.8 %	9.1 %	2.3 %	2.65	13
Opportunity to gain new experience	86.6 %	6.1 %	6.4 %	0.9 %	2.78	10
Training	85.0 %	7.0 %	6.1 %	1.8 %	2.75	11
Coaching	73.0 %	9.1 %	13.2 %	4.8 %	2.50	21
Contact with modern technologies	93.0 %	3.9 %	0.5 %	2.7 %	2.87	4
Expanding knowledge	86.4 %	7.3 %	5.2 %	1.1 %	2.79	8-9
Pressure						
Penalty hazard	20.9 %	35.2 %	29.8 %	14.1 %	1.63	23
Scope and intensity of control	24.3 %	37.3 %	23.9 %	14.5 %	1.71	22
Respondents aged 18-24 with no work experience (Z1)						
Material values						
Pay	92.0 %	6.3 %	1.8 %	0.0 %	2.90	2
Safe working conditions	84.8 %	6.3 %	5.4 %	3.6 %	2.72	12
Job security	54.5 %	30.4 %	9.8 %	5.4 %	2.34	21
Material rewards	90.2 %	6.3 %	3.6 %	0.0 %	2.87	6-7
Bonuses and additional benefits	91.1 %	7.1 %	1.8 %	0.0 %	2.89	3-4
Relationships						
Organisational culture	70.5 %	17.0 %	7.1 %	5.4 %	2.53	18
Work atmosphere	93.8 %	6.3 %	0.0 %	0.0 %	2.94	1
Relationships in the team	91.1 %	7.1 %	1.8 %	0.0 %	2.89	3-4
Relationships with the superior	88.4 %	5.4 %	3.6 %	2.7 %	2.79	10
Organisational credibility	64.3 %	18.8 %	9.8 %	7.1 %	2.40	20
Achievements						
Status of the position held	67.9 %	15.2 %	11.6 %	5.4 %	2.46	19
Opportunity to succeed	72.3 %	16.1 %	8.0 %	3.6 %	2.57	16
Recognition, appreciation	76.8 %	17.0 %	3.6 %	2.7 %	2.68	13
Delegation of responsibility (powers)	72.3 %	16.1 %	4.5 %	7.1 %	2.54	17
Promotions	74.1 %	14.3 %	9.8 %	1.8 %	2.61	14
Development						
Work in a creative team	85.7 %	7.1 %	4.5 %	2.7 %	2.76	11
Opportunity to gain new experience	91.1 %	6.3 %	2.7 %	0.0 %	2.88	5
Training	88.4 %	5.4 %	4.5 %	1.8 %	2.80	9
Coaching	77.7 %	8.9 %	7.1 %	6.3 %	2.58	15
Contact with modern technologies	90.2 %	7.1 %	0.0 %	2.7 %	2.85	8
Expanding knowledge	90.2 %	6.3 %	3.6 %	0.0 %	2.87	6-7
Pressure						
Penalty hazard	21.4 %	25.0 %	32.1 %	21.4 %	1.46	23
Scope and intensity of control	27.7 %	26.8 %	28.6 %	17.0 %	1.65	22
Respondents aged 18-24 with work experience (Z2)						
Material values						
Pay	94.2 %	4.6 %	1.2 %	0.0 %	2.93	1
Safe working conditions	87.3 %	6.4 %	2.9 %	3.5 %	2.77	10-11
Job security	64.2 %	27.2 %	4.0 %	4.6 %	2.51	20-21
Material rewards	88.4 %	4.0 %	3.5 %	4.0 %	2.77	10-11
Bonuses and additional benefits	84.4 %	11.0 %	2.9 %	1.7 %	2.78	9

Cont. table 3.

Relationships						
Organisational culture	74.6 %	16.2 %	6.4 %	2.9 %	2.62	14
Work atmosphere	93.1 %	3.5 %	1.7 %	1.7 %	2.88	3
Relationships in the team	93.6 %	4.0 %	1.2 %	1.2 %	2.90	2
Relationships with the superior	91.3 %	4.0 %	2.9 %	1.7 %	2.85	4
Organisational credibility	72.3 %	16.8 %	6.9 %	4.0 %	2.57	18
Achievements						
Status of the position held	68.8 %	18.5 %	8.1 %	4.6 %	2.51	20-21
Opportunity to succeed	70.5 %	19.7 %	7.5 %	2.3 %	2.58	17
Recognition, appreciation	78.0 %	17.9 %	2.9 %	1.2 %	2.73	12
Delegation of responsibility (powers)	73.4 %	17.3 %	5.2 %	4.0 %	2.60	15-16
Promotions	74.0 %	15.6 %	6.9 %	3.5 %	2.60	15-16
Development						
Work in a creative team	78.0 %	11.6 %	8.7 %	1.7 %	2.66	13
Opportunity to gain new experience	89.6 %	5.2 %	4.0 %	1.2 %	2.83	6-7
Training	88.4 %	6.9 %	4.0 %	0.6 %	2.83	6-7
Coaching	72.3 %	11.0 %	13.3 %	3.5 %	2.52	19
Contact with modern technologies	92.5 %	3.5 %	0.0 %	4.0 %	2.84	5
Expanding knowledge	87.3 %	5.8 %	5.8 %	1.2 %	2.79	8
Pressure						
Penalty hazard	22.5 %	32.9 %	31.2 %	13.3 %	1.65	23
Scope and intensity of control	26.0 %	38.7 %	20.2 %	15.0 %	1.76	22
Respondents aged 25-30 with work experience (Z3)						
Material values						
Pay	98.1 %	1.9 %	0.0 %	0.0 %	2.98	1
Safe working conditions	91.0 %	4.5 %	2.6 %	1.9 %	2.85	6
Job security	80.6 %	12.3 %	3.2 %	3.9 %	2.70	9
Material rewards	87.7 %	5.2 %	4.5 %	2.6 %	2.78	7
Bonuses and additional benefits	78.1 %	11.0 %	5.8 %	5.2 %	2.62	15
Relationships						
Organisational culture	76.1 %	14.8 %	7.1 %	1.9 %	2.65	11
Work atmosphere	92.9 %	3.9 %	1.9 %	1.3 %	2.88	4
Relationships in the team	92.3 %	4.5 %	1.3 %	1.9 %	2.87	5
Relationships with the superior	94.2 %	3.9 %	1.9 %	0.0 %	2.92	2-3
Organisational credibility	74.2 %	15.5 %	7.7 %	2.6 %	2.61	16-17
Achievements						
Status of the position held	70.3 %	18.7 %	7.7 %	3.2 %	2.56	19
Opportunity to succeed	72.3 %	20.6 %	4.5 %	2.6 %	2.63	12-14
Recognition, appreciation	74.8 %	17.4 %	3.9 %	3.9 %	2.63	12-14
Delegation of responsibility (powers)	67.7 %	17.4 %	11.0 %	3.9 %	2.49	20
Promotions	74.2 %	14.2 %	10.3 %	1.3 %	2.61	16-17
Development						
Work in a creative team	74.8 %	9.7 %	12.9 %	2.6 %	2.57	18
Opportunity to gain new experience	80.0 %	7.1 %	11.6 %	1.3 %	2.66	10
Training	78.7 %	8.4 %	9.7 %	3.2 %	2.63	12-14
Coaching	70.3 %	7.1 %	17.4 %	5.2 %	2.43	21
Contact with modern technologies	95.5 %	1.9 %	1.3 %	1.3 %	2.92	2-3
Expanding knowledge	82.6 %	9.7 %	5.8 %	1.9 %	2.73	8
Pressure						
Penalty hazard	18.7 %	45.2 %	26.5 %	9.7 %	1.73	22
Scope and intensity of control	20.0 %	43.2 %	24.5 %	12.3 %	1.71	23

Source: own studies.

The assessments and the different hierarchies of importance of individual means of motivation were very different in the three analysed groups of respondents. Among the younger respondents aged 18-24 and never employed (group Z1), “work atmosphere” (2.94) was ranked

first, followed by “pay” (2.90), “relationships with the superior” (2.89), “bonuses and benefits” (2.89) and “opportunity to gain new experience” (2.88). It is worth noting that the last two issues mentioned above were not among the most important for the respondents in general.

In Group Z2 (aged 18-24 and employed) and in Group Z3 (aged 25-30 and employed), the most important were the same means as those indicated by the respondents in general, but in a different order. In group Z2, the importance hierarchy was as follows: “pay” (2.93), “relationships in the team” (2.90), “work atmosphere” (2.88), “relationships with the superior” (2.85) and “contact with modern technologies” (2.84). In Group Z3 “pay” also turned out to be the most important (2.98), but then there were: “relationships with the superior” (2.92), “contact with modern technologies” (2.92), “work atmosphere” (2.88) and “relationships in the team” (2.87). The groups (Z1, Z2 and Z3) agreed only in relation to the issues defined as “scope and intensity of control” and “penalty hazard”, included in the “pressure” area. In each group they took the last two places.

Analysing the development of the assessments of the importance of motivation means in the groups of respondents, it should be noted that in the case of as many as fifteen of the twenty-three analysed means, there is a linear relationship between their importance and the age of the respondents and their work experience (Table 4). In all the groups of the respondents (Z1, Z2, Z3), the importance of nine means of motivation: “pay”, “safe working conditions”, “job security”, “organisational culture”, “relationships with the superior”, “organisational credibility”, “status of the position held”, “opportunity to succeed” and “penalty hazard” increased. In contrast, six means were assessed lower in importance: “bonuses and additional benefits”, “work atmosphere”, “work in a creative team”, “opportunities to gain new experience”, “coaching” and “learning”. For the remaining eight means under analysis, no such clear-cut relationship was found.

Table 4.

Change in the importance of individual motivation means in the respondents' opinion (on a scale from 1 /not important/ to 3 /important/)

Item	Total		Groups of respondents						Change in importance with age and gained work experience
			18-24 years of age, no work experience (Z1)		18-24 years of age, with work experience (Z2)		25-30 years of age, with work experience (Z3)		
	Assessment	Place	Assessment	Place	Assessment	Place	Assessment	Place	
Material values									
Pay	2.94	1	2.90	2	2.93	1	2.98	1	↑
Safe working conditions	2.79	8-9	2.72	12	2.77	10-11	2.85	6	↑
Job security	2.53	19	2.34	21	2.51	20-21	2.70	9	↑
Material rewards	2.80	7	2.87	6-7	2.77	10-11	2.78	7	-
Bonuses and additional benefits	2.85	6	2.89	3-4	2.78	9	2.62	15	↓

Cont. Table 4.

Relationships									
Organisational culture	2.61	14-15	2.53	18	2.62	14	2.65	11	↑
Work atmosphere	2.90	2	2.94	1	2.88	3	2.88	4	↓
Relationships in the team	2.89	3	2.89	3-4	2.90	2	2.87	5	-
Relationships with the superior	2.86	5	2.79	10	2.85	4	2.92	2-3	↑
Organisational credibility	2.54	18	2.40	20	2.57	18	2.61	16-17	↑
Achievements									
Status of the position held	2.52	20	2.46	19	2.51	20-21	2.56	19	↑
Opportunity to succeed	2.60	16	2.57	16	2.58	17	2.63	12-14	↑
Recognition, appreciation	2.68	12	2.68	13	2.73	12	2.63	12-14	-
Delegation of responsibility (powers)	2.55	17	2.54	17	2.60	15-16	2.49	20	-
Promotions	2.61	14-15	2.61	14	2.60	15-16	2.61	16-17	-
Development									
Work in a creative team	2.65	13	2.76	11	2.66	13	2.57	18	↓
Opportunity to gain new experience	2.78	10	2.88	5	2.83	6-7	2.66	10	↓
Training	2.75	11	2.80	9	2.83	6-7	2.63	12-14	-
Coaching	2.50	21	2.58	15	2.52	19	2.43	21	↓
Contact with modern technologies	2.87	4	2.85	8	2.84	5	2.92	2-3	-
Expanding knowledge	2.79	8-9	2.87	6-7	2.79	8	2.73	8	↓
Pressure									
Penalty hazard	1.63	23	1.46	23	1.65	23	1.73	22	↑
Scope and intensity of control	1.71	22	1.65	22	1.76	22	1.71	23	-

Source: own studies.

To sum up this part of the research, it should be noted that “material values”, including pay, are generally the most important factors motivating Generation Z representatives. Next are the means of persuasion (“relationships”, “development”, “achievements”), and by far the least important are the means of coercion (“pressure”). However, the hierarchy of the importance of the groups of the means is slightly different in individual groups of the respondents distinguished for the purposes of the survey. Moreover, differences were also observed in the assessment of the importance of specific motivation means made by the members of the different groups under analysis.

5. Summary and conclusions

Generational diversity translates into the situation on the labour market, where representatives of different generations meet. It also affects the functioning of generationally diverse organisations. Rational management of motivation in such organisations requires the development of a balanced, extreme-free approach to the issue of generational diversity of

employees. A special group, composed of the representatives of the youngest Generation Z, is now gradually entering the market and gaining first work experience. The members of this cohort are not only specifically different from previous generations, but they also demonstrate considerable diversity within their own collectivity.

The results of the research are consistent with those indicating that financial aspects are generally the most important factor motivating to work. The impact of other factors is smaller and at the same time varied (Dziopak-Strach, 2018; Jawor-Joniewicz, 2016; Sajkiewicz, 2016). On the other hand, it should be emphasised that Generation Z is not homogeneous in this respect. There are differences in attitudes towards work depending on the age and work experience of Generation Z representatives, including attitudes to issues such as the career goal, gratification/pay for work, work-life balance, teamwork, changing jobs, training and development. Hypothesis 1, accepted in the research, has thus been confirmed. It turns out that with age and growing work experience the following phenomena occur in relation to Generation Z representatives:

- the expectation of a “fast career” decreases,
- the attitudes and expectations concerning gratification for work materialise (respondents expect “quick pay” and indicate a “well-paid job as the most important factor”),
- the readiness to “put work over personal life” according to the “I live to work” principle grows,
- the importance of “teamwork” and “the readiness to submit to the group with a view to achieving collectivity objectives” become greater,
- the willingness to change jobs, which is considered as the “ultimate necessity”, and which is accompanied by a “fear of losing the achieved position”, decreases,
- the readiness for “continuous education as a way of career development at different places” decreases.

Hypothesis 2 has also been confirmed. According to it, Generation Z representatives find the biggest motivation in incentives means, the most important being “material values”, followed by persuasion means (related to “relationships”, “development” and “achievements”). This cohort considers the means of coercion (“pressure”) as the least motivating.

Hypothesis 3 has been confirmed in part. Although there are differences in the assessment of the motivation means depending on the age and work experience of the members of Generation Z, they are a bit different from what was assumed. According to the assumptions, with the respondents’ age and work experience, the importance of incentive and persuasion means should increase, while the means of coercion should gradually lose significance. But it turns out that there appears an increase in the importance of not only incentive but also coercive means (“material values” and “pressure”, respectively), while in the case of persuasion means, which include a great variety of measures, one of them becomes more important (“relationships”), another loses its significance (“development”), and yet another

(“achievements”) does not show a clear-cut dependence on the age and work experience of the respondents.

The presented research may be an introduction to future in-depth studies on the role and importance of motivation in human resource management in generationally diverse organisations. It would be particularly interesting to create a panel of respondents and cyclical surveys indicating changes in their attitudes towards work as well as the role of individual groups of motivation means. With the respondents' transition from one age group to another and with increased work experience, the new potential research area is the identification and characterisation of factors related to job satisfaction or professional burnout.

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ANALYSIS OF SOLUTIONS AND BARRIERS IN THE DECARBONISATION OF TRANSPORT PROCESSES

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Purpose: The main aim of the article is to identify and analyse solutions and barriers of the road transport decarbonisation (RTD) in Poland. In reference to the identified research gap, two research questions were posed concerning approaches and challenges in the context of RTD.

Design/methodology/approach: The study utilises literature review and empirical research. The literature review characterises the organisation of transport processes and presents the main assumptions of the concepts of decarbonisation and sustainability. The Scopus database is analysed using VOSviewer software. This analysis presents the relationships between keywords related to the decarbonisation of transport processes. The empirical part uses expert research to identify and analyse solutions and barriers related to RTD. Twelve experts with extensive experience in the road transport sector participate in the research.

Findings: The article presents the main methods of decarbonisation and the associated barriers. The research found that the most effective initial step towards transport decarbonisation is to prioritise ecodriving training, while HVO fuel presents the highest potential among alternative fuels. Based on the results of expert research, the main barriers related to RTD were presented and classified into five categories: economic and cost-related barriers, operational efficiency, underdeveloped infrastructure, limited availability of alternative fuels, regulatory and policy frameworks. Cost related factors including vehicle acquisition, infrastructure and alternative fuels were identified as the most significant barrier to RTD.

Research limitations/implications: The principal limitation of the research was the challenge of obtaining a substantial number of expert responses. This constraint was predominantly attributable to the limited availability of managers and specialists engaged in sustainable development initiatives. However, the twelve responses obtained are sufficient given the high level of experience of the experts participating in the study.

Practical implications: The research results present a list of potential methods for decarbonising transport processes and the challenges that are currently most important at the domestic level. The results presented can be used by transport carriers to facilitate the selection of methods for decarbonising their transport processes.

Originality/value: The article presents a summary of methods and barriers related to RTD issues in national conditions. Research offers insights into the challenges of transport decarbonisation.

Keywords: decarbonisation, sustainability, transport processes.

Category of the paper: Research paper.

1. Introduction

In view of growing economic development, the importance of the transport sector is increasing significantly. Rising customer expectations regarding environmental protection, along with legal regulations at both national and EU levels, are leading carriers to seek ways to reduce the carbon footprint generated by transport processes. According to Eurostat data, road transport is the dominant mode of transport in Poland, accounting for 70% of total transport performance expressed in tonne-kilometres. This mode of transport exerts a significant environmental impact in terms of carbon dioxide emissions, as well as external costs to society. These costs encompass congestion, noise, and traffic accidents. Given the importance of the transport sector and the challenges it faces, society is putting pressure on carriers to implement changes in their operations.

According to data contained in the report on road transport in Poland in 2024/2025 developed by the SpotData analysis centre, the most important trends in the sector include consolidation of the domestic market, development of VAS (value-added services) and decarbonisation. The issue of decarbonisation of transport processes is currently also the subject of extensive scientific debate. Although this issue has been addressed in numerous studies (Załoga, Szaruga, 2016; Nouni et al., 2021; Ghisolfi et al., 2022; Wan et al., 2025) there remains a notable gap in the literature concerning the specific solutions and barriers in the decarbonisation of national road transport sector. In response to the identified gap in existing studies, two research questions were posed:

- Q1 - what solutions are currently being implemented to advance the decarbonisation of road transport processes?
- Q2 - what challenges impede the effective decarbonisation of road transport processes?

The main aim of the research is to identify and analyse solutions and barriers of the road transport decarbonisation (RTD) in Poland. To answer the research questions, the study employed an integrated approach combining a literature review with empirical research. The literature review entailed a bibliometric assessment conducted using the Scopus database and VOSviewer software, with an emphasis on the decarbonisation of transport processes. The literature review concentrated on the organisational characteristics of transport processes, the theoretical frameworks of decarbonisation and sustainable development within the transport sector, as well as the examination of solutions and technologies designed to mitigate the carbon footprint of road transport. The empirical part utilised expert research to identify and analyse solutions and barriers related to RTD. Representatives of carriers and the scientific community with extensive experience were selected as experts. The empirical part discusses solutions and challenges related to RTD identified on the basis of questionnaire surveys among experts, as well as determining which of the factors have the greatest potential in national conditions. The article closes with a summary of the main findings and a critical discussion of its limitations.

2. Decarbonisation of transport sector

The transport sector plays a major role in the economy, which relies on enabling efficient movement of goods from producers to customers to meet transport needs. Transport needs, in turn, result from uneven access to material goods in different locations. Transport also plays an integrative role in the logistics system, which includes the integration of information, space, resources, and organisation (Mindur, Stajniak, 2009). The literature often emphasises that the concept of transport is much broader than the concept of carriage (Wierzejski, Kędzior-Laskowska, 2014). Activities related to the transport process include both the movement of cargo and additional services related to, among other things, route planning and forwarding services. Forwarding services, in turn, cover the organisation of the transport process, including the selection of the means of transport, preparation of documentation and coordination of loading and unloading activities (Bartczak, Barańska, 2016). The relationships between the basic elements of the concept of transport are shown in Figure 1.

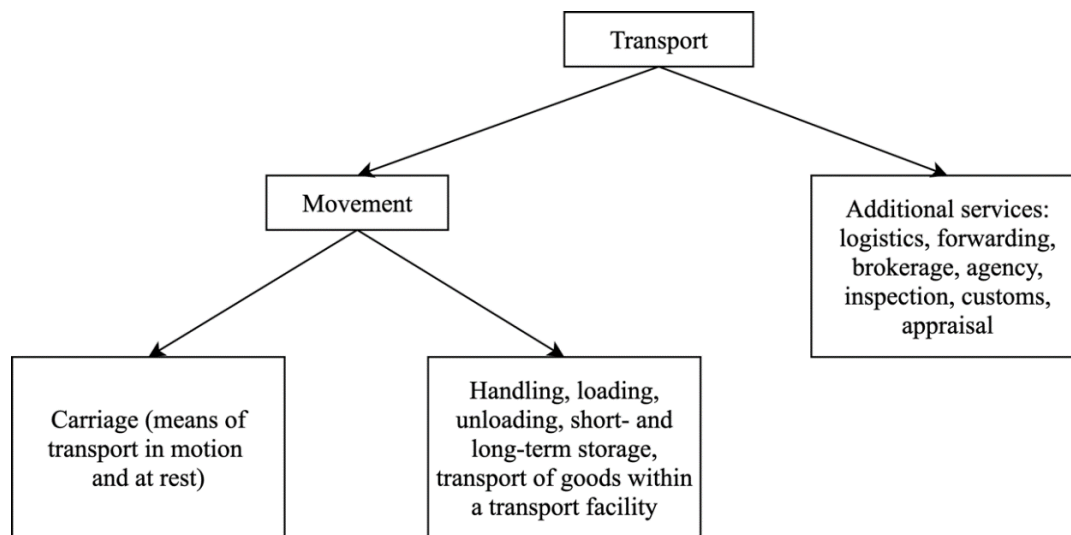


Figure 1. Basic elements of transport concept.

Source: (Wierzejski, Kędzior-Laskowska, 2014, p. 8).

Changes in the transport sector are shaped by both the demand side (trade and production) and the supply side (logistics and transport systems), as well as by legal regulations (Ottemöller, Friedrich, 2016). Many researchers have considered the identification of contemporary trends in transport processes. In one research, based on a survey of 63 experts, the most important factors in terms of their impact on the transport sector and time horizon were identified. According to the results of this research, the development of the e-commerce market, autonomous and electric vehicles, and the growing importance of omnichannel have the greatest impact on the industry (Letnik et al., 2022). All of these factors are linked to the main goal of decarbonising the transport sector. To achieve this goal, it is necessary to have a proper understanding of how transport processes are organised.

2.1. Organisation of transport processes

One of the most important decisions in transport process organisation is the selection of the appropriate mode and means of transport (Stajniak, 2016). The literature predominantly uses a classification system that distinguishes between road, rail, pipeline, air and water transport. The choice of mode depends mainly on the distance over which the cargo is transported, as well as its size, time criteria and the availability of infrastructure in a given region. The transport process consists of three main activities: organisational, executive and commercial (Krupa, 2017). Organisational activities include planning, coordination and management of operations related to the movement of cargo. The organisational activities also include the valuation of the transport service. The executive activities concern the physical movement of cargo and activities related to loading and transshipment. The commercial activities are carried out after the executive activities have been completed and focus on settling transport costs and completing the required documentation. The analysis of the transport process also includes forwarding activities, which involve receiving and processing orders and planning transport routes. Another important aspect is the selection of the appropriate transport technology. Its decision depends on the characteristics and transport susceptibility of finished products. Transport technology not only determines the choice of means of transport, but also influences the need for transshipment infrastructure equipment. Transport technologies can be divided into universal, specialised and unified. Universal technologies are dedicated to the movement of cargo with standard requirements that do not need special conditions during transport. Specialised technologies are suitable for cargo that is highly sensitive to changes in temperature, humidity or other factors, such as food products requiring refrigeration, pharmaceuticals or chemical products. Unified technologies, on the other hand, are based on standards for the transport of cargo in standardised units, such as ISO containers (Mindur, 2008).

Considerable research is currently being conducted on the growing role of information technology in the organisation of transport processes. IT systems used in the transport sector are most often based on satellite navigation systems (GPS) and telematics infrastructure, which facilitates continuous monitoring of the location of vehicles and cargo. Carriers also use IoT (Internet of Things) sensors, which can measure vehicle speed, location, temperature, fuel consumption and mechanical parameters to enable real-time monitoring and predictive maintenance (Rey et al., 2021). These systems can be integrated and supported by machine learning technologies, which increase the precision of route optimization. The integration of ICT (Information and Communication Technology) systems with freight transport can also significantly contribute to the reduction of greenhouse gas emissions, with the greatest effect observed in the integration of ICT systems in rail, inland and multimodal transport (Chatti, 2021). Given the consensus among researchers on the growing role of information

systems in transport processes, it is worth further analysing the classification and application of these systems and other tools in terms of the decarbonisation of transport sector.

2.2. The concept of decarbonisation and sustainability

The concept of decarbonisation gained prominence at the turn of the 20th and 21st centuries. An analysis of the number of scientific publications on this subject shows a particular increase in the last decade. The term refers to the reduction of carbon dioxide emissions from anthropogenic sources, primarily through the transition from fossil fuel-based energy systems to low-carbon or carbon-neutral alternatives (Tzeiranaki et al., 2023). To investigate the relationship between the transport sector and decarbonisation, a bibliometric analysis was performed using the Scopus database in conjunction with VOSviewer software. The study focused on publications containing both the keywords “Transport” and “Decarbonisation”. This search yielded a total of 1767 relevant scholarly articles. To enhance the clarity of the resulting network map, the analysis was restricted to keywords appearing at least 35 times within the dataset. A visual representation of the connections is provided in Figure 2, illustrating the most prevalent topics addressed in the literature.

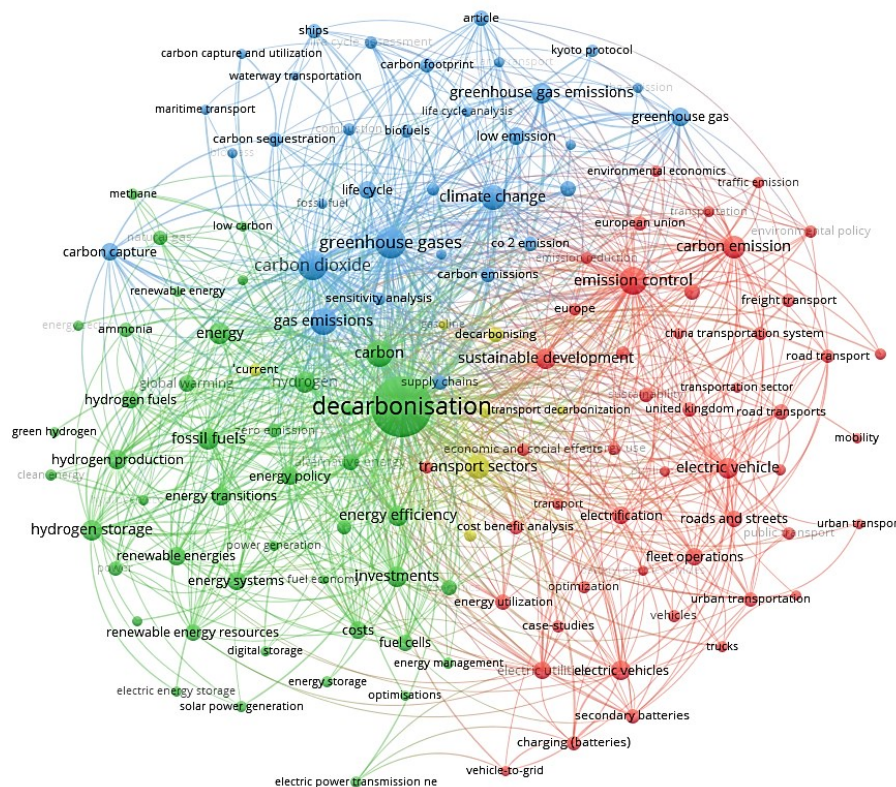


Figure 2. Connections between the main keywords based on Scopus database.

Source: own elaboration with the use of VOSviewer, 03.09.2025.

During the analysis, attention was paid to the linkages of transport with innovation, technology, electric vehicles and hydrogen fuels. The concept of decarbonisation is also closely linked to the idea of sustainable development, which, in addition to environmental

considerations, also takes social and economic aspects into consideration. Based on the bibliometric analysis, a literature review was conducted to assess the relevance and solutions of the decarbonisation process in transport sector.

2.3. Solutions for transport decarbonisation

In the literature, the solutions for RTD are examined within the framework of research on technologies aimed at decarbonising transport processes, with the principal examples summarised in Table 1. Solutions in this area can range from simple to complex. The simplest and the most cost-efficient solution is eco-driving. Factors influencing eco-driving include speed, acceleration and deceleration, distance, as well as issues related to air conditioning (Huang et al., 2018). It is also possible to make certain modifications to trucks that would reduce their weight or improve their aerodynamics. Alternative fuels are also an important element of decarbonisation, including CBG (Compressed Biogas), LNG (Liquefied Natural Gas), FAME (Fatty Acid Methyl Esters) and HVO (Hydrotreated Vegetable Oil). In recent years, HVO has gained increasing significance, although researchers emphasise that its wider adoption requires the implementation of appropriate government policies addressing operational costs (Aryanpur, Rogan, 2024). Among the more complex solutions to be implemented, the literature mentions BEV (Battery Electric Vehicle) and FCEV (Fuel Cell Electric Vehicle). It should be noted that FCEV have a favorable twelve-year total cost of ownership compared to BEV and hold considerable potential for sustainable and affordable adoption (Vengatesan et al., 2024).

Table 1.

Main methods of decarbonising road transport processes

Decarbonisation method	Characteristic
Ecodriving	Implementing vehicle operation techniques that enhance fuel efficiency
Improvement of fuel efficiency	Optimising vehicle design, engine performance, and aerodynamics to reduce fuel consumption
Route optimisation	Determining the most efficient paths for vehicles to minimize travel time, fuel consumption, and associated emissions.
Alternative fuels	Adopting biofuels, hydrogen, synthetic fuels, or renewable natural gas.
Electrification of vehicles	Replacing internal combustion engine vehicles with electric vehicles (EVs), including battery-electric and plug-in hybrid vehicles.
Carbon offsetting	Compensating for greenhouse gas emissions produced by vehicles through the reduction, removal, or avoidance of an equivalent amount of carbon dioxide elsewhere.

Source: own elaboration based on: (Aryanpur, Rogan, 2024; Vengatesan, Jayakumar, Sadasivuni, 2024).

When analysing examples of solutions for the RTD in Europe, attention should be paid to the ehigway project implemented in Germany. This project involves modifying the linear infrastructure of motorways by adding a traction network. The results of research conducted over a period of three years indicate that only a five percent electrified stretch of a trip, 14-17% of direct greenhouse gas emissions are saved compared to a conventional truck (Schöpp et al., 2024). Based on literature research, the most important factors influencing the decarbonisation process of road transport in Europe have been identified, including fuel prices, biofuel

availability and the role of emission regulations, in particular the scope and severity of future carbon dioxide emission reduction targets (Cendon, 2024).

3. Methods

Expert research was used to answer the research questions posed in the article. For this purpose, an survey questionnaire was created based on literature review. The questionnaire consisted of two parts. The first part concerned information about the experts and included questions about their professional experience and specialisations. The second part of the questionnaire consisted of two open-ended questions prepared based on the RTD concept presented in the literature section. The first question concerned the identification of solutions for the decarbonisation of transport processes, while the second question concerned the identification of barriers and challenges in the RTD. The research was conducted between August and September 2025 using the CAWI method. The questionnaire was addressed to transport company management, specialists from departments responsible for sustainable development and individuals involved in researching the transport sector. Twelve national experts in the field of road transport participated in the research. All of the experts surveyed had higher education in logistics or transport. Four experts (33.33%) had 3 to 5 years of practical experience, three experts (25%) had 6 to 10 years of experience, three experts had 11 to 15 years (25%), and two experts had 16 to 20 years of practical experience in managerial positions (16.67%). Based on the research conducted, an analysis of the results was performed.

4. Results

Based on the collected research results, the most frequently mentioned methods of decarbonisation of the road transport sector were identified. These solutions were divided into two categories. The first concerned the organisation of transport processes. Within this category, as well as in the entire research, the most frequently mentioned method of decarbonisation by 66.67% of experts was eco-driving. This solution was also recognised by many researchers in the literature review, which proves its important role in the transport sector. Many experts emphasised that this solution can be implemented by any carrier, regardless of the size of their fleet and available financial capital. One expert also highlighted the need to equip vehicles with appropriate tools to measure driving efficiency, as well as training to raise drivers' awareness of driving style. The second factor that also received a high score was route optimisation, which was mentioned by half of the experts in the questionnaire.

This solution affects both the costs of operations and the carbon footprint generated by transport services. When asked about decarbonisation methods, 33.33% of experts also mentioned the elimination of empty mileage as a way to save costs and protect the environment.

The use of intermodal transport, in which a given cargo unit is transported using at least two modes of transport, is also becoming increasingly important. However, this solution has certain limitations in domestic conditions. In the case of road and rail transport, there is limited access to rail infrastructure, particularly in the eastern parts of the country. Furthermore, this type of transport is most often used over long distances, which excludes its effective use in transport between entities located relatively close to each other. When analysing the other solutions proposed by experts, 16.67% of them mentioned improving fuel efficiency through changes in the design of lorries or semi-trailers and carbon offsetting, i.e. offsetting the carbon footprint in other processes in a situation where the carrier is unable to eliminate pollution from transport processes. The results of the expert research presented above are shown in Figure 3.

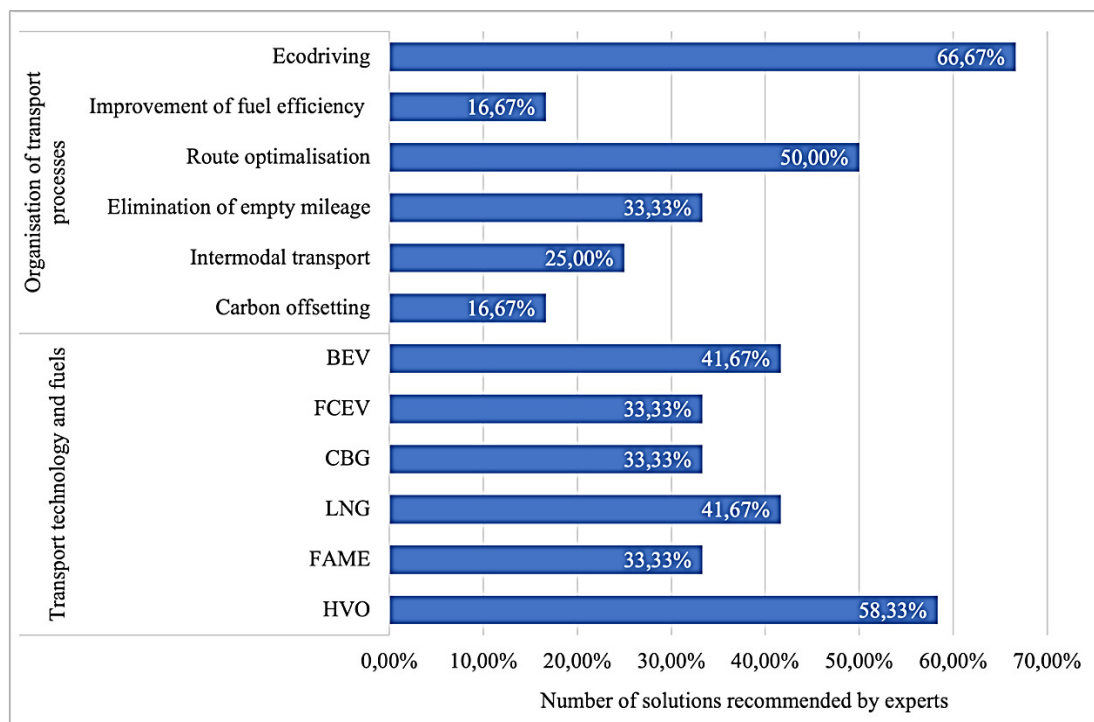


Figure 3. Results of expert research on RTD solutions.

Source: own elaboration.

When analysing the results, attention should also be paid to the second identified category of decarbonisation concerning technology and alternative fuels. Within this category, the most frequently mentioned type of alternative fuel by 58.33% of experts was HVO. Its use is associated with a reduction in carbon dioxide emissions into the atmosphere of between 40% and 90% compared to regular diesel fuel. Experts see the potential for its further dissemination in Poland, as is the case in other European countries such as Germany and the Netherlands. 41.67% of experts also point to the role of LNG fuel, while 33.33% of experts

point to other alternative fuels. The growing role of BEVs in transport is also recognised, but the development of this type of drive is subject to certain limitations.

When analysing the results of international studies, it should be noted that the growing importance of alternative fuels and eco-driving are highlighted in many publications (Huang et al., 2018). The authors emphasise that eco-driving is effective for carriers in both economic and environmental terms. The use of alternative fuels is also highlighted as one of the main methods of decarbonisation. Other decarbonisation solutions include BEV and FCEV (Breuer et al., 2022). However, the above RTD solutions are associated with certain barriers.

The barriers and challenges to decarbonising road transport sector identified based on expert research have been divided into five categories, as shown in Figure 4.

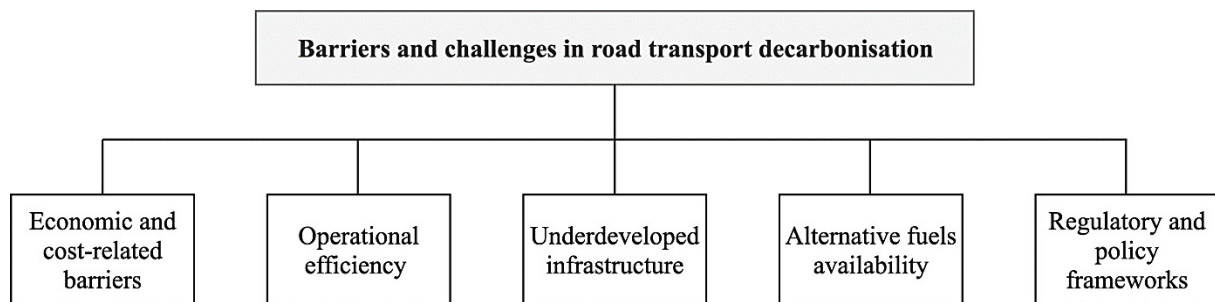


Figure 4. Barriers and challenges in RTD.

Source: own elaboration.

The first category of challenges identified in the study was related to economic and cost-related barriers. It should be noted that all 12 experts referred to the high costs associated with the decarbonisation process. The experts pointed to the higher costs associated with alternative fuels, as exemplified by the 30% higher price of HVO compared to standard diesel fuel. They also pointed to the high costs associated with the purchase of BEVs and the need to invest in appropriate charging infrastructure. The second barrier identified was operational efficiency. In the case of electric tractors, the range is shorter and the charging time is longer, which affects the operational efficiency of the carrier. The third category of challenges was related to underdeveloped infrastructure. Experts referred to this mainly in the context of BEV charging infrastructure. Some experts also pointed to the limited availability of certain alternative fuels (e.g. HVO), which was identified as the fourth barrier. The final barrier concerned regulatory and policy frameworks. In this regard, experts pointed to the small number of financial incentives and insufficient cooperation between the authorities and the transport sector.

When comparing the results of the research with those obtained in international studies, their similarities should be pointed out. Research on barriers to global transport decarbonisation also points to infrastructure challenges and the impact of policies and regulations as the biggest barriers to RTD (Patil et al., 2024). Among other barriers, the authors mention the lack of qualified workers and the unwillingness of carriers to implement changes in transport processes. The impact and necessity of introducing changes in decarbonisation policies are also noted in other studies (Tzeiranaki et al., 2023). It should be emphasised that the national barriers

identified in the studies largely overlap with the challenges that affect the global aspect of road transport decarbonisation.

5. Discussion and Conclusion

The actions and initiatives available to road transport carriers for decarbonising their operations exhibit considerable variability. The results of expert research point to the solutions that currently have the greatest prospects. The analysis presented allowed to answer the first research question (Q1) by identifying the most implemented RTD solutions. The results indicate that the simplest and, at the same time, the first step towards decarbonisation of transport should be to focus transport carriers' attention on ecodriving training, while in the case of alternative fuels, the use of HVO fuel offers the greatest potential. To answer the second research question (Q2), barriers and challenges related to RTD were identified and classified into five categories. The most significant barrier in this area is related to the costs of purchasing vehicles, infrastructure, and alternative fuels, which all experts agreed on.

The principal limitation of the research was the challenge of obtaining a substantial number of expert responses. This constraint was predominantly attributable to the limited availability of managers and specialists engaged in sustainable development initiatives. However, the twelve responses obtained are sufficient given the high level of experience of the experts participating in the study. The results obtained are relevant for future research, which could potentially be extended to a wider group of experts. Furthermore, in the future, it will be possible to conduct research on the decarbonisation of other modes of transport, considering factors related to rail, air and maritime transport.

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PRO-ECOLOGICAL SOLUTIONS IN ORGANIZATIONS IN THE ERA OF SUSTAINABILITY AND DIGITAL TRANSITIONS

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Purpose: The paper aims to outline challenges for implementing voluntary environmental programs (VEPs) against the background of changing institutional arrangements specific to sustainability and digital transitions. The paper concludes with possible approaches to changing institutional arrangements that can be used depending on the possibilities for using new technologies and the acceptance of their consequences by organizational members.

Design/methodology/approach: The paper applies a critical literature review, and initial insights from interviews conducted with EMAS representatives support the reasoning. Based on the data collected from literature and interviews, an analysis is performed.

Findings: By proposing a framework for analyzing the consequences of changing institutional arrangements for the implementation of VEPs, the author formulates suggestions as to the main reasons behind the impact of given elements of institutional arrangements and what can be done to improve the situation. The directions for further analysis are outlined.

Practical implications: The paper's considerations can be a hint for policymakers and managers responsible for implementing and functioning EMAS or other VEPs in their organizations.

Social implications: Since the paper discusses the issues of shaping the legitimacy of VEPs, it can help all those stakeholders who attempt to assess the importance of efforts undertaken by organizations that implement different solutions for challenges resulting from sustainability and digital transitions.

Originality/value: The paper's originality lies in its attempt to combine conclusions derived from transition studies and research on the legitimacy of efforts undertaken by organizations exposed to the challenges that sustainability and digital transitions bring.

Keywords: voluntary environmental programs, sustainability and digital transitions, legitimacy.

Category of the paper: Viewpoint.

1. Introduction

By focusing on how organizations can realize their aims in addressing Sustainable Development Goals (SDGs), Hurst et al. (2025) emphasize the importance of gaining the legitimacy for so-called multi-stakeholder voluntary environmental programs (VEPs). Those programs, based more on soft regulation, can be understood as a form of "private governance or market-based policies aimed at encouraging organizations to address environmental and/or societal problems" (Hurst et al., 2025, p. 2). VEPs, in general, can include public VEPs, negotiated agreements between businesses and governments, single voluntary environmental management practices, and unilateral agreements by firms regarding environmental management systems. ISO 14001 and Eco-management and audit scheme (EMAS) can be mentioned here (Ziegler, Nogareda, 2009).

VEPs are said to be used to address sustainability challenges linked to Sustainable Development Goals (Hurst et al., 2025). The popularity of VEPs stemmed from several factors. It can be mentioned that although environmental regulation in the form of mandatory command or control regulations contributed to the reduction of industrial pollution, they were also assessed as inflexible and cost-ineffective. As a result, other solutions like economic incentives became much more common. However, designing such instruments for numerous pollutants appeared to be difficult (and costly), and they met some opposition from industry. Hence, voluntary proactive approaches to environmental protection became useful supplements for mandatory solutions and economic incentives (Ziegler, Nogareda, 2009).

While focusing on strengths and weaknesses of VEPs, Hurst et al. (2025) pay attention to research (conducted by e.g. Borkey et al., 1998; Callery, 2022) on possible improvements in the field of environmental performance that can be achieved because of using VEPs, as well as on the issues related to how VEPs can be perceived as tools for raising awareness. According to Hurst et al. (2025), VEPs can be considered legitimate programs (Haack, Rasche, 2021) because they can be widely used by organizations and/or effective in addressing SDGs. The former refers to cognitive legitimacy, and the latter applies to moral legitimacy. This is because VEPs signal their cognitive legitimacy when signaling diffusion, and when signaling impact, VEPs signal their moral legitimacy (Hurst et al., 2025). Hence, for further analysis, it can be assumed that decisions about whether to implement or not the given VEP should be assessed about its impact on organizational legitimacy. While the results of the implementation of VEPs can be ambiguous (see next paragraph), it has been proven that some organizations can derive important advantages from the implementation of VEPs. That is why it should be important for those organizations to maintain their engagement in some activities that result from the fact that they can perform some activities that are additional to what is required by law. While VEPs need legitimacy, which can be understood in such a way that they need to contribute to improvements in performance and be used by enough entities,

their usefulness is to be assessed compared to other regulations (Piras et al., 2021). Hence, the problem can arise when those other (obligatory in this case) regulations are to cover more issues, which may cast doubt on the usefulness of VEPs and, therefore, on their legitimacy. The problem is how to describe institutional arrangements that are mainly responsible for this situation, and what can be proposed to overcome the threat of having an important organizational field of activities undermined by new institutional requirements.

The emphasis is put on how changes induced by those requirements may make it more difficult for organizations to derive advantages from established routines and to decrease the motivation to do more than is required. To some extent, the abstract considerations included in the paper can be reflected in the current institutional environment and how it changes. Requirements resulting from new obligatory regulations (CSRD directive) are to be implemented in the context of the growing importance of technologies (especially artificial intelligence) that enable companies to collect and interpret more data. While potentially useful, those new solutions can influence established ways of doing a good job for the organization and environment with which people are familiar and appreciate. The paper aims to outline challenges for implementing VEPs against the background of changing institutional arrangements specific to sustainability and digital transitions. It requires finding suitable questions and outlining possible answers regarding how companies can attempt to meet future institutional arrangements in a way that makes it possible to still respect what was and can be achieved thanks to existing institutional arrangements. By referring to the overview of digital innovations from an institutional perspective presented by Hinings et al. (2018), the paper considers ways for organizations to maintain their participation in VEPs in a way that aligns with the necessity to build competencies tailored to institutional changes in their business environment. To support this effort, a reference to literature discussing sustainability and digital transitions is made, since this literature gives some insight into what categories of actors may be worth considering and the temporal consequences of activities undertaken by engaged actors.

2. Methods

The current study is based on a critical literature review of institutional theory, sustainability, and digital transitions. When searching for the literature for the analysis purposes, firstly the papers written in the last 10 years in English and included in databases (Scopus, Web of Science) are mainly considered. This step allows for the presentation of main trends in approaches to sustainability issues and to the development of technologies (including artificial intelligence). Secondly, the presentation of clear basis for considerations requires referring to the literature discussing some basic assumptions on which further important developments in the field of sustainability and transition studies are based. Hence, the literature

also dating back to the beginning of the 21st century is included in this literature review. What should be added is that the considerations included in the text are supported by initial insights from 10 interviews with EMAS representatives conducted by the author in 2025. This additional insight justifies why it is worth paying attention to both challenges resulting from new requirements (especially ESG reporting) and the digital transition. It becomes increasingly important for organizations for which the implementation of VEPs (especially EMAS) is an important part of their activities. That is why the references to research papers related to the consequences of the implementation of EMAS occurring in different countries are made to supplement literature review findings. At the same time, models proposed by authors dealing with transition studies can provide the analysis with additional points to consider. When discussing current changes in the institutional environment, it is useful to apply institutional theory. Here, main emphasis is put on showing how widely accepted approaches to the topic (e.g. Lawrence, Suddaby, Leca, 2009; Scott, 2003) can be applied when outlining the context for transition studies. The key insights from the literature review are presented below.

3. Results

3.1. Implementation of VEPs and benefits - the example of EMAS

EMAS can be considered an example of VEP for environmental management systems (Ziegler, Nogareda, 2009). EMAS is a certified environmental management system that imposes additional requirements on organizations compared to those resulting from ISO 14001. One of the most important additional requirements is the preparation of an environmental statement, which means comprehensive information provided to the public and other interested parties regarding such elements of the organizational functioning as, among others, environmental policy and environmental management system, program, environmental objectives and targets, environmental performance (Regulation 1, Regulation 2, Act of Parliament). One important feature of VEPs (and EMAS as well) that was mentioned by Darnall and Sides (2008) is whether the conformance with the program is assured by external certification by an independent third party (as in the case of EMAS) or is assured by VEPs' participants who self-report their adherence to program requirements. What is worth mentioning, when the first case occurs, then additional external legitimacy related to how the organization approaches its environmental commitments is conferred (Bansal, Hunter, 2003; Darnall, Sides, 2008). Considering the above-mentioned ways of understanding cognitive and moral legitimacy (Hurst et al., 2025), it appears that environmental statements can be perceived as an important tool for building moral legitimacy, since they communicate about

the effects of the environmental policy and the extent to which objectives and targets are fulfilled or not. In addition to this, the extent to which environmental statements are known among stakeholders may provide a clue regarding cognitive legitimacy. And here it must be added that, on the one hand, in general, it appears that those statements tend to be prepared carefully. It can enable organizations to motivate employees.

However, those statements may not be widely known among stakeholders. Hence, cognitive legitimacy is limited. Further comments focused on results that could be derived from EMAS, and their consequences are included in Table 1.

Table 1.
Results of the implementation of EMAS

Authors	Results	Comments – legitimacy perspective
I. Heras-Saizarbitoria, O. Boiral, A. de Junguitu (2020)	The analysis of 414 environmental statements of Spanish organizations allowed researchers to show only a weak improvement of the effects of environmental activities in the research period, whereas the efforts put into this field by organizations were being limited.	The opinion about the positive impacts of EMAS is not unequivocally confirmed. It may result in difficulties in gaining moral legitimacy.
L. Marrucci, T. Daddi (2022)	The analysis of 268 environmental statements of Italian production companies allowed researchers to show the deterioration of the effects of environmental activities in the research period.	The opinion about the positive impacts of EMAS on organizations' pro-ecological attributes was undermined. This may mean that not only should more emphasis be put on building cognitive legitimacy, but also that the requirements to be met by organizations entering the system could be higher.
A. Matuszak-Flejszman, B. Paliwoda (2022)	In the period between 2015 and 2020, the average effectiveness of EMAS in Polish organizations increased in comparison to the period between 2007 and 2014.	Whereas EMAS's positive impacts on environmental results are more visible for organizations registered in EMAS for a longer time, the importance of learning how to operate within the system could be emphasized, which accounts for the challenge of building moral legitimacy.
F. Murmua, L. Bravi, G. Santos (2022)	The analysis of 231 Italian production companies registered in EMAS allowed researchers to show that its impact on obtaining environmental benefits was dependent on the organization's profile and the time that had passed since certification.	The opinion about the positive impacts of EMAS on environmental issues appears to be contingent on organizational factors. It can be treated as an additional hint for policymakers to propose solutions more tailored to the industry, which could increase moral and cognitive legitimacy.

Source: author's own based on Heras-Saizarbitoria, Boiral, de Junguitu (2020); Marrucci, Daddi (2022); Matuszak-Flejszman, Paliwoda (2022); Murmua, Bravi, Santos (2022).

As shown in Table 1, the advantages for organizations resulting from EMAS cannot be treated as obvious since different organizational and environmental factors can cause the implementation of EMAS to be (or not) beneficial for the organization. In general, one significant literature review conducted by Erauskin-Tolosa et al. (2020), which was based on 53 research works and as many as more than 180,000 companies, proved positive impacts of the implementation of EMAS on corporate environmental performance. To better understand how organizational approaches towards the commitments made because of the implementation

of EMAS or other VEP, it appears to be useful to reconsider the relationship between different institutional arrangements that may be important regarding how organizations approach the issue. To analyze the problem, it is necessary to consider the broader context of sustainability and digital transitions. The challenges predicted about 10 years ago by Kenney et al. (2015) focused on the consequences of challenging existing institutional arrangements during digital disruption. While occurring, they may require policymakers to rethink how to talk about societal objectives and economic value creation.

3.2. Socio-technical changes and their impact on organizations

Kivimaa et al. (2019) emphasize a difference between mainstream innovation studies and the literature on sustainability transitions. The latter is not focused only on product or process innovation but covers issues related to “systemic change for sustainable futures” (Kivimaa et al., 2019, p. 1063). This literature defines sustainable transformative change as a “set of processes leading to fundamental shifts in socio-technical systems” (Kivimaa et al., 2019, p. 1063). Markard et al. (2012) mention that different dimensions can be transformed – technological, material, organizational, institutional, political, economic, and socio-cultural. What is important is that this approach, when describing transformative changes in socio-technical systems, pays attention to 3 levels. The key issue here is that, on the one hand, configurations of technologies, practices, and institutions that are relatively stable and shared (“regimes”) can be recognized. On the other hand, there are spaces (“niches”) in which both radical innovations and experimentation take place. In addition to niches and regimes, “landscapes” as slow-moving developments that occur in the exogenous environment can be recognized (Geels, 2002, 2005). For the researchers, it is important to notice that different concepts can describe the interaction between the first two levels. On a broader perspective, it is possible to recognize the dialectic development between niche action and regime response¹. The interaction between niches and regimes can be perceived through the prism of institutional structures established by incumbents. Those structures can be treated as barriers that need to be overcome by the agency in the micro-level processes. What is also important, the interface between niches and regimes can be characterized by different institutional logics (Kivimaa et al., 2019b; Smink et al., 2015). In processes of demand and vision articulation for issues related to the interactions between niches and regimes, there is a need for translation, e.g., citizen demands could be translated towards the government to inform policies (Kivimaa et al., 2019b, p. 113). Since this paper attempts to describe the relation between existing institutional arrangements and emerging institutional arrangements in the context of the implementation of VEPs (especially EMAS), it is worth referring to how Scott (2003) describes translation. Following Czarniawska and Joerges (1986) and Latour (1986), Scott (2003) appears to support the view that top-down models, in case of which institutions impose their meanings on organizations and individuals, are not adequate to the contemporary world. Translation mechanisms may threaten existing institutions, and what is important, technology

can magnify its impact. For example, legislators, judges, policy administrators, and managers may negotiate the significance of laws (Scott, 2003, pp. 885-886). When considering different relations between niche action and regime response, this concept can be useful as it indicates that time needs to pass for the existing institutional arrangements to allow the new ones to have the relevant impact on actors. For example, the distinction between niche actors and regime actors makes it possible to approach the problem of conflict between the “articulation of societal needs” and the “reluctance to change” existing institutional configurations (Kivimaa et al., 2019b, p. 113).

Although sustainability transition tends to be described as processes taking decades (Kivimaa et al., 2019), it does not mean that some experimentation does not take place in change-resistant sociotechnical regimes. That small-scale exploratory action can be accompanied (or followed or preceded) by regime destabilization that can involve significant changes in regime rules or removing support for non-sustainable technologies (Kivimaa, Kern, 2016). The other possibility for sustainability transition is regime optimization, which implies institutional change but of a different nature (Yang et al., 2022). The problem is how to make new institutional arrangements related to sustainability relevant in times when digital transition and the need to keep up with it come to the forefront.

Following Borrás and Edler (2020) and Münch et al. (2022), Colovic et al. (2025, p. 3) define the digital transition as “a process in which the adoption and diffusion of digital technologies take place at different levels in society, resulting in overwhelming changes in industries, sectors, value chains, and geographical areas”. The current digital transitions' main features are focused on finding new combinations between existing and new technologies, markets, and society (Colovic et al., 2025; Lee et al., 2018). This process covers such stages as conceiving digital technologies, designing digital technologies, facilitating the adoption and diffusion of digital technologies, or integrating those digital technologies into the operations of private and public organizations (Russo et al., 2022). For policymakers, the problem that is especially worth discussing is the relation between the need to support the digital transition and the promotion of the ethical use of technologies (Kenney et al., 2015). The task to be considered involves increasing its influence in the condition of high-speed technological change and the growing impact on the part of technological giants. Some additional points require further attention. It can be noticed that when digital technology becomes a critical facilitator of value co-creation, then it can be used for resource integration that impacts the kind of value created (Sklyar et al., 2019). What is more, Sklyar et al. (2019) pay attention to institutional rules within which the ecosystem can socially construct technologies and their resource value. While weakly linked actors can see operant properties of new technologies, they are not subjected to core rigidities that are to determine which resources (and how) should be integrated. That is why they can see those properties as resources that produce effects. Alternatively, they can be seen as operand resources, on which an act is performed. Then, as the example of Kodak and other strongly linked actors showed, the discovery of new resource integration patterns becomes more difficult (Sklyar et al., 2019, p. 978).

Kushida (2014) argues that national-level and socio-economic dynamics influenced the rapid disruptions experienced by global ICT industries. Here, the conclusion was that in the early stages of technological trajectories, local regulatory and technology choices can be key factors in shaping global industry disruptions (Kenney et al., 2015; Kushida et al., 2014). Kushida et al. (2014) emphasize the possibility of commoditizing previously high-value-added activities by new technological developments in the ICT sector. When new potential activities become enabled, dominant business models may become challenged (Kenney et al., 2015; Kushida et al., 2014).

As it has been stated above, a part of the discussion on digital transition and its consequences is related to how to use artificial intelligence, which is also discussed in the context of how AI can enable organisations to meet requirements regarding collecting and interpreting more data. When machine learning, algorithms, and other AI tools are used to disclose ESG-related information and generate a score based on it, more uniform and consistent disclosure scores for the stakeholders should be generated (Adi et al., 2015; Sharma, Banerji, 2024). Rating agencies may use AI tools to analyse the reports, which is why they can provide the investors with useful insights. One more interesting application refers to the use of machine learning techniques in the identification of “exaggeration” (that is, a specific way in which companies potentially overstate certain positive aspects of their actual environmental performance – Luo et al., 2025, p. 1) in ESG reports. Potential of AI to bring some uniformity and consistency is assumed when it comes to estimating the environmental performance (Billio et al., 2021; Sharma, Banerji, 2024). Kirikkaleli et al. (2025) showed that AI investment contributed to sustainable development in the USA. The investment in AI significantly impacts the achievement of SDGs. This is because AI can transform daily and repetitive operations in organizations. It should occur by integrating cutting-edge technologies and supporting data-driven policy development. However, the use of AI is also related to challenges. AI may require increased financial investment to upgrade the system. What is also important is that the societal pillar of the ESG can be worsened because AI tools may increase unemployment (Sharma, Banerji, 2024). In the case of policymakers, the task is to attempt to establish regulations and standards. They should enable users to use AI safely and ethically. The target would be to minimize risks and maximize the societal and economic benefits of AI investment (Kirikkaleli et al., 2025). In the case of organizations, the growing amount of data collected by them because of the adoption of new requirements related to ESG reporting may lead to the question about the role of organizational practices and structures created previously due to the need to collect data for certification purposes, resulting from the implementation of VEPs. Albert (2024) considers the use of artificial intelligence in preparing ESG reports in the context of growing expectations for those reports. Although it is believed that AI tools could help collect data and automate reporting to some extent, some reservations concerning its use could be observed, which was reflected by the pace of investment (Albert, 2024).

It is also worth mentioning that there are clear linkages between sustainability and digital transitions. When making comparisons between them from the point of view of actions performed by intermediaries, Colovic et al. (2025) emphasize that, to some extent, some forms of institutional work (like mobilization of actors to promote the transition by intermediaries) occur both in the field of sustainability transition and in the field of digital transition. In digital transition, similarly to the case of sustainability transition, the level of analysis (organization, network, ecosystem) is important since both the nature and the relevance of cultural-cognitive, normative, and regulative institutions differ depending on this level (Colovic et al., 2025, p. 5). When analysing the situation in the fashion industry, Sarker and Bartok (2024) attempt to uncover green transforming factors and digital shifting factors. The former set includes factors like e.g. green materials, green energy, and cleaner production. The latter set includes factors like artificial intelligence, the Internet of Things, and robotics. The task that should be assigned to practitioners and policymakers is to integrate green and digital technologies into the fashion industry. In general, the use of technology to drive sustainability was assessed as being central to both the green and digital transitions – a “symbiotic relationship” (Sarker, Bartok, 2024, p. 12) was observed between the green and digital transitions in this industry. This was due to the convergence of sustainability and technology.

To better understand the challenges that may result from many sources of pressure, models are created that discuss how actors, technologies, as well as rules and institutions, may change depending on a few factors related to regime actors, niche actors, landscape, and their interactions. Those models are believed to provide some help when discussing current topics. Hence, different transition pathways are proposed in the literature on socio-technical transitions. According to one of the propositions (built based on two dimensions, that is the timing of interactions among landscape, regime, and niche as well as the nature of multi-level interactions through which regime that have a competitive or symbiotic relationships with niche can be reinforced or disrupted) four transition pathways are possible (Geels et al., 2016; Geels, Schot, 2007): (1) landscape pressure impacts on the regime when disruptive niche-innovations are sufficiently developed (substitution pathway); (2) incumbent actors are stimulated by landscape pressure to gradually adjust the regime when niche-innovation are not sufficiently developed (transformation pathway); (3) symbiotic niche-innovations trigger adjustments under landscape pressure after being incorporated into the regime (reconfiguration pathway); (4) landscape pressure impacts on the regime when disruptive niche-innovations are insufficiently developed and next new regime around them is re-created (de-alignment and re-alignment pathway). This typology was next reformulated to consider agency and institutions (since interpretation and mobilization by actors influence landscape developments). The role to be played by institutions is especially important because institutional embeddedness, in addition to technical characteristics, determines whether niche innovations can be symbiotic or disruptive. The reformulated version is based on global conceptual logic and local logic of the transition pathways that refer to micro elements like ideas, decisions, etc. It is important

because the new model emphasizes the role of "shifting actor coalitions" (Geels et al., 2016, p. 897) in shifts between transition pathways (hence, to a lesser extent, those shifts are dependent on external landscape pressure). Below, an attempt is made to apply some assumptions of those models and previously presented insights to discuss the main problem outlined in this paper.

4. Discussion

Hinings et al. (2018) admit that, on the one hand, a huge amount of data available causes AI systems to have fast improvement. On the other hand, examples from the past show that considerable periods are needed for institutional changes to take place (e.g., 5-10-year time horizons that may be needed for regulators and policymakers). This time leg can be interpreted as the time for experimentation. Then, companies may look for appropriate business models. Nevertheless, this appropriateness is determined by society. The issue that emerges is to consider what institutional arrangements should look like for VEPs to have a broader impact on organizations and society in general. The assumption is that when EMAS, like other VEPs, is exposed to the diffusion-impact paradox (Hurst et al., 2025) for its navigation to be conducted effectively, there is a need for specific institutional arrangements. The lens of institutional theory may be helpful when considering the possibilities for defining appropriate institutional arrangements. Issues required by the EMAS policy tend to be obligatory as new institutional arrangements are to be implemented in the context of an increasingly demanding regulatory mandate that is related to growing technological possibilities. Even from the point of view of organizations with extensive experience in collecting information, such new conditions can be challenging. To exploit opportunities that can be derived from the transitions, companies need to redesign their activities to align them more with the emerging approaches. The problem can be considered as the issue of new institutions attempting to support or replace old ones. The model of transition pathways suggests, e.g., the path that would involve integrating new institutional arrangements with existing ones. However, to understand how this integration should take place, an analysis of different elements of institutional arrangements should be performed.

Although it is possible to indicate that research shows positive conclusions related to the real impact of EMAS, some difficulties still need to be solved (Table 1). Conducted interviews showed that new requirements to report more data can make assessing the efforts put into implementing and maintaining EMAS problematic. Nevertheless, it could be possible to consider what people responsible for EMAS or other VEPs in companies can do to make existing institutions more aligned with the requirements of the organizational world currently under a socio-technical transition. This issue can also be important from the point of view of

how new technologies can be integrated into the socially constructed system of norms, beliefs, and values. On the one hand, the adoption of new digital technologies can be hampered by informal institutions (Van De Kerkhof, Noorderhaven, 2019). On the other hand, digital transition can affect institutional arrangements while digitalization occurs through resource integration (Sklyar et al., 2019). What is important, Hinings et al. (2018) assume that existing institutional arrangements are decisive factors in gaining acceptance by novel institutional arrangements. When applied to digital transformation (defined as "the combined effects of several digital innovations bringing about novel actors (and actor constellations), structures, practices, values, and beliefs that change, threaten, replace or complement existing rules of the game within organizations, industries or fields - Hinings et al., 2018, p. 53), this assumption allows researchers to outline important implications for practice. When encouraging researchers to apply the institutional perspective to study digital innovation and transformation, Hinings et al. (2018) identify three types of novel institutional arrangements critical for digital transformation: digital organizational forms, digital institutional infrastructures, and digital institutional building blocks. The institutional perspective implies that companies are expected to align with appropriate behavior constituted by social expectations and prescriptions. Socio-cultural beliefs are so important because, for organizations to gain acceptance, it is important to consider the existence of different kinds of pressures from outside. Hinings et al. (2018) emphasize that even in the case of the rapid and unprecedented disruption, existing institutional arrangements do not disappear, and the need to change can still be challenged by them.

For monitoring the compliance of organizations with existing institutions (especially socio-cultural rules of the game – Hinings et al., 2017), there is a need for institutional infrastructure consisting of the most important actors within the field, as well as various events. The reasoning behind institutional theory that pays attention to the issues of adaptation of organizations to the environment is that those organizations are not "purely rational actors" (Hinings et al., 2018, p. 53). In addition to linking different actors, the institutional infrastructure is to provide governance and establish legitimate logic among others (Hinings et al., 2018, p. 55). The next important issue is to understand how, in each institutional context, a digitally enabled arrangement of practices (that is, a novel organizational form), structures, and values is perceived in the eyes of its users. The issue is that what constitutes an organization is changing. What are the elements of this new organizational form the most important from the point of view of possibilities for this form to be established? The issue of legitimacy is even more underlined when considering proposal for the concept of digital institutional building blocks. Hinings et al. (2018, p. 54) define them as "generally-accepted, ready-made or customizable modules encompassing sets of digital technologies for running or creating an organization". Each building block needs its own legitimacy and collective legitimacy for a new institutional arrangement. Following Berente and Yoo (2012) as well as Majchrzak and Markus (2012), Hinings et al. (2018, p. 55) pay attention to special features of those building blocks, like having

a value-laden design or having a varying degree of "the action potential or what people can do with it".

Regarding all the above-mentioned digital innovations, emphasize the importance of relationships among new, existing institutional arrangements and timing as important to possible solutions to how organizations can pursue advantageous VEPs while at the same time they need to adjust to new requirements. The question related to the impacts of those innovations on organizations can be the starting point for the further analysis: if the pressures from the external environment for collecting more data arise when technologies to deal with them are not sufficiently developed, how should organizations create their digital institutional infrastructures and building blocks while at the same time allowing for their organizational forms to be built on digital solutions to the growing extent?

The necessity for developing new solutions (as elements of digital institutional building blocks) that can make it possible for organizations to deal with sustainability and digital transition challenges may lead to the acceleration of investments in new technologies made by actors possessing sufficient resources and obliged to meet new requirements earlier or to the development of hitherto used solutions by actors having fewer resources but obliged to meet new requirements later. From the point of view of further participation in VEPs, it may mean the necessity to create internal solutions that should allow organizations to meet hitherto unmet requirements and, at the same time, to take at least some steps towards meeting new obligatory requirements. Then it becomes clear that when comparing the situation of actors having fewer resources but obliged to meet new requirements later to the situation of actors possessing sufficient resources and obliged to meet new requirements earlier, the emphasis that needs to be put on the translation of new institutional arrangements is greater for the category of actors having fewer resources. Instead of using externally acquired tools to deal with new requirements, regardless of the importance of those activities from the point of view of the meaningfulness of the maintenance of the participation in VEPs, they must deal with the problems of changing hitherto existing solutions due to the need for wider use of already possessed tools. However, if it turns out that those new solutions are not suitable, then thanks to a more gradual approach to their adoption, the existing institutional arrangements maintained can be of some help to them and not a source of disturbance. It also means that the pressure for the increase in the demands to be met by actors having fewer resources can appear, and because of this, the cognitive legitimacy for those solutions may decrease, but moral legitimacy may increase.

The necessity for developing new solutions (as elements of digital institutional infrastructure) that can enable effective management of data can be assumed to lead to the dominance of weak ties among actors responsible for the field functioning, experienced especially by actors having fewer resources but obliged to meet new requirements later. This can be advantageous for them since it enables the infusion of new ideas from outside. In this way, it contributes largely to the translation of new institutional arrangements.

From the point of view of further participation in VEPs, it may mean the necessity to maintain organizational focus on collecting evidence and, at the same time, to create a sense of participation in VEPs as the reason for maintaining the cooperation. This can allow organizations to prove the necessity of participating in those programs. Here, the pressure for the increase in cognitive legitimacy can appear as well. Again, when comparing those actors' situation to those who possess sufficient resources and are obliged to meet new requirements earlier, the interaction between institutional arrangements is more inclined towards integrating than replacing existing institutional arrangements with the new ones. In the case of actors possessing sufficient resources, faster implementation of new digital tools due to strong ties may expose them to the risk of overlooking possible harmful effects of using those tools on solutions and motivations on each hierarchical level of the organization.

The necessity for developing new digitally-enabled solutions (as part of their organizational forms) that can enable effective participation of organizational members in processes performed potentially to a greater extent with the support of new technologies can lead to emphasis on the creation and permanent development of suitable organizational structures (e.g. ESG teams) by actors possessing sufficient resources and obliged to meet new requirements earlier and to the more dispersed distribution of those responsibilities adopted by actors having fewer resources but obliged to meet new requirements later. From the point of view of further participation in VEPs, it may mean for both categories of actors, the necessity to find new motivational factors that can be more focused on the possibility to engage in the activities for the environment in itself than on the chance to boast in collecting data showing good environmental performance since those processes of collecting data are to become automated to the greater extent as well as the environmental data are to be only the small part of the all collected data. It can again demand an increase in the moral legitimacy of VEPs, as the perceived results should be outstanding and become a source of motivation for employees.

5. Conclusions

The abovementioned analysis derives from both practical insights and conclusions formulated in the literature. Although the results of implementing VEPs (including EMAS) are not easy to assess, there is much evidence that engaging in the additional activities resulting from those programs may impact organizations. It appears to be justified to say that sustainability and digital transitions are leading to more obligatory demands. Moreover, The issue is that although those changes are not directed at worsening organizational performance in the discussed fields, the risk emerges that organizations attempting to adapt to those new requirements can withdraw from some practices that were good for them, their

employees, and the business environment. Those factors were starting points for the analysis presented in this paper.

The analysis has some limitations. It should be emphasized that the solutions proposed in the paper are general, and there is a possibility of developing them by making references to all pillars of institutions and carriers that can be used to convey them. To achieve this aim, the concept of institutional work (Lawrence, Suddaby, Leca, 2009) can be applied. Considering that so-called institutional logics (cf. Janiszewski, 2022) may result in tensions within and among different categories of actors, it is reasonable to notice the need to attempt to define “a multiplicity of institutional work strategies of a multitude of actors” (Yang et al., 2022, p. 754). Studying institutional work that actors perform can bring interesting results in the interplay between sustainability and digital transition. The importance of institutional work under such conditions may result from the changes in routines and behaviors that economic agents may require (Colovic et al., 2025; Redmond, 2003). What is more, since routines are based on tacit knowledge (Scott, 2003), when attempting to change routines, the practitioners may also be forced to engage in new relationships. This is because the situation may make them need to externalize their knowledge (Nonaka, 1994). Those issues are important since discussion on how AI can change reporting occurs, and it may appear to be important to consider the types of policies to be changed. However, at the same time, considering how it can impact daily work is equally important. In the current analysis, this issue was presented as possibly causing organizational members to be disturbed by institutional changes. However, this issue can be analyzed in greater detail, which is why the concept of identity work (Watson, 2016) may be useful to implement as well.

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Footnotes

- ¹ The action of niche actors does not have to be understood as challenging the existing institutional arrangements. Similarly, the action undertaken by regime actors does not have to be understood as defending those arrangements. It is possible to make different assumptions about which regime actors promote niche or niche actors do not want to destabilize the regime (Yang et al., 2022). For this paper, the abovementioned distinction will be interpreted in such a way that two categories of actors can be recognized. The first category refers to actors that possess sufficient resources, thanks to which they can adapt to changing circumstances up to date, and they are inclined to defend them. The second category refers to actors that do not possess sufficient resources to avoid difficulties when adapting to changing circumstances and are inclined to challenge or delay changes.

HUMAN-MACHINE COLLABORATION IN 3PL SERVICES – BIBLIOMETRIC ANALYSIS

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Purpose: The purpose of this study is to examine the state of research on human-machine collaboration (HMC) in the third-party logistics (3PL) sector through bibliometric analysis, with a focus on identifying dominant research streams, knowledge gaps, and future directions.

Design/methodology/approach: The study applies bibliometric methods to a dataset of 299 publications retrieved from the Scopus database. Using VOSviewer software, keyword co-occurrence networks and thematic clusters were generated to capture the structure of the literature. The analysis covers scientific articles, conference papers, and review papers published up to September 2025.

Findings: The results reveal five main thematic clusters: decision support systems and 3PL provider selection, supply chain management and digital market contexts, optimization and metaheuristics in logistics operations, 3PL services and economic conditions, and outsourcing and digital transformation. The analysis shows a strong emphasis on technological aspects such as artificial intelligence and decision support, whereas strictly human-centric issues such as ergonomics, trust, and acceptance are less prominent. The findings indicate that HMC is often framed implicitly through automation and AI, leaving space for more explicit research on socio-technical interactions.

Research limitations: The study is limited to Scopus-indexed publications and relies on bibliometric techniques, which emphasize frequently occurring terms and may underrepresent emerging or niche topics. Qualitative insights from case studies or in-depth empirical research are not captured.

Originality/value: This research contributes to the understanding of HMC in 3PL services by providing a structured overview of publication dynamics, thematic clusters, and global research distribution. The study also identifies specific areas where research remains scarce, particularly on the human side of collaboration, and points to directions for future investigation. Greater attention to human factors – such as trust, acceptance, and ergonomics – should complement technological progress.

Keywords: 3PL, human-machine, bibliometric analysis.

Category of the paper: Research paper.

1. Introduction

Over the past two decades, technologies such as advanced analytics, automation, and artificial intelligence have reshaped supply chains, particularly in the areas of demand forecasting, transport coordination, and warehouse management. Logistics operators, particularly third-party logistics (3PL) providers, face increasing pressure to improve efficiency, reduce costs, and ensure high-quality customer service under conditions of global competition. In this context, the use of tools based on artificial intelligence, automation, and cyber-physical systems, which support the planning, monitoring, and execution of logistics operations, has gained increasing importance (Ivanov, Dolgui, 2020). One of the key issues accompanying these transformations is human-machine collaboration (HMC). In practice, HMC combines human strengths – such as adaptive decision-making and problem solving – with machine capabilities in rapid data processing and precision execution (Wilson, Daugherty, 2018). The literature emphasizes that the effective implementation of HMC is a necessary condition for fully exploiting the potential of Industry 4.0 and Logistics 5.0 and at the same time reshape managerial approaches in 3PL services (Loo, 2025; Klumpp, Zijm, 2019).

Existing studies indicate that applications of HMC in logistics include order picking with the involvement of collaborative robots, transport route optimization, demand forecasting, and warehouse process automation (Ramachandran Venkatapathy et al., 2017; Yang et al., 2025). At the same time, attention is drawn to a number of challenges associated with implementing such solutions, including issues of trust in artificial intelligence systems, employee acceptance, and the design of ergonomic human-machine interfaces (Pantera et al., 2024; Haesevoets et al., 2021). Consequently, there is a need for in-depth literature analyses that can capture the current state of knowledge and identify key areas for further research. Bibliometrics, as a tool for the quantitative analysis of scientific publications, makes it possible to identify research trends, authors, institutions, and thematic areas that dominate a given field (Donthu et al., 2021; Aria, Cuccurullo, 2017). Its application in the context of research on HMC in 3PL services allows for obtaining an objective picture of the literature structure, as well as identifying research gaps and future directions.

The purpose of this article is to conduct a bibliometric analysis of the literature on human-machine collaboration in the 3PL services sector. The analysis is based on data obtained from the Scopus database and was conducted using the VOSviewer software. The results of the study enable the determination of publication dynamics, the identification of key authors, countries, and sources, and the presentation of a keyword co-occurrence map that reflects the main research streams in this field.

2. Theoretical background

Human-machine collaboration (HMC) is currently one of the most important areas of research on digital transformation in logistics and the operations of 3PL providers. In the context of increasing complexity in global supply chains, the integration of human competencies and the potential of artificial intelligence and automation allows for achieving synergistic effects that translate into both operational efficiency and social acceptance of new management models (Dashaputre, 2023; Jarrahi, 2018). The origins of artificial intelligence date back to the 1950s; however, practical applications in logistics only emerged with the development of data analytics and computing power in the 2000s (Dashaputre, 2023). Initially, these technologies primarily supported routine tasks such as route planning and demand forecasting (Russell, Norvig, 2020). Over time, their applications expanded to decision-making processes and tasks requiring greater human-machine interaction (Haesevoets et al., 2021).

Research shows that the greatest benefits are achieved in hybrid models, where decisions result from collaboration rather than competition between humans and technology. Wilson and Daugherty (2018) emphasize that organizations gain the most when AI supports humans in decision-making rather than completely replacing them. This approach is also relevant to 3PL services, where automation and human competencies are combined in areas such as order picking, transport planning, and documentation handling. The development of Industry 4.0 has brought the proliferation of cyber-physical systems (CPS) and the Internet of Things (IoT), which in logistics have enabled the decentralization of process control (Schuhmacher, Hummel, 2016). In the next phase – Industry 5.0 and Logistics 5.0 – the focus shifts to human-centric manufacturing and value-driven supply chains, where humans regain a central role as creative and adaptive partners to machines (Loo, 2025). Ramachandran Venkatapathy et al. (2017) indicate that in intralogistics, the synergy of humans and machines is made possible through digital twins and real-time data analytics. Yang et al. (2025) demonstrate that considering learning and forgetting effects among employees can significantly improve planning system performance, which is particularly important for 3PL providers, where workforce turnover is high.

The implementation of human-machine collaboration requires appropriate human-machine interfaces (HMI), which should be intuitive, ergonomic, and ethically designed. Pantera et al. (2024) emphasize that HMI design within the Industry 5.0 paradigm should focus on user needs and the creation of environments conducive to collaboration. Similarly, Seeber et al. (2020) note that treating machines as “coworkers” in teams requires redefining communication rules and shared responsibility. The acceptance of machines as partners in logistics processes is not straightforward. Haesevoets et al. (2021) showed that managers prefer a model in which machines have a limited decision-making role (about 30%), with humans holding the dominant

position. This reflects the phenomenon of algorithm aversion, described by Dietvorst et al. (2015), whereby people avoid using algorithms if they observe an error, even if such solutions are statistically more accurate. At the same time, studies indicate that in many tasks AI outperforms humans – for example, in medical diagnostics or forecasting (Grove et al., 2000; Wang et al., 2020). Building trust models that enable constructive collaboration is therefore crucial. McAfee and Brynjolfsson (2017) note that it is not “competition” with machines but rather the ability to use them effectively that determines competitive advantage.

Klumpp (2018, 2019), however, warns against the risk of creating an “artificial divide” between humans and AI systems, which could weaken the social sustainability of logistics processes. In this context, Fleming et al. (2019) argue that the future of work requires a new approach to human-technology relations, in which soft skills, empathy, and collaboration abilities become as important as technical skills. In practice, 3PL providers are increasingly implementing human-machine collaboration models that combine the capabilities of cobots, automated transport systems, and demand forecasting algorithms. Such solutions not only increase efficiency but also support sustainable development goals by reducing resource consumption and enhancing workplace safety (Klumpp, Zijm, 2019). Malone (2018) highlights that future organizations will operate as “superminds”, combining the potential of humans and machines to solve complex problems. Bigman and Gray (2018) add that a particular challenge is the development of ethical frameworks that define the scope of human and machine responsibility in critical situations. In the case of 3PL, this is significant not only for operational efficiency but also for legal and social accountability. Human-machine collaboration in 3PL logistics constitutes a key element of the sector’s transformation. It requires, on the one hand, investments in technological development and, on the other, building trust and developing employee competencies. Only then will it be possible to fully exploit the potential of HMC synergy as a foundation for resilience and innovation in future logistics.

3. Methods

In this study, bibliometric analysis was chosen because it allows a structured examination of scientific output on HMC in 3PL logistics, highlighting publication trends, co-author networks, and keyword patterns. (Donthu et al., 2021). By employing tools such as VOSviewer or Bibliometrix, it is possible to visualize relationships between publications and concepts and to create science maps. The literature highlights that bibliometrics is particularly applicable in the social sciences, management, and logistics, where the dynamic development of new technologies and concepts requires continuous assessment of research directions (Aria, Cuccurullo, 2017). These methods rely on the analysis of large bibliographic datasets (e.g., from Scopus or Web of Science), which allows for the objective capture of phenomena

that cannot be identified solely through traditional literature reviews. As Zupic and Čater (2015) note, bibliometrics enables not only a quantitative summary of research but also the creation of intellectual maps that reveal relationships between research streams. For this reason, it constitutes a valuable tool in identifying research gaps and directions for future analysis. In this study, a five-stage procedure (Figure 1) was adopted, presented in the diagram. Each step was designed to reflect a key stage of the bibliometric process, ensuring that the outcomes remain coherent and interpretable.

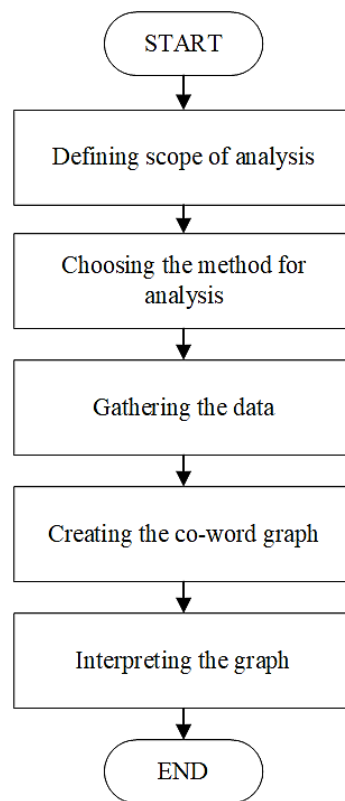


Figure 1. Bibliometric analysis procedure.

Source: own elaboration based on Donthu et al. (2021).

The first stage was to define the subject and scope of the analysis. The study focused on the issue of human-machine collaboration in the context of 3PL logistics providers. The time frame covers publications released up to September 2025, and the analysis included scientific articles, conference papers, and review papers. A precise definition of the research objective makes it possible to limit the number of analyzed documents to those relevant to the research topic. The second stage involved identifying the analytical technique. A keyword co-occurrence analysis was applied, which allows for the identification of thematic clusters and the main research streams in the analyzed area. This is one of the most commonly used methods in bibliometric studies, as it enables capturing the structure of the examined field of knowledge and the relationships between concepts (Aria, Cuccurullo, 2017). The tool used for constructing and visualizing the co-occurrence network was VOSviewer.

In the next step, bibliographic data were collected from the Scopus database. This is one of the largest and most reliable databases indexing scientific publications in the social sciences, technical sciences, and natural sciences. Table 1 presents the query used for data retrieval.

Table 1.
Query used in bibliometric analysis

Advanced search in SCOPUS based on query:
TITLE-ABS-KEY(("human-machine collaboration" OR "human-machine collaboration" OR "human-machine interaction" OR "human-computer interaction" OR "human-AI collaboration" OR "human artificial intelligence collaboration" OR "man-machine collaboration" OR "cobotics" OR "collaborative robots" OR "human-robot interaction" OR "automation" OR "autonomous systems" OR "decision support systems" OR "artificial intelligence" OR "cyber-physical systems" OR "logistics 4.0" OR "logistics 5.0") AND ("3PL" OR "third-party logistics" OR "third party logistics" OR "logistics service provider" OR "logistics service providers" OR "outsourced logistics" OR "contract logistics" OR "logistics outsourcing" OR "logistics operator" OR "logistics providers")) AND (LIMIT-TO(DOCTYPE, "ar") OR LIMIT-TO(DOCTYPE, "re") OR LIMIT-TO(DOCTYPE, "cp")) AND (LIMIT-TO(LANGUAGE, "English")) AND (EXCLUDE(SRCTYPE, "k"))

Source: own work.

The data were obtained in CSV format, containing information on publication titles, authors, keywords, sources, and citation counts. These data form the basis for further quantitative and qualitative analysis. Based on the collected records, a keyword co-occurrence network was developed. This process includes, among other steps, identifying the frequency of individual terms, establishing thresholds for the minimum number of occurrences, and analyzing the strength of associations between words. The result is a map visualizing thematic clusters that represent the main research areas related to the examined issue.

The final step was the interpretation of the results. The analysis of keyword clusters enables the identification of dominant research areas, such as the automation of logistics processes, the role of artificial intelligence in 3PL services, and the social aspects of human-machine collaboration. The interpretation of the map allows for linking the results with the existing literature, as well as identifying potential research gaps and future directions.

4. Results

Based on the Scopus query, a set of 299 publications related to the issue of human-machine collaboration in 3PL services was obtained (Figure 2). This number was large enough to capture diverse research streams, while still keeping the co-occurrence map clear and free from excessive noise. The VOSviewer software was used to construct the keyword co-occurrence network, with the settings shown in the figures. Node size was defined based on the number of occurrences (Weights: Occurrences), which made it possible to highlight the most frequently used terms in the research. Labels were limited to a maximum of 30 characters, and the graphic layout was enriched with colored, curved lines illustrating the strength of associations between individual terms. The use of the Cluster Colors option allowed for the visual separation of thematic clusters, which greatly facilitates the interpretation of the map. The analysis employed the Association strength normalization method, commonly used in bibliometric studies, as it ensures a balance between frequency of occurrence and co-occurrence strength of terms. Default layout settings were applied (attraction = 2, repulsion = 0), which allowed for generating a clear network structure. The clustering process was carried out at a resolution of 1.0 with the Merge small clusters function enabled, thus capturing the main thematic groups while avoiding fragmentation of the map.

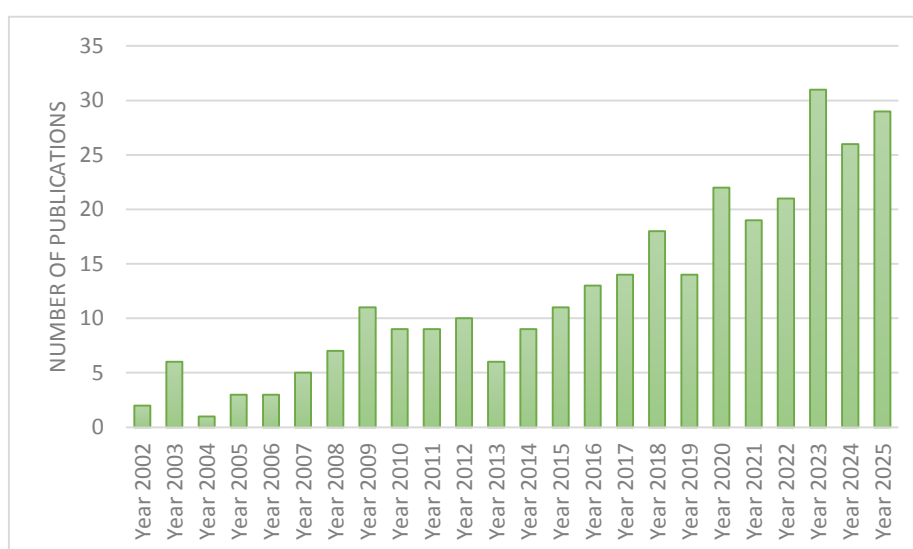


Figure 2. Number of publications per year.

Source: own work.

The analysis of the annual number of publications indicates a clearly increasing interest in the issue of human-machine collaboration in the context of 3PL providers (Figure 2). In the initial period (2002-2010), the number of articles was relatively low and did not exceed a dozen publications per year, confirming the exploratory nature of the research. Between 2011 and 2017, a gradual increase in interest was observed, followed by a marked acceleration in publication dynamics after 2018. Particularly noteworthy is the period after 2020, during

which the number of publications increased significantly, reaching its highest level in 2023 (over 30 publications). The upward trend suggests that HMC has become a recognized research area within logistics and 3PL services. This increase coincides with broader supply chain digitalization and with the practical roll-out of AI-driven tools such as automated picking systems and predictive analytics. Figure 3 presents the percentage share of individual publication types in the total number of publications.

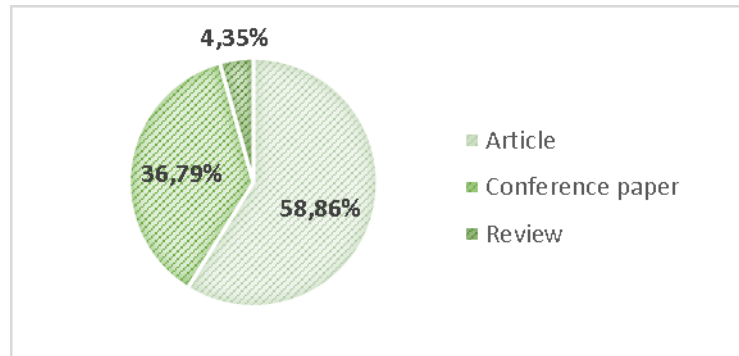


Figure 3. Shares of particular publications types.

Source: own work.

The structure of the analyzed set of publications indicates that the dominant form is scientific articles, which account for 58.86% of all documents (Figure 3). Conference papers rank second (36.79%), suggesting that research on human-machine collaboration in the context of 3PL is a dynamically developing area, often presented at academic and industry forums prior to journal publication. Review articles constitute a small share (4.35%), which confirms that this field is still in a phase of intensive exploration and that the literature is only beginning to undergo systematic syntheses. These results highlight the need for further review studies and meta-analyses that could organize the existing knowledge and indicate directions for future research. Figure 4 shows the number of publications in the top 10 countries based on the number of authors affiliated with the publications.

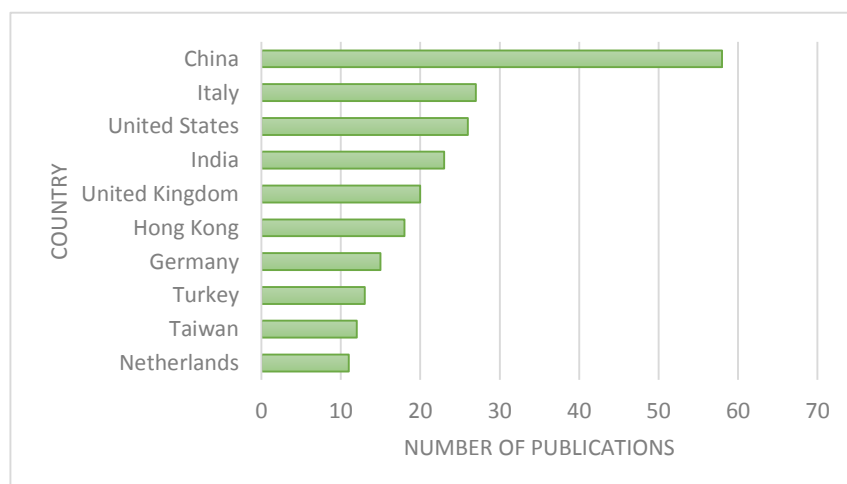


Figure 4. Number of publications in TOP10 countries (accordingly to affiliations numbers).

Source: own work.

The co-occurrence map (VOSviewer, association strength normalization, weights = occurrences, colors = clusters) for the set of 299 records reveals five distinct thematic clusters:

- Cluster 1 (red) – Decision support systems and 3PL provider selection.
- Cluster 2 (blue) – Supply chain management (SCM) and digital market contexts.
- Cluster 3 (green) – Optimization and metaheuristics in 3PL operations.
- Cluster 4 (purple) – 3PL as a service category and the economics of operations.
- Cluster 5 (yellow) – Outsourcing and digital transformation.

The first cluster encompasses issues related to decision support systems and the selection of 3PL providers. At its core are terms such as decision support systems, logistics providers, supplier selection, AHP, fuzzy logic, and data mining. This cluster highlights a concentration of research on methods supporting the evaluation, selection, and management of logistics providers. The second cluster focuses on supply chain management and digital market contexts. The most important concepts include supply chain management, electronic commerce, forecasting, information systems, real-time systems, and freight transportation. This indicates a strong link between research on 3PL and the development of e-commerce and the digitalization of logistics processes.

The third cluster covers optimization and the application of metaheuristics in logistics operations. It is dominated by terms such as vehicle routing, scheduling, optimization, genetic algorithms, ant colony optimization, linear programming, and transportation. Research in this cluster addresses operational challenges common to 3PL providers, such as vehicle routing in last-mile delivery or the use of metaheuristics for large-scale scheduling. The fourth cluster directly addresses 3PL services and their economic conditions, with terms such as 3PL, third-party logistics, logistics services, costs, investments, competition, warehouses, and manufacture. This cluster includes research concerning the role and scope of services provided by operators, as well as their impact on cost efficiency and business competitiveness. The fifth cluster relates to outsourcing and digital transformation, including the concepts of Industry 4.0 and Logistics 4.0. At its core are outsourcing, Industry 4.0, and Logistics 4.0, which connect the issue of external service providers with processes of digitalization and automation in logistics.

Two central “hubs” – artificial intelligence and decision support systems – have the highest total link strength, serving as bridges between the methodological optimization cluster (green) and the application-focused 3PL clusters (purple) and supplier selection (red). This reflects a pattern of AI/DSS → decision-making → 3PL operations. Outsourcing lies at the intersection of 3PL and digital transformation, confirming that a significant portion of the literature conceptualizes 3PL primarily as a tool for outsourcing logistics functions rather than solely as a network integrator. Warehouses appears near the DSS and 3PL nodes, pointing to a large body of research on decision-oriented warehouse automation (e.g., technology selection, automation levels, resource planning).

Strictly “human-centric” terms (human-robot interaction, cobotics, HMI/HMC) are less represented or peripheral – the theme of human-machine collaboration in 3PL is most often implied through the presence of AI/DSS/automation, and less frequently explored as a distinct research thread. This highlights a research gap concerning the role of humans (trust, acceptance, ergonomics, XAI) in 3PL processes.

5. Discussion

5.1. Findings

The findings of this study confirm that research on human-machine collaboration (HMC) in 3PL services is expanding rapidly, with a notable focus on artificial intelligence, decision support systems, and logistics process automation. However, the bibliometric analysis also shows that strictly human-centric aspects, such as ergonomics, acceptance, and trust, remain underrepresented. This observation aligns with Grosse (2024), who emphasized that despite significant technological progress in supportive and substitutive solutions for order picking, human factors continue to be central determinants of operational outcomes. In particular, Grosse’s content analysis highlights that while technologies such as augmented reality, exoskeletons, or automated guided vehicles can enhance efficiency, their adoption is constrained by psychosocial aspects, resistance to change, and concerns over job autonomy. These insights reinforce our observation that human-centric considerations in HMC research are often marginalized in favor of efficiency-driven perspectives.

In parallel, the role of HMC extends beyond warehouse operations to the wider supply chain context. Lv et al. (2018) illustrate this by proposing a human-centered IoT-based framework for omni-channel logistics services, which directly links consumer behaviors with logistics operations. Their model suggests that IoT-enabled, human-centered systems can ensure seamless omni-channel experiences by integrating customer data, in-transit inventory, and flexible delivery solutions such as crowd-sourced transport. This perspective broadens the interpretation of HMC in logistics, moving it from an operational tool within the warehouse to a systemic enabler of customer-centric supply chain management. Compared to our bibliometric findings, this indicates that future research should more strongly connect HMC with omni-channel distribution and digital retail transformation.

Results confirm earlier literature emphasizing the hybrid nature of HMC models, where humans and machines complement rather than replace each other (Wilson, Daugherty, 2018; Haesevoets et al., 2021). Yet, the dominance of AI and DSS as central nodes in bibliometric maps reveals that the literature frequently frames HMC implicitly through technological components, rather than explicitly analyzing the socio-technical balance. This corresponds with

Klumpp's (2018, 2019) concern about an "artificial divide" between humans and AI systems, which could undermine social sustainability.

5.2. Limitations and further research

The study is not without limitations. First, the bibliometric analysis was restricted to Scopus-indexed publications, which, although comprehensive, may omit relevant studies published in other databases or in grey literature. Second, the use of co-occurrence analysis privileges frequently used terms, potentially underrepresenting emerging but less frequently mentioned concepts such as trust-building mechanisms, algorithm aversion, or gamification in logistics. Third, while the bibliometric method provides a structured overview of research trends, it does not capture the depth of qualitative insights that case studies or ethnographic research could provide regarding HMC implementation in 3PL services.

Future research should build on the identified gaps by integrating human-centric factors into analyses of HMC in logistics. As emphasized by Grosse (2024), further empirical studies are needed to evaluate the psychosocial impacts of supportive and substitutive technologies, including stress, motivation, and job satisfaction, particularly in hybrid order picking environments. The IoT-based framework proposed by Lv et al. (2018) indicates the potential for combining HMC with dynamic inventory management, crowd-sourced delivery, and big data-driven customer experience optimization. Exploring how 3PL providers can align HMC practices with omni-channel retailing will be a critical research area. Building on earlier calls for ethical frameworks (Bigman, Gray, 2018), further research should address responsibility-sharing, liability, and transparency in AI-supported decision-making in 3PL operations. As suggested by recent works in logistics technology, integrating digital twins with HMC could support predictive analytics, adaptive scheduling, and ergonomic interventions in 3PL networks.

6. Conclusions

The analysis examined how human-machine collaboration (HMC) has been addressed in research on third-party logistics (3PL) services. The results confirm that the field has gained increasing attention over the past two decades, with a particularly dynamic growth after 2020. The analysis highlighted the dominant role of artificial intelligence, decision support systems, and process optimization methods in shaping the current research landscape. At the same time, human-centric aspects such as ergonomics, trust, and employee acceptance remain underexplored, despite their critical importance for the successful implementation of HMC in logistics. The results demonstrate that HMC in 3PL services is most often framed through technological solutions, while explicit discussions of the human dimension are less frequent.

Nevertheless, evidence from the identified thematic clusters suggests that the integration of human competencies with machine capabilities offers significant opportunities for improving operational efficiency, flexibility, and resilience of logistics networks. From a managerial perspective, the study underlines the necessity of developing strategies that not only focus on technological investments but also address organizational culture, workforce development, and the design of collaborative processes. The global distribution of publications further emphasizes that HMC is a universal challenge and opportunity for logistics service providers across different regions and market conditions.

Looking ahead, future research on human-machine collaboration (HMC) in 3PL services should move toward longitudinal and interdisciplinary approaches. Longitudinal studies could capture how the integration of human and machine roles evolves over time, particularly in environments characterized by high employee turnover and rapid technological change. Interdisciplinary research that combines logistics, computer science, and organizational psychology would make it possible to investigate not only operational efficiency but also behavioral and cultural dimensions of HMC adoption. Moreover, expanding bibliometric analyses with complementary methods – such as systematic literature reviews or meta-analyses – could help validate bibliometric findings and provide a more holistic understanding of the field. Finally, close collaboration with industry stakeholders may facilitate the development of experimental or pilot studies that test the practical application of HMC models in real-world logistics operations, thereby bridging the gap between theory and practice.

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ACTIVITIES OF DAIRY COOPERATIVES FROM THE SOUTH-EASTERN POLAND IN THE AREA OF FINANCIAL SERVICES

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Purpose: Identification of activities of value creation for customers from different geographical markets in the area of financial services.

Design/methodology/approach: Direct interviews using a questionnaire survey were conducted among representatives of dairy cooperatives from southeastern Poland representing 33% of the population, which resulted from the willingness to participate in the survey.

Findings: Activities of offering additional financial services while selling own products are not provided by most of cooperatives for different kind of customer groups from different geographical markets. There are clear differences in the approach to offering additional financial services when selling their own products between cooperatives from different voivodeships.

Research limitations/implications: The limitation of the study is the number of cooperatives and the geographic area examined.

Originality/value: The comparison of financial services provided and outsourced by selected cooperatives from southeastern Poland voivodships.

Keywords: financial services, customer value creation, cooperatives.

Category of the paper: Research paper.

1. Introduction

A market offering is something separate that has a group of features that can be physical or not, clear or unclear, and might be seen by possible buyers as something that meets their needs (Hunt, 2000, p. 43). If a seller has more valuable things to offer, customers will want to keep relationship with them. Trust and communication are important for building good relationships between customers and sellers. But these relationships can also depend on specific service features. These include things like service customization and waiting time. Customers notice, judge, and value these features (Hansen, 2010, pp. 4-5). Companies can create a comparative

advantage for nonfinancial firms over financial intermediaries in providing short-term corporate financing to their customers (Barrot, 2016, p. 1982). Short-term corporate financing aims to create customer value and in consequence retaining existing customers, capture new business, attract specific customers and achieve specific marketing aims. Short-term corporate financing can serve as a versatile marketing and relationship management instrument and/or as a way to convey details to the market or certain customers regarding the company, its offerings, and its future intentions (Summers, Wilson, 2003, p. 439).

The aim of this article is to identify the activities of value creation for customers from different geographical markets in the area of financial services. Activities have been divided into the performed activities, outsourced and controlled activities, outsourced and uncontrolled activities, and activities that are not present in the cooperative.

- H1: Most cooperatives offer additional services in the form of financial services while selling their products to consumers.
- H2: Cooperatives that provide additional activities in the form of financial services prefer to offer them for their customers from home voivodeship market than from other markets.
- H3: Cooperatives prefer to control additional activities in the form of financial services for their customers that are outsourced to external entities than to provide them by themselves.
- H4: Cooperatives from different voivodeships in similar extend provide additional activities in the form of financial services for their customers.

2. The characteristic of selected financial services offered by nonfinancial companies to their customers

A non-financial company can offer its customers a range of financial services that not only support sales but also build long-term business relationships by creating value for the customer. Among the many forms of such services, we can distinguish: trade credit, assets leasing, installments or installment systems (BNPL), factoring, financial advice, add-on insurance, loyalty programs with financial elements:

1. Companies that have the capacity to give loans can serve as lenders to their customers by allowing them to delay payments for what they buy (Karaca, 2023, p. 156). This way of financing is called trade credit. Trade credit is a deal between a seller and a buyer, in which the seller lets the buyer buy items on account without needing to pay in cash or through a bank right away. This deal gives the buyer the chance to use their purchases to earn money before settling their bills with the sellers. Additionally, trade credit offers convenience to both trading partners since it helps reduce the financial strain that immediate payments would create (Jou, Li, Wang, 2023, p. 1). It is enhancing financial results, decreasing costs of transactions, and improving the effectiveness of managing

inventory, along with lessening financial struggles for the recipient of trade credit, particularly during challenging periods (Karaca, 2023, p. 156). Trade credit is an important source of short-term funding for companies (Jou, Li., Wang, 2023, p. 1) and the way of creating value form customers. Sellers willingly provide trade credit because lengthy payment periods in case of trade credit could stop their competitors from joining, growing, and lasting in the market (Barrot, 2016, p. 1976).

2. Leasing is a popular way for businesses to finance their needs, allowing them to access property, equipment, and machinery without needing to spend a lot of money upfront (Bolea, Cosma, 2015, p. 295). A lease refers to the temporary handover of an asset in exchange for regular payments known as rent. Usually, the lessor is the individual who owns the asset and receives it back once the lease period ends. The lessee has the right to use the asset without any interruptions from the lessor during the lease, as long as the lessee pays the rent and fulfills other responsibilities outlined in the lease agreement (Merrill, 2020, pp. 221-222). Leasing agreements can meet different business requirements, whether for using assets for a short time or for financing them over a longer period. Leasing is appealing as a financing option due to its adaptable nature (Bolea, Cosma, 2015, p. 295). Asset leasing enabling businesses to offer flexible and on-demand access to assets while minimizing financial risks. By leveraging leasing, companies can provide customers with a wide range of support, cater to their evolving preferences, and stay ahead in this dynamic market (Grip, 2025) creating this way the value for them.
3. Buy Now Pay Later (BNPL) has risen in popularity as a payment choice, enabling customers to settle their bills in interest-free payments in installments over a brief timeframe (Maesen, Ang, 2024, p. 13) to help them manage their finances. This payment method that allows consumers to make purchases and defer payment to a later date, usually in installments over a period (Mukhtar et al., 2023, p. 804). Such actions by companies are aimed at creating value for customers attracting new or retaining existing ones. In this way, customers receive the opportunity to spread payments over time, which makes even more expensive goods affordable for customers with a smaller budget, and fixed, predictable installments help plan expenses and are not as financially burdensome as a single payment. Additionally, companies often allow early repayment without additional costs or a change in the repayment schedule.
4. Companies can offer their customers an additional service in the form of factoring, in which a factoring company takes over receivables from customers. Factoring is a form of funding for businesses where companies sell their reliable money owed from customers for less than its total value (usually covering interest and service charges) to get quick cash (Klapper, 2006, p. 1). It not only enhances the flow of money, but with factoring, a business can take on a large order from a customer that would have otherwise tied up the company's funds. The business can also buy in large quantities

with the funds obtained, allowing them to receive additional discounts, which can be utilized to boost sales and profit margins (Sarma, 2012, p. 211). With better money management, companies can seize chances for growth by purchasing new equipment, broadening their activities, or exploring new markets (Corporate Factoring). In this scenario, it is a beneficial situation for everyone involved (Sarma, 2012, p. 211).

5. Companies can provide financial advice to their customers by helping them optimize their purchasing costs, e.g. by analyzing TCO (Total Cost of Ownership). Total cost of ownership is a way to help customers buy things, and a way of thinking, that helps them understand the real cost of buying something from a certain seller (Ellram, 1995, p. 4). By calculating the TCO, entities can find new ways to save money in the long-term scenario. TCO calculation takes into account the upfront spending and gathers as much information as possible to factor in expenses connected to the ongoing use of the asset (Machado Pureza, 2021). Total cost of ownership is a complicated method that needs the purchasing company to figure out which costs they think are the most critical or noteworthy in the buying, owning, using, and eventually getting rid of a product or service. Besides the amount spent on the product, TCO might consider factors like placing orders, finding and vetting suppliers, shipping, receiving, checking, returning, replacing, lost time due to malfunctions, and costs for disposal, among others (Ellram, 1995, p. 4).
6. Add-on insurance is a type of insurance that is offered to consumers in addition to another product, including: Consumer Credit Insurance (CCI), Guaranteed Asset Protection Insurance (GAP Insurance), Tyre and Rim Insurance, Extended Warranty/Mechanical Breakdown Insurance (AFCA, 2025). This kind of additional insurance offer can create value for customers as instead of visiting various sellers, a consumer can get multiple items at once and in the same place or online. Add-ons insurance helps sellers to create products that suit a diverse group of buyers and provide more options for customers as they can choose anything from a 'basic' item without extras to one that comes with different add-ons (Oxera, 2014).
7. The important elements of a loyalty program with financial elements are the fact that it is designed to create both value for the customer and value for the company itself. The value for customers is additional benefits of a financial, social, emotional nature that enrich the basic relationship, while the value for the company is the deepening of knowledge about customers and the ability to influence their attitudes and purchasing behaviors regarding both scale, scope, and frequency (Spyra, 2013, p. 59). Loyalty programs achieve their goal of increasing customers' loyalty by offering true value (Butscher, 2002, p. 5).

The services listed above can be provided independently or in cooperation with financial institutions, e.g. banks or leasing companies.

3. Activities creating value for individual customer groups of dairy cooperatives in the form of financial services – research results

The subject of the research conducted among representatives of the dairy cooperatives of Southeastern Poland was the identification of activities constituting the customer value in the sphere of financial services, which have been divided into the performed activities, outsourced and controlled activities, outsourced and uncontrolled activities, and activities that are not present in the cooperative. The respondents had to indicate activities, taking into account customers from home voivodeship, from other voivodeships, from the European Union and from other markets. Direct interviews using a questionnaire survey were conducted among representatives of the cooperative representing 33% of the population, which resulted from the tendency to participate in the research. Research results are presented in Table 1 and Figure 1.

Table 1.

Activities creating value for different kind of customer groups from different geographical markets in the form of financial services provided by dairy cooperatives from southeastern Poland.

Voivodeship	Carried out activities				Controlled activities outsourced to external entities				Uncontrolled activities carried out by external contractors			
	Home voivodeship	Other voivodeships	UE markets	Other main markets	Home voivodeship	Other voivodeships	UE markets	Other main markets	Home voivodeship	Other voivodeships	UE markets	Other main markets
Lubelskie	40%	40%	0%	0%	20%	20%	20%	20%	0%	0%	0%	0%
Małopolskie	25%	0%	0%	0%	25%	0%	0%	0%	0%	0%	0%	0%
Podkarpackie	0%	0%	0%	0%	33%	0%	0%	0%	0%	0%	0%	0%
Śląskie	100%	80%	60%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Świętokrzyskie	0%	0%	0%	0%	67%	0%	0%	0%	33%	0%	0%	0%
Mean taking into account all cooperatives at particular geographical markets	40%	30%	15%	0%	25%	5%	5%	5%	5%	0%	0%	0%

Source: own work.

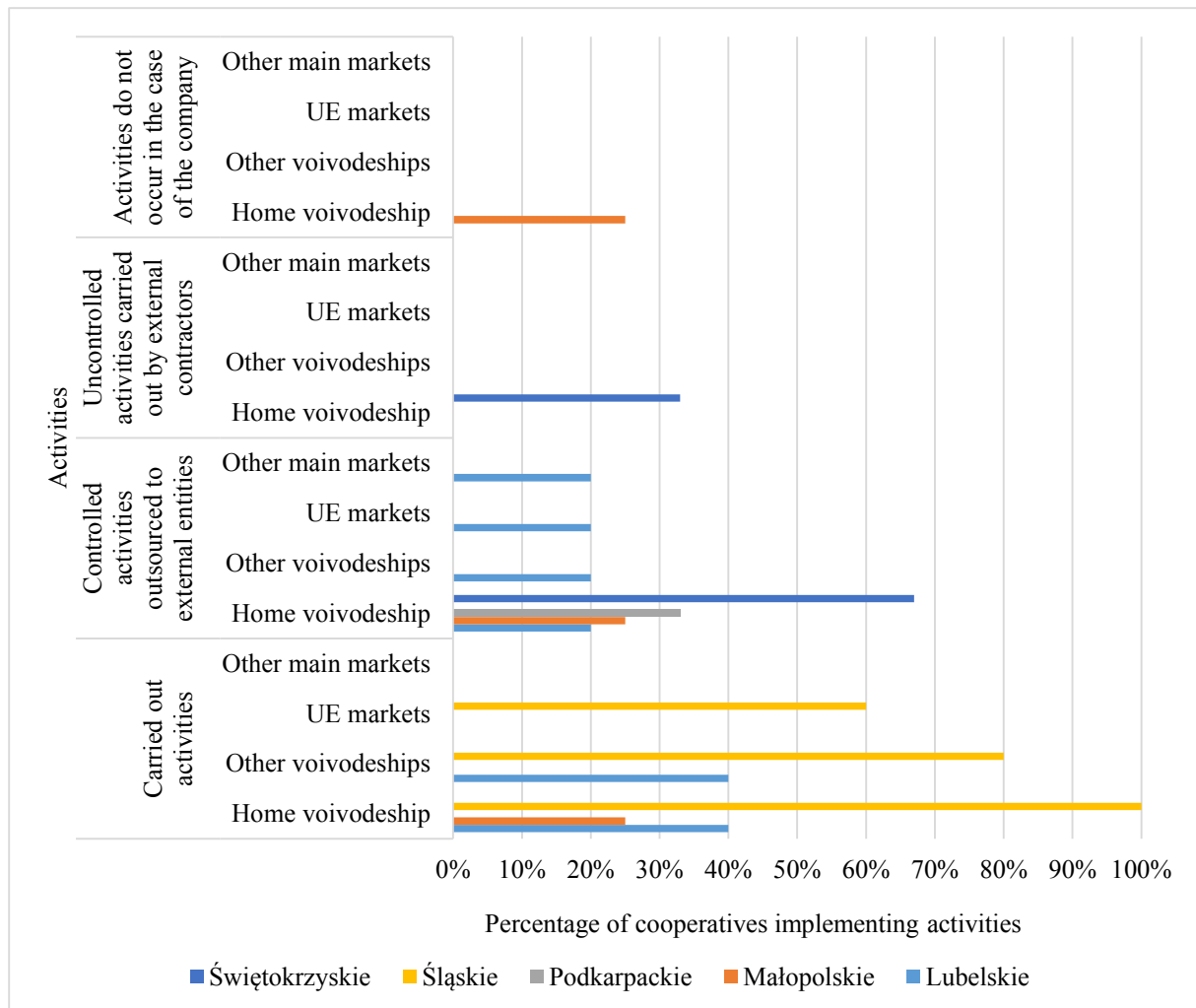


Figure 1. Activities creating value for individual customer groups from different geographical markets in the form of financial services provided by dairy cooperatives from southeastern Poland.

Source: own work.

Taking into account research results shown in Table 1 and Figure 1 it can be seen that activities creating value for different kind of customer groups from different geographical markets in the form of financial services are not provided by all of cooperatives.

The results show that activities carried out or controlled by other entities within the home voivodeship predominate. On average, 40% of all activities performed by cooperatives take place in their home voivodeship. The Silesian Voivodeship, in particular, demonstrates 100% implementation of financial services as additional activities to the sale of its own products in the local market, suggesting a strong commitment to meeting the needs of customers in the home voivodeship to the greatest extent possible. In contrast, cooperatives in the Podkarpackie and Świętokrzyskie voivodeships do not independently implement additional financial services as part of the sale of their products. In the Lublin voivodeship, 40% of cooperatives conduct such activities, and in the Małopolskie voivodeship, 25%.

Some cooperatives that do not provide financial services as additional activities related to the sale of their own products in their home voivodeship outsource these services to other entities while simultaneously controlling them. This approach is particularly favored by cooperatives from the Świętokrzyskie Voivodeship, with 67% of them indicating such activities. A similar strategy was chosen by 33% of cooperatives from the Podkarpackie Voivodeship. Some cooperatives from the Małopolskie (25%) and Lublin (20%) voivodeships, on the other hand, provide such services and/or outsource them to other entities while maintaining control over them.

Among all cooperatives, only 33% of cooperatives from the Świętokrzyskie Voivodeship outsource additional financial services performed when selling their own products on the domestic market to other entities, without controlling them.

Another market where additional financial services are provided as part of the sale of their products is the market of other voivodeships. However, these activities do not apply to cooperatives from all the analyzed voivodeships. Similarly to the home market of the voivodeship, such services in the market of other voivodeships are primarily provided by cooperatives from the Silesian Voivodeship, as evidenced by the declaration of independent implementation of these activities by 80% of cooperatives. Another group of cooperatives that independently implement such activities in other voivodeships is 40% of cooperatives from the Lublin Voivodeship. At the same time, 20% of cooperatives from this voivodeship indicated that they supervise the implementation of such activities, which are outsourced to external entities. Cooperatives from the other voivodeships do not provide or outsource additional financial services as part of the sale of their products.

Only cooperatives from the Silesian Voivodeship indicated that they provide additional financial services as part of the sale of their products in EU markets. This is the case for 60% of cooperatives in this voivodeship.

In other major markets, such activities are outsourced to other entities and controlled by cooperatives only in the case of 20% of cooperatives in the Lublin Voivodeship.

4. Conclusions

Offering additional financial services while selling one's own products can bring many benefits to businesses by creating value for customers. However, research has shown that most cooperatives do not provide such activities for different customer groups from different geographical markets. Therefore, hypothesis H1, which states that most cooperatives offer additional financial services while selling their products to consumers, was not confirmed. The research results show that the largest number of cooperatives implementing such activities is 40% and concerns the implementation of such activities in the home voivodeship market.

The research results show that cooperatives primarily focus on the Polish market, particularly their home market. This means that cooperatives are focused on creating value primarily for regional customers, building loyalty and trust. However, the average share of such activities directed at EU and other major markets is low. Therefore, hypothesis H2, stating that cooperatives that provide additional activities in the form of financial services prefer to offer them to their customers from the home province market rather than from other markets, was confirmed.

Cooperatives that choose to offer financial services as additional services when selling their products prefer to provide them themselves rather than outsource them. At the same time, they prefer to maintain control over these services, even when outsourcing them to other entities. Therefore, hypothesis H3, which states that cooperatives prefer to control additional activities in the form of financial services for their customers that are outsourced to external entities rather than provide them themselves, was rejected. This may indicate that cooperatives prefer to ensure the scope and quality of services themselves, thus having limited trust in external entities providing such services.

There are clear differences in the approach to offering additional financial services when selling their own products between cooperatives in different voivodeships. Cooperatives from the Silesian Voivodeship are a clear leader, as all cooperatives independently conduct such activities for clients in their home voivodeship. These cooperatives also stand out in terms of the geographic scope of their activities, as most also conduct such activities in other voivodeships and on EU markets. The Lublin and Małopolskie Poland voivodeships demonstrate a mixed business model, with some activities performed independently and others outsourced under supervision to external entities. Cooperatives from the Świętokrzyskie and Podkarpackie voivodeships demonstrate very limited additional activities in the form of additional financial services, with small percentages or no activities performed independently. They rely more on controlled outsourcing than cooperatives from other voivodeships. Furthermore, only cooperatives from the Świętokrzyskie Voivodeship outsource such activities without supervision. Thus, H4, stating that cooperatives from different voivodeships in similar extend provide additional activities in the form of financial services for their customers, was rejected.

The limitation of the research which results were showed here is the quantity of cooperatives and the territorial research area. Suggestions for future research could involve exploring the constraints of this study by conducting research on cooperatives in different regions to determine if they carry out additional financial services while selling their products.

The limitation of the study whose findings are presented here is the number of cooperatives and the geographic area examined. Suggestions for future research could involve exploring the constraints of this study by conducting research on cooperatives in different regions to determine if they carry out additional financial services while selling their products.

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USING ARTIFICIAL INTELLIGENCE FOR ROUTE OPTIMIZATION AND PLANNING

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Purpose: The objective of this article is to examine the impact of artificial intelligence applications on solutions employed in logistics, with a particular focus on the transportation sector. The analysis investigates how AI-based technologies contribute to the optimization of transport processes, the improvement of fleet management, route planning, and the enhancement of operational efficiency. The article also aims to identify the potential benefits of implementing intelligent systems, as well as the challenges and limitations associated with their deployment in the logistics industry.

Design/methodology/approach: This study's methodology is grounded in analysis, synthesis, abstraction, and generalization. The use of these scientific methods facilitates a detailed examination of the study's subject and object, along with gathering and analyzing data to assess how information systems optimize transport routes (TMS). In addition, the study employs the case study method.

Findings: Data analysis shows that artificial intelligence is currently most effective in road transport. This is primarily due to the current level of technological development, industry experience, and the practical outcomes achieved.

Practical implications: The research findings give practical guidance for evaluating whether AI-based systems are sufficiently effective, economically justified, and applicable across all modes of transport. Moreover, the research helps to partially systematize current literature on AI in logistics and transport, serving as a valuable reference for further studies.

Originality/value: This is an original study that could be applied to address specific problems either independently or in combination with other research methods. The comparison of results for a given research problem obtained through the application of different methods may prove highly insightful.

Keywords: artificial intelligence, optimization, planning, transport.

Category of the paper: Case study.

1. Introduction

Artificial intelligence (AI), defined as a data processing system that emulates the functions of the human brain, continues to expand into new areas of life rapidly. It is increasingly being applied across diverse sectors, supporting decision-making processes or streamlining day-to-day operations. Today, this phenomenon can be seen in fields like robotics, education, and e-commerce. AI significantly transforms the way individuals perform professional tasks and acquire information in everyday life. The development of intelligent systems, a key driver of economic growth, results in major shifts in production structures and methods, while also affecting the range and quality of consumer goods and services. Fields such as management, and logistics in particular, will not remain unaffected by this revolutionary technology – on the contrary, they are poised to undergo a profound transformation in the near future.

One of the areas where artificial intelligence finds particularly extensive application is transportation and logistics. AI enables the effective optimization of processes such as route planning, fleet management, delivery monitoring, and demand forecasting. Machine learning algorithms enable dynamic real-time route adjustments by considering current road, weather conditions, and changing logistical priorities.

Artificial intelligence plays a main role in modernizing traditional transport systems and improving methods for route planning and optimization. Using AI algorithms and machine learning (ML) methods allows for analyzing extensive datasets, processing data instantly, and continuously improving decision-making in logistics systems. Assisted, augmented, and autonomous AI-based solutions are designed to take over key tasks and improve their execution. These include handling large volumes of online orders with immediate route generation and delivery time estimation, considering variable factors such as weather conditions, traffic congestion, and other relevant parameters. In addition, these systems facilitate the creation of optimized routing algorithms and the evaluation of the effectiveness of implemented logistics strategies (Krishna Vaddy, 2023).

Advanced AI-driven systems analyze large volumes of data, including historical and real-time information, which enables higher operational efficiency, lower transportation costs, and quicker delivery times. AI also supports the development of sustainable transport by enabling optimal fuel management, minimizing CO₂ emissions, and improving route planning from an environmental perspective.

The implementation of intelligent solutions in logistics not only enhances the competitiveness of enterprises but also improves customer service quality by enabling more accurate delivery time predictions and quicker responses to potential delays. Altogether, artificial intelligence is becoming an indispensable component of modern transportation systems, redefining the way the entire industry operates.

2. Literature Review

The optimization of transport processes constitutes a fundamental component of operational efficiency in the management of contemporary enterprises. Advanced Transportation Management Systems (TMS) are a key element in the optimization of corporate logistics. They enable effective planning, execution, and monitoring of transport operations, which translates into cost reduction and improved efficiency. By applying optimization algorithms, it becomes possible to determine the most efficient routes with precision, taking into account economic, temporal, and operational factors (Coyle, Langley, Novack, Gibson, 2016).

According to Simchi-Levi (Simchi-Levi, Simchi-Levi, Kaminsky, 2017), modern Transportation Management Systems (TMS) play a crucial role in the effective optimization of logistics processes. They allow for the automatic planning, monitoring, and analysis of routes, thereby contributing to increased efficiency and cost reduction. TMS also supports the decision-making process by enabling dynamic route optimization in real time and efficient utilization of resources, which directly translates into improved profitability of transport operations.

Hines (2016) emphasizes the importance of Transportation Management Systems (TMS) as an integral element of an integrated logistics strategy. According to him, TMS makes decision-making easier by handling essential tasks automatically, including route planning, choosing carriers, and auditing freight costs. By providing access to real-time data, these systems facilitate transport performance monitoring, operational cost reduction, and the improvement of service quality.

To achieve efficiency in route planning and optimization, a TMS must account for numerous factors. This includes traffic patterns, road conditions, weather, vehicle capacity, fuel usage, delivery timing, distances, and other pertinent data to identify the best route. In other words, simply planning delivery routes using only an order list, destinations, and expected delivery dates is not enough. (Roundy, 2024).

Vehicle route optimization involves determining an optimal plan (lowest cost, highest service level, or lowest risk) for a fleet of vehicles. Such planning includes identifying the set of nodes (or customers) to be visited by each vehicle in the fleet, as well as the sequence in which they should be visited. Depending on the problem's characteristics, it is also necessary to determine the route start and end times, driver rest periods, and the paths between each pair of customers. In general, optimization aims to manage resource constraints in the most efficient way possible (Tyszkiewicz, Pawlak-Wolanin, Ulewicz, 2017). Transportation refers to the movement of individuals or goods. This definition underscores the primary benefit of transport services – the delivery of passengers and cargo. However, at the international level, transport is also perceived as a system that creates utility in time and space. Utility refers to the capacity of a good to satisfy needs. The main objective of a product purchased by a consumer is to fulfil a specific need, associated with a particular activity or the provision of a sense of satisfaction (Manzini, Gamberini, 2008).

Transport logistics is crucial for optimizing how resources are distributed spatially and for managing transportation demand. In practice, this involves the comprehensive management and supervision of shipments – from the moment they are collected from the sender to their delivery to the final recipient. Key challenges in distribution involve the traveling salesman problem and the time window problem, both of which are addressed through optimization methods. In the case of the cyclic transport problem, a critical assumption is that all planned points are visited by vehicles along the shortest possible route. The time window problem is even more challenging, as it requires servicing customers within strictly defined time intervals, individually established by each of them (Pečený et al., 2020). To meet all customer expectations, including a larger number of vehicles in the route planning process, is mandatory. Enterprises need to tackle both simple and complex routing challenges to improve operational efficiency, cut costs, and maintain high service standards.

The development of the economy and social progress are closely linked to the functioning of transportation. An efficiently functioning transportation system promotes trade growth by providing access to areas that were previously difficult to reach, both within the country and abroad. This expansion not only increases market size but also enhances its complexity and quality through the freer flow of innovations and products. The influence of transport, however, is not limited to the economic sphere – it also has significant social and cultural implications. Efficient transport systems integrate communities, facilitating the exchange of ideas, experiences, and values (Toth, Vigo, 2014). Moreover, the development of transport infrastructure affects ways of thinking and perceiving the world – both at the national and global levels. For example, it would be difficult to imagine the smooth functioning of nationwide press distribution or postal systems without fast and efficient transport means. Transport not only reduces the costs of distributing goods and services but also contributes to shaping a sense of belonging to a broader culture that extends beyond an individual's immediate surroundings.

Planning involves organizing activities by developing a plan that outlines sequential implementation stages and assigns time to various activity areas. In simplified terms, two basic types of schedules can be distinguished: the first is a template designed for individuals attending numerous business meetings in various locations with different partners; the second is intended for planning time-limited activities (Pasierbski, 2020). Based on these two models, a new type of schedule has been developed, one that is based on planning according to time intervals and also takes into account the location of specific tasks. Additionally, each element of such a plan can be described and labeled, which facilitates more integrated and transparent time management.

Routes, typically composed of geometric elements such as straight lines, circular arcs, or transition curves, may be global or local in nature (Ezell, 2010). A global route is usually generated offline, on a map of the entire operational environment, while a local route is generated online – considering dynamic obstacle avoidance based on data from external sensors installed on an autonomous vehicle. A route is characterized by a series of points that

the autonomous vehicle must reach or come within a certain distance of, beginning from the starting point and ending at the destination (Figure 1). For a route to be effectively implemented in a given environment, it must meet certain requirements – primarily matching the vehicle's kinematic and dynamic constraints, which greatly support trajectory planning. Furthermore, routes should pass exclusively through permitted areas, in compliance with current traffic regulations, while avoiding nature protection zones such as green areas or vegetation-covered regions (e.g., lawns or flower beds). Additionally, the system responsible for route generation should allow for offline calculations while maintaining low memory and computational requirements (Badzińska, Cichorek, 2015).

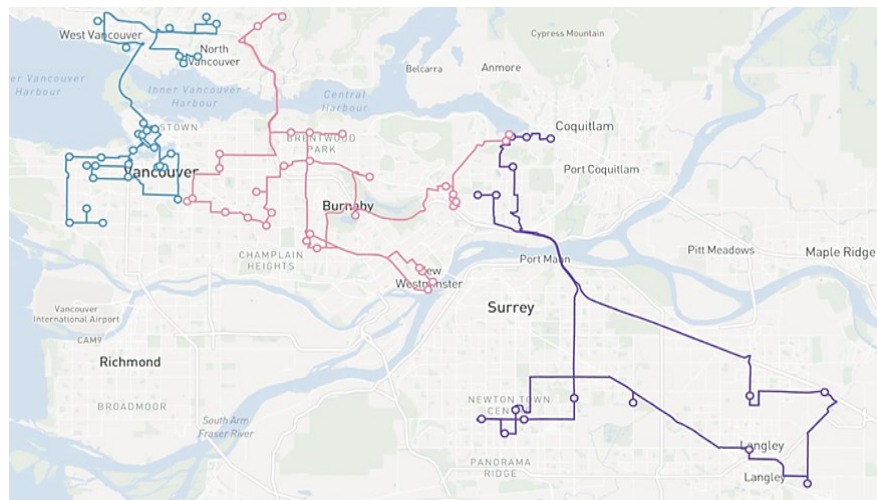


Figure 1. Example of routes as sets of points.

Source: (Kuo, 2023).

In the context of route planning, it can be observed that over the last decade, the topic has received considerable attention from software developers, resulting in the emergence of many efficient approaches based on fundamental concepts of graph algorithms (Badzińska, Cichorek, 2015). From a scientific perspective, the route planning problem can be formulated as a variant of an optimization problem involving the identification of the shortest path between two points. Translated into graph theory, the objective function becomes the selection of edges with the lowest cost – most often interpreted as travel time – connecting the starting node to the destination node. In the current project, additional optimization criteria are also considered, such as distance, fuel costs, and energy consumption. Although travel time remains the main priority, in some cases financial savings or emission minimization are of particular importance (Ozbaygin, Karasan, Yaman, 2018).

With the arrival of the Fourth Industrial Revolution, the freight transportation industry must tackle the challenge of enhancing sustainability and boosting delivery efficiency by adopting innovative technologies. Modern logistics solutions offer businesses and management teams more opportunities than threats, enabling them to refine and modernize existing business models without the need for substantial investments in entirely new systems. Most innovative technologies focus on automation and process streamlining. Tasks like inventory control and

route planning will likely need much less human input soon. Presently, The progression of freight transportation is strongly influenced by emerging technologies such as AI, big data analytics, IoT, and blockchain. (Dong, Akram, Andersson, Arnäs, Stefansson, 2021).

Although implementing these modern solutions in information systems involves costs, logistics companies are expected to benefit from lower operating and fixed expenses, more efficient delivery execution, and higher customer satisfaction levels. The extensive use of expensive RFID tags in IoT has prevented the technology from fully realizing its benefits although transport operates on tight margins, it is expected that continued IoT hardware development will lower implementation costs, making this technology more cost-effective and applicable even to low-value freight transport.

Digitalization is gaining increasing importance as part of the extended transportation process optimization. This involves implementing integrated data exchange platforms using blockchain technology and advanced data analytics tools. Digital transformation enhances operational efficiency and considerably minimizes errors caused by manual processes. Automation spans a wide range of activities – from warehouse process robotization to the deployment of intelligent loading and unloading systems – resulting in a noticeable productivity increase throughout the supply chain (Ramasamy, Natarajan, Sathyamoorthy, 2024).

Blockchain is another example of a promising digital technology, enabling secure, transparent, and immutable data recording in the supply chain. With its distributed architecture and the use of smart contracts, this technology supports process automation, enhances trust between trading partners, and reduces the risk of errors and fraud. Optimization, in its simplest form, means finding the best solution in a given situation or when using specific resources. The field of route planning is developing dynamically, supported by a diverse array of digital platforms customized to meet the unique needs of enterprises across different industries (Pasierbski, 2020). From delivery route planning systems to next-generation advanced logistics tools – the market offers solutions that meet diverse requirements.

Although businesses have historically used manual route planning, traditional approaches are struggling to keep up with the complexity and dynamic nature of modern transport networks. The Vehicle Routing Problem (VRP) involves determining the shortest possible routes while minimizing the use of available fleet resources. These routes typically start and end at a warehouse, with the goal of delivering goods to geographically dispersed customers. Planning must account for constraints such as maximum vehicle capacity and varying customer demand (Pawlikow, Petersen, Sørensen, 2023).

VRP-solving methods fall into two main categories: exact algorithms and approximate algorithms. Exact algorithms aim to find the optimal solution but are seldom used in practice because their computation time grows exponentially with the number of customers. Approximate algorithms, in contrast, deliver high-quality solutions more quickly, but they do not guarantee optimality (Battarra, Golden, Vigo, 2006). Among exact methods, branch-and-

bound algorithms are notable (Pereira, Tavares, 2009). Their initial step involves addressing the problem through a linear programming relaxation, allowing variables to take non-integer values. Approximate methods are an effective alternative to exact algorithms, enabling solutions to problems involving even thousands of points (Badzińska, Cichorek, 2015). This group includes classical heuristics and metaheuristics. In solving the VRP, metaheuristics like simulated annealing, genetic algorithms, and neural networks are commonly employed, tabu search, ant colony optimization, and GRASP (Ochelska-Mierzejewska, Sztajerowski, 2014).

To solve complex optimization problems effectively, logistics companies use dedicated software. Route planning and optimization require not only specialized software but also several preparatory and analytical stages. The process begins with systematic data collection, including information on demand, available vehicle fleet, operating costs, load capacity, warehouse locations, and customer addresses. Other key operational parameters influencing overall system efficiency are also taken into account. Modern logistics platforms also factor in past data, including traffic flows, delivery requirements, and driver schedules. Next, the company must determine the type of VRP it faces to align the appropriate strategy with its business objectives. The following step involves customizing and configuring either an off-the-shelf or dedicated software solution and applying suitable algorithms, enabling efficient calculations and the generation of optimized routes (Pečený, Meško, Kampf, Gašparík, 2020). The results of these calculations support planners and managers in making operational decisions. Once the planned routes are implemented, specialists monitor key performance indicators – such as delivery times, customer satisfaction levels, and cost savings. Data from completed routes are used to further improve processes, initiating another planning iteration.

It is notable that many optimization algorithms operate iteratively, building a solution step by step. In practice, the algorithm starts with an initial solution and iteratively adds the element judged best according to the chosen standard (Chao, Golden, Wasil, 1993). Improvement methods, in turn, focus on enhancing the quality of an already valid solution – for example, by swapping delivery points within a single route or between different routes. These are known as local search techniques, which operate within a subset of the solution space to find the best possible local solution (Wilck, Cavalier, 2012).

Despite their previous effectiveness, traditional methods of route planning and optimization increasingly face significant limitations that reduce their efficiency. They largely rely on the quality of available historical data, while failing to incorporate real-time information or integrate it into the current decision-making process. Meanwhile, modern logistics is becoming increasingly demanding – the number of delivery points is growing, market competition is intensifying, and customer expectations regarding punctuality and service quality are steadily rising. All of this makes the route optimization process increasingly computationally complex. Additionally, companies need to consider various dynamic factors, including weather conditions, traffic, and unexpected events along routes. External constraints are also becoming

more frequent, including street congestion or environmental regulations, which require a flexible and intelligent approach to route planning. The table below presents the types of route planning platforms.

Table 1.
Types of route planning platforms

Types of Platforms	Description
Basic route planning program	a) basic route planning capabilities, such as creating point-to-point routes and performing basic travel plan optimization. b) ideal for small businesses or those beginning to automate their planning processes. c) Google Maps and Waze: point-to-point route searches, where there is no need for optimization or operational parameterization (Segerstedt, 2014).
Advanced route planning software	a) more advanced features, such as integration with real-time GPS systems, multi-variable optimization (weather, traffic), and predictive analytics (Ochelska-Mierzejewska, Sztajerowski, 2014). b) offer greater customization capabilities. c) can be integrated with other logistics systems.
Comprehensive logistics solutions	a) all-in-one solution (Archetti, Speranza, 2012). b) drivin: provides full control over logistics operations, standing out as a robust solution for efficient and effective shipment route management (Xia, Fu, 2018). c) offer a full range of route planning functionalities, from scheduling to delivery. d) can be integrated with real-time tracking and monitoring systems. e) combine route planning with other logistics management functions, such as inventory management, fleet management, and real-time tracking.

Source: own study based on (Segerstedt, 2014, p. 76; Xia, Fu, 2018, p. 13).

This study focuses on transportation route planning, especially systems that use artificial intelligence. The object of the research comprises AI algorithms and methods for planning and optimizing transport routes.

The aim of the study is to analyze existing solutions based on artificial intelligence techniques, identify the types of transport in which they are most effective, and formulate forecasts regarding the further development of AI in logistics.

To achieve this aim, it is necessary to:

- a) analyze contemporary logistics approaches to transport organization,
- b) examine AI algorithms used in solving the Vehicle Routing Problem (VRP), and
- c) conduct case studies of real-world implementations of AI-based systems.

The practical significance of this study lies in the fact that the conclusions and recommendations obtained will allow assessment of whether AI-based systems are sufficiently efficient, economically justified, and applicable across different modes of transport. Furthermore, the study contributes to the partial systematization of existing scientific literature on the application of AI in transport logistics. It could serve as a valuable starting point for future research in this field.

The research methodology relies on analytical approaches, synthesis, abstraction, and generalization methods. These universal scientific techniques allow for a thorough examination of both the subject and the object of the study, as well as the collection and interpretation of data to assess how information systems are used for route optimization within Transportation Management Systems (TMS).

Additionally, the study employs the case study method, a universal methodology that allows in-depth analysis of a specific phenomenon, event, or entity to gain a precise understanding of the researched problem. This approach integrates various techniques, including document analysis, survey methods, and observation. While the case study is categorized as a qualitative approach, it is advisable to supplement it with quantitative methods to achieve a holistic understanding of the situation. The choice of this methodology is justified by the relatively new and dynamically evolving nature of the research topic, which makes conducting independent experiments or tests challenging. Consequently, using data from business practice and available secondary sources appears to be the most appropriate research approach.

Moreover, the literature used for both analyzing real-world AI applications and developing the theoretical part was selected using the Systematic Literature Review (SLR) method. A systematic literature review is an effective tool for organizing, comparing, and synthesizing existing knowledge sources and supports evidence-based decision-making.

The SLR approach differs from meta-analysis, which focuses on the quantitative assessment of results, and from citation network analysis, which examines relationships between references. The benefit of SLR is its capacity to perform a consistent, transparent, and thorough review of existing literature, it allows for better insights into the phenomenon being analyzed. In this study, the SLR method was applied to systematically synthesize the available knowledge regarding the use of AI in various branches of transport – road, air, maritime, and rail. Only publications from reliable scientific sources focusing on the implementation of artificial intelligence in transport logistics were considered. Works unrelated to this topic or failing to meet quality criteria were excluded.

In the next phase of the research, the case study method was used to deeply analyze specific examples of AI applications focused on enhancing logistics, especially in planning and optimizing delivery routes. This combined methodological approach allows for obtaining both a broad theoretical overview and practical insights into real-world technology applications in logistics enterprises.

Future research could focus on examining the attitudes of companies and drivers towards AI-based solutions and the factors influencing the pace of their implementation. A limitation of the study is the small sample size, meaning that the analysis included only selected transport companies described in the case study.

3. Case study

Practical examples clearly demonstrate that the use of artificial intelligence can significantly enhance operational efficiency and contribute to cost reduction in route planning processes. The most representative examples is the SenseAware ID system, developed and implemented

by FedEx. Built on machine learning, the platform integrates data streams from multiple inputs, including GPS technology, environmental sensors, and weather forecasts, enabling dynamic real-time optimization of delivery routes.

The system not only allows continuous shipment monitoring but also predicts potential disruptions in the supply chain, enabling FedEx managers to take proactive measures to mitigate risks at early stages of the logistics cycle (Veluru, 2023). By allowing immediate route adjustments, the platform substantially improves operational efficiency and enhances customer satisfaction. Data and observations collected clearly indicate that the use of the SenseAware system contributes to a reduction in operational costs.

FedEx also employs the ORION system, which is examined as a case study of a modern Transportation Management System (TMS). ORION enabled UPS to achieve annual savings of USD 300-400 million by reducing operational costs. The system helps UPS optimize the supply chain by offering route data that accounts for both energy efficiency and delivery time. ORION analyzes over 200,000 potential routes for each driver, based on a single day of operational data. Calculations consider factors like pickup times, past route efficiency, and the number of stops, which often reaches 100 (Holland, Levis, Nuggehalli, Santilli, Winters, 2017). Consequently, the average daily driving distance was reduced by 6-8 miles. Annually, ORION reduces total mileage by approximately 100 million miles. Importantly, the latest system is capable of adjusting routes dynamically in response to real-time traffic data (Weise, 2019).

Unlike traditional manual route planning and outdated systems, ORION does not require specialized staff for route determination. Each driver inputs a destination address and gets the most efficient route, optimized for travel time, distance, and fuel use. The system evaluates traffic data using artificial intelligence and machine learning to deliver the best solution. This enables drivers to deliver shipments faster while avoiding congestion and other obstacles. Additionally, AI enables real-time route adjustments when facing sudden changes like new orders, bad weather, or traffic incidents, helping to save time and fuel and ensuring more punctual deliveries.

Similarly, DHL leverages machine learning models to reduce delays and avoid failed deliveries. The implemented system significantly enhances last-mile delivery efficiency by predicting potential logistical disruptions. AI algorithms analyze historical delivery performance, weather data, and real-time traffic conditions to dynamically adjust routes (Veluru, 2023). These technologies make the delivery process more predictable, accurate, and reliable, benefiting both logistics operators and end customers.

Moreover, DHL uses advanced technologies not only to optimize routes but also to enhance warehousing and international trade services. The company has partnered with Robust.AI to implement AI-assisted robots that support employees in tasks such as sorting, order picking, and loading shipments onto vehicles. These robots, named Carter, are capable of learning from the specific conditions of individual warehouses and are designed to collaborate effectively

with humans. Their purpose is to assist employees, reducing cognitive workload and increasing overall operational efficiency in warehouses (AIX, 2024). Real-world implementations confirm that AI serves as a transformative factor in the transport and logistics sector, enhancing both efficiency and service quality.

Another successful AI-based implementation is the route management system employed by Walmart. The company uses AI in combination with big data analytics to optimize last-mile logistics, one of the most costly stages of delivery. The algorithms analyze real-time factors such as warehouse stock levels, customer preferences, traffic intensity, and weather forecasts (Ping, Zhu, Ling, Niu, 2024). Based on this analysis, the system dynamically adjusts routes and delivery schedules, considering both cost efficiency and environmental aspects of transport.

Walmart also uses AI for demand forecasting and automatic allocation of transport resources to locations where they are most needed. This approach reduces order fulfillment time, minimizes empty vehicle trips, and decreases fuel consumption. Consequently, the company achieves higher operational efficiency, lowers CO₂ emissions, and improves customer service. By implementing AI for route optimization, Walmart has eliminated 110,000 inefficient routes, reduced total mileage by 30 million miles, and avoided the emission of 94 million pounds of CO₂. The success of this software encouraged Walmart to diversify by offering the developed technology to other companies (Avila, 2024), allowing external firms to benefit from advanced route planning systems without investing in their own development.

The Chinese technology giant Alibaba uses its logistics network, Cainiao, which integrates reinforcement learning and deep learning technologies to improve distribution processes and intelligent scheduling (Stroh, 2023). Traffic management and monitoring systems provide full control over inventory, first-mile pickup, sorting, and last-mile logistics. AI analyzes historical data and current sales trends, enabling accurate demand forecasting for specific products. This allows strategic placement of goods closer to customers, reducing transport time, speeding up order fulfillment, and lowering logistics costs. Cainiao offers customers real-time package tracking, ensuring transparency at every delivery stage. By leveraging AI, the system analyzes multiple data sources, identifies potential delays or disruptions, and automatically takes corrective actions, increasing service reliability and customer satisfaction.

Other companies successfully implementing AI-based route optimization technologies include Amazon and Lyft.

Lyft, a U.S.-based ride-sharing company, has implemented advanced AI algorithms that dynamically optimize rides. By using real-time data from drivers and passengers, the system continuously improves route efficiency and reduces waiting times. This approach boosts customer satisfaction and increases fleet utilization.

Amazon extensively employs AI in transportation and logistics to increase operational efficiency and shorten delivery times. AI supports planning of optimal routes for drivers (Amazon Delivery Service Partners) by considering real-time traffic data, weather forecasts, package and customer locations, and historical route performance. This results in shorter

delivery times, reduced fuel consumption, and faster response to disruptions (Ulmer, Thomas, Lütke, Entrup, 2020). AI enables Amazon to fulfill commitments under Prime services, providing same-day or two-day deliveries. The system's flexibility allows real-time adaptation to changing conditions, forming a key competitive advantage in customer service.

Within Amazon Logistics (AMZL) and Last Mile AI, artificial intelligence manages the “last mile” – the final stage of delivery – by assigning packages to delivery personnel, determining the optimal delivery sequence, and predicting potential delays. Amazon is also developing autonomous transport technologies, such as the Scout delivery robot, which navigates sidewalks, and the Zoox autonomous electric vehicle for urban driverless transportation. Additionally, Prime Air uses AI-controlled drones to deliver packages in under 30 minutes, avoiding obstacles and selecting the shortest routes. In distribution centers, AI controls robot movement (e.g., Kiva robots), optimizes shelf placement, and predicts demand, moving products closer to customers to accelerate order fulfillment and reduce operational costs.

These case studies demonstrate that automating logistics and incorporating AI lead to increased operational efficiency, lower costs, and better service quality. The use of large language models, deep learning, and predictive techniques allows companies to respond flexibly to transportation and fleet management challenges while developing more adaptive and innovative logistics strategies.

4. Discussion

Road transport is among the most widely used modes of transportation, particularly for cross-border deliveries and direct-to-customer shipments. Its primary advantage lies in its high level of flexibility – enabling “door-to-door” deliveries and dynamic adjustment of routes and schedules in real time, which differentiates it from other transport modes. It performs especially well over short and medium distances and is suitable for transporting diverse types of cargo, such as perishable goods, hazardous materials, or small parcels.

Despite increasing congestion of road infrastructure in highly developed countries, average delivery times and road transport costs remain acceptable for both customers and providers. Moreover, road transport plays a key role in integration with other transport modes, facilitating both first-mile and last-mile deliveries – capabilities that other transportation modes cannot provide to the same extent.

Conversely, road transport faces limitations as it is not ideal for moving oversized or bulk cargo, given vehicles' lower carrying capacity compared to maritime or rail options. Truck fleets incur high fuel consumption, require costly maintenance, and contribute significantly to

emissions. Additionally, road transport is vulnerable to external factors for example as traffic congestion, accidents, and road closures, making delivery times difficult to predict accurately.

These weaknesses make the implementation of artificial intelligence solutions in road transport particularly promising. AI can greatly improve fleet management and route planning, leading to higher efficiency and lower costs. A crucial step is estimating potential gains from implementing planning and optimization systems for each transport mode. A key benefit of modern transportation management software is its capacity to significantly lower fuel expenses and reduce pollutants released into the environment.

Table 2 presents fuel consumption by U.S. carriers in 2016. Data published by the Bureau of Transportation Statistics (2016) were used to calculate annual total fuel costs by transport mode. The results confirm that road transport generates the highest fuel consumption during deliveries, which translates into the highest average operational costs. Air transport ranked second in fuel consumption, while maritime transport proved to be the least fuel-intensive sector in the United States during the analyzed period.

Table 2.

Fuel consumption by mode of transportation in the US

Type of transport	A million liters	Average price	Total fuel cost (mln USD)
Road transport (all vehicles except buses)	659417	0,65	428621,05
Air transport	42273	0,65	27477,45
Rail transport (class 1 freight)	12814	0,65	8329,1
Sea transport	28381	0,65	18447,65

Source: own study based on (Bureau of Transportation Statistics, 2016).

The application of artificial intelligence can lead to significant reductions in operational costs, although the effects might vary depending on the area of implementation. Table 3 presents estimated fuel cost savings resulting from the adoption of AI-based solutions. The smallest benefits are observed in the optimization of air transport routes, allowing for an average cost reduction of 7.5%. Preventive maintenance has the greatest positive impact, reaching up to 20%, while optimization of land transport routes provides approximately 5% less savings (Miller et al., 2024). Additionally, autonomous navigation systems, aside from enhancing safety, enable a 12.5% reduction in fuel consumption.

Assuming these technologies had been implemented by all U.S. carriers in 2016, the largest financial savings would have been achieved in road transport, where route optimization could have generated as much as \$642 million in savings. In air transport, costs would have decreased by approximately \$20 million, and in maritime transport by \$23 million. The lowest level of savings was observed in rail transport, despite the highest potential percentage reduction in energy consumption. This outcome is justified by the fact that the greater the total fuel consumption in a sector, the greater the potential for generating savings through the adoption of modern technologies.

Table 3.
AI Applications and Energy Efficiency

Type of transport	AI Applications	Medium energy efficiency impact	CO ₂ reduction	Cost reduction (mln \$)
Road transport	Route optimization	15%	11%	642,932
Air transport	Flight path optimization	7,5%	6%	20,608
Rail transport	Predictive maintenance	20%	16,5%	16,658
Sea transport	Autonomous navigation systems	12,5%	9%	23,060

Source: own study based on (Kaushik, 2024; Miller et al., p. 14).

It's important to note that the proportion of different transport modes in total fuel use can differ by region. However, a similar situation occurred in the European Union in 2022. According to statistical data, road transport consumed more energy than any other sector (73.6%), far ahead of maritime transport (13.0%), air transport (11.4%), and rail transport (1.4%) (Eurostat, 2025). This indicates that European carriers could also achieve significant fuel savings, depending on the type of transport mode used.

CO₂ emissions reduction is directly linked to energy consumption levels. The lowest potential for emissions reduction concerns air transport, while the highest applies to rail transport (see Table 3). Nevertheless, it should be emphasized that cutting road transport emissions by 11% would generate the greatest environmental advantages because of its leading role in fuel consumption (TechHive NextGen, 2025). As a result, companies that perform road deliveries can save a substantial amount of money by adopting modern technologies and also play a direct role in developing a sustainable, eco-friendly business model.

5. Conclusions

Transport is a process that encompasses cyclical activities aimed at moving people, goods, or space in a way that increases their utility in a new location. Undoubtedly, transportation is a vital component of economic and social progress, as it links producers to consumers via the movement of goods and services. Transport routes, which are a series of points scheduled to be visited within a certain timeframe, are essential for logistics and supply chain operations. Well-organized routes enable companies to substantially lower operational expenses, such as fuel use and the number of drivers needed.

Route planning focuses on finding the most efficient travel path, whereas optimization aims to attain the best possible result with the resources at hand. In practice, managers start with the planning stage and subsequently optimize the planned routes based on delivery performance, considering both time and cost.

Therefore, organizations are motivated to increasingly moving away from traditional, manual planning in favor of Transport Management Systems (TMS). These solutions may be basic, advanced, or comprehensive, depending on the operational needs of the enterprise.

TMS can be developed in-house (by an IT department), purchased as an on-premises solution, or used as a cloud-based service.

Currently, artificial intelligence techniques find the most favorable conditions for implementation in road transport, primarily due to fewer implementation barriers and the highest potential for reducing operational costs. In rail transport, AI technologies are most often applied in predictive maintenance, generating substantial savings and positively impacting the cost efficiency of the entire system. In maritime transport, autonomous navigation systems reduce fuel consumption by 12.5%, although these digital solutions are not yet fully mature. Calculations have shown that aviation also benefits financially and environmentally from route optimization, albeit to a lesser extent compared to other transport modes. Based on quantitative results, land transport should be prioritized for implementing such systems to significantly lower costs and increase profits.

The application of artificial intelligence algorithms allows for more precise route planning and demand forecasting for transport services. Advanced data analysis methods enable rapid adjustment of transport resources to changing conditions, enhancing flexibility and efficiency in logistics processes. Route optimization and improved fleet management can reduce costs and improve service quality.

In summary, each transport mode possesses unique advantages and limitations that determine its suitability under specific operational conditions. The costs of building and maintaining infrastructure vary depending on the mode of transport, which also affects the complexity of logistics-supporting software. Road transport generates the highest annual fuel consumption due to the need to execute numerous last-mile deliveries. Rail transport is a more cost-effective alternative for long-distance shipments, though its flexibility is limited by rigid infrastructure. Maritime and air transport, despite limited route variability, can also benefit from route optimization techniques, although to a slightly lesser extent than road transport.

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MODERN MARKETING ACTIVITIES IN NZOZ

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Purpose: Changing market conditions, the continued development of artificial intelligence, the spread of online tools and, of course, technological developments are undoubtedly affecting changes in the management of non-public health care facilities in Poland. These changes also affect marketing activities. The purpose of this article is to try to look, to a small extent, at the introduction of these changes to the management activities of non-public health care institutions and the perception of patients. The premise of the paper is that modern marketing activities undertaken by NZOZs are noticed and positively evaluated by patients.

Design/methodology/approach: The study was based on a targeted survey. An author's survey questionnaire was placed on websites available to people in the Silesian region with a request to voluntarily participate in the study. The scope of the topic was presented. The tool of the study was the author's survey questionnaire. The survey lasted from April to June 4, 2025. Responses were obtained from 80 people.

Findings: The survey can help managers of non-public health care facilities to identify marketing activities that may be important to patients in choosing a facility. Based on the survey, it was possible to identify activities with a potentially greater impact on patients' decisions to choose a facility.

Research limitations/implications: This survey should be expanded to include a much larger number of respondents and from all over the country. The problems of the survey were the relatively, short time allotted for data collection and the poor response from respondents. In the future, the author may be tempted to conduct comparative surveys from further years to try to identify trends emerging in patients' perceptions of the marketing activities of healthcare facilities

Practical implications: Assistance to managers of health care facilities. The requirements of a competitive market and legislative measures allow and, in a sense, enforce the application of marketing and marketing management principles in healthcare facilities. There are certain limitations that determine the course of action, but they do not prevent their application. Proper marketing management allows a healthcare facility to increase its competitive advantage and better adapt to the needs of patients, and on a macro scale, to accelerate the development of the healthcare sector.

Social implications: Better management of a healthcare facility and the use of modern marketing principles and tools will allow more effective communication of offerings to patients, reduce frustration levels, and can contribute to better use of available resources. Above and beyond this, well-run marketing can contribute to, greater employee engagement and improved customer/patient service.

Originality/value: This survey can help managers understand the need to properly apply marketing principles, modernize operations, and highlight the areas best perceived by patients/customers.

Keywords: health care facilities, management, modern marketing, patients.

Category of the paper: Research paper, case study.

1. Introduction

The healthcare services sector also like other industries is subject to development processes in many aspects. The 4.0 revolution in industry is causing the development of technology, improving communication, data processing (Barlow, Mendryk, 2024). The 4.0 revolution also extends to the healthcare sector. Among other things, it allows customized therapies, reducing costs and increasing quality (Gaciong, 2016; Jose et al., 2022; Mathur, Sutton, 2017). However, it is important to note that this is a sector that is slow to adapt these changes (Chanchaichujit et al., 2019; Jose et al., 2022). However, this still entails the need for healthcare facility managers to apply principles related to modern management and marketing. One of these is the need for integrated marketing activities. However, due to the specifics of the sector, these activities are subject to legal restrictions. Generally accepted marketing activities related to its management, that is, marketing activities performed by professionals, include (Andruszkiewicz, Kaczmarczyk, 2002, p. 193):

- marketing activities that coordinate, integrate, are among the preparatory, support and executive activities,
- implementation of marketing management is the responsibility of the division director but also of managers and employees of middle and lower levels of management,
- management of marketing activities is carried out at the same level as with the management of procurement, production or finance,
- the basic tools used here are marketing plans, the subject of management is the activities (employees) of the enterprise related to the implementation of marketing functions.

“Thus, in practice, marketing management involves taking management actions and decisions in relation to these elements and implementing them in practical activities” (Andruszkiewicz, 2007, p. 79).

The basic scope of marketing activities is contained in the areas of product, promotion, price and distribution. In the case of services – here health services, it also includes people/staff (Bukowska-Piestrzyńska, 2007; Payne, 1997; Rutkowski, 2007).

One of the elements most often perceived by the public is the entire sphere of promotion, which, precisely in the health sector, is subject to a number of legal and ethical strictures. (Pabian, 2027; Przybyłowski et al., 1998).

“Interpreting the legal basis, it can be considered that a medical facility to the public can provide only persuasion-free information about the services provided. In such information, the following can be used:

- medical title,
- name,
- place and days of admission,
- degree,
- academic title,
- specialization,
- a list of skills in narrower medical fields,
- a list of specific medical services provided,
- specific entitlements,
- telephone number.

All of the above information must be truthful (relevant diplomas and certificates), and can be made public with the prior approval of the district medical council. Information regarding a doctor or private medical facility may be posted under the following rules:

- a maximum of two boards on noticeboards on the building where the practice is carried out, and possibly two boards along access roads,
- newspaper advertisements and information in telephone and information books only in sections that pertain to medical services,
- in the form of electronic information, on the Internet, through special telephone lines.

Information must not contain encouragement, promises, colloquial words. In their content, information about methods and time of treatment or terms suggesting price or method of payment are also not allowed” (Sprzęty Medyczne, 2013).

However, these regulations can be legally circumvented. This is because the law prohibits public advertising, i.e. advertising aimed at some abstract group of people, which is common, open and generally available. Thus, NZOZ can use advertising that will be directed to an individual, specific patient. It should also be about health promotion, not about health services themselves.

Modern marketing activities in NZOZs (Non-Public Health Care Institutions) include the use of online and offline strategies to effectively reach patients and build a positive image of the facility. They focus on building an online presence, being active on social media, creating valuable content and personalizing communication with patients (Kotler et al., 2024, 2025).

Marketing activities in NZOH can be divided into:

1. On-line activities:

- website – treated as a business card of the facility, it should contain information about the doctors, the range of services, possibly a price list, and contact information. It can serve as a source of information about news at the facility.

It should be consistent with the image of the facility and constantly updated (Lazorko, Syrkiewicz-Świła, 2011);

- search engine positioning – involves optimizing the website for search engines so that patients can easily find information about the facility online (Ćwiertniak, Wikowska, 2024);
- social media – leads to actively maintaining e social media profiles (e.g., Facebook, Instagram) to provide information about services, promotions, medical tidbits and build a community around the facility (Gaál et al., 2015);
- content marketing – establishments create valuable content related to health and medicine, which allows patients e understanding of health problems and encourages them to visit NZOZ (Syrkiewicz-Świła, Świła, 2012);
- search engine marketing (paid campaigns)-using Google Ads to reach patients looking for specific medical services (Rafalko, 2017);
- email marketing-personalized messages to patients with information about services, promotions, appointment reminders (Elrod, Fortenberry, 2020);
- affiliate marketing.

2. Activities of line:

- direct marketing is mainly visits to family doctors, leaflets with information about clinics,
- event marketing – we can include organizing open days, lectures on topics related to preventive health care, workshops on health-related topics (Khan, Kulshreshtha, 2020),
- cooperation with local media,
- sponsoring local events,
- personalization,
- building a positive image,
- monitoring and analysis of indicators.

Due to the nature of health services, the main focus should be on building a relationship with the patient and trust in the facility.

2. Methods

For the purpose of this issue related to an attempt to look at the introduction of modern marketing into the management activities of NZOZs and patients' perceptions of these activities, a survey was conducted using a survey questionnaire. The questionnaire consisted of 19 questions. The questions were both closed-ended and semi-open-ended. Due to the clearly

defined purpose, scope of the topic, and time and budget constraints, the survey was based on a non-random survey. The survey questionnaire was created on the example of the Google forms questionnaire. It consisted of an introductory section that outlined the purpose of the survey, assured anonymity and indicated how to complete the questionnaire. The main part contained 15 questions. The third part was a metric with four questions. The questionnaire was posted on websites related to the author. The survey was voluntary. Interested respondents participated in the survey and were guaranteed anonymity. The survey lasted from May to June 2025. 80 people responded to the questionnaire. 45 women, 33 men, two people did not specify gender. Most of the respondents were from large cities. The main objective of the survey was to confirm or reject the assumption that modern marketing activities undertaken by NZOZ are noticed and positively evaluated by patients.

3. Results

The survey was conducted from May to June 2025. The survey included 80 respondents: 45 women, 33 men, two people did not specify gender.

The main research hypothesis was that patients notice modern marketing activities introduced by NZOZs. In addition, it was assumed that these activities are evaluated positively.

It was also assumed that the use of modern marketing tools is noticed by those who are young or in the working age.

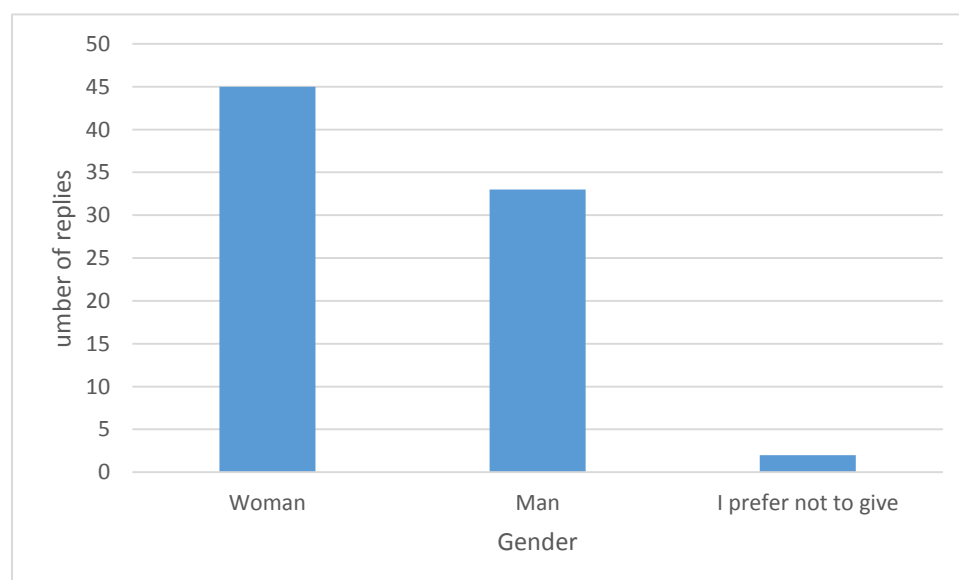


Figure 1. Gender of respondents.

31 respondents were in the age range of 18-29 years, the second group was made up of people aged 45-59 years – 23. 19 people were in the range of 30-44 years and 7 people were 60 years and older. From the age distribution, it can be surmised that most of the respondents, use social media and modern technologies on a daily basis, which for them are everyday life.

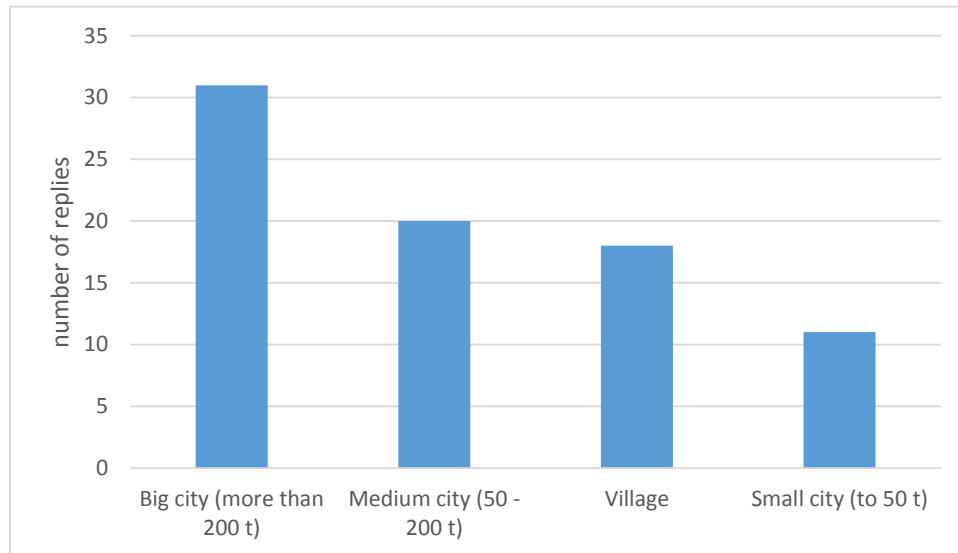


Figure 2. Place of residence.

As can be seen from the chart above, most respondents were from large and medium-sized cities.

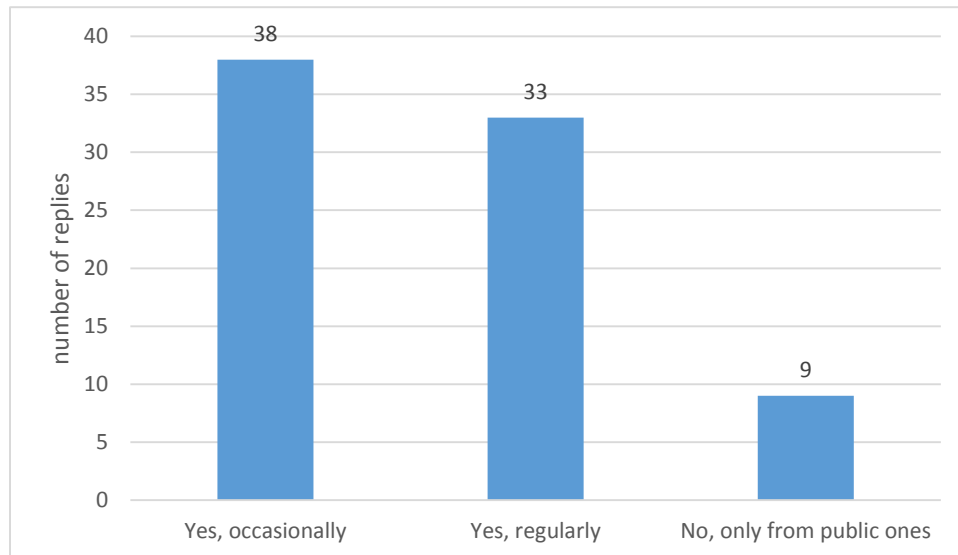


Figure 3. Use of non-public healthcare facilities (NZOZ) by respondents.

As can be seen, most people used occasionally (38 people), regularly – 33 people and 9 people used only public establishments. There is suspicion here as to whether respondents are able to distinguish between a public facility and a non-public one with, for example, a contract with the National Health Fund. One can take these answers as a limitation of the survey and in the future detail the questions related to health services to paid services and free services available on the National Health Fund.

Moving on to the core questions, the first question in this area concerned how to familiarize oneself with the facility's offerings.

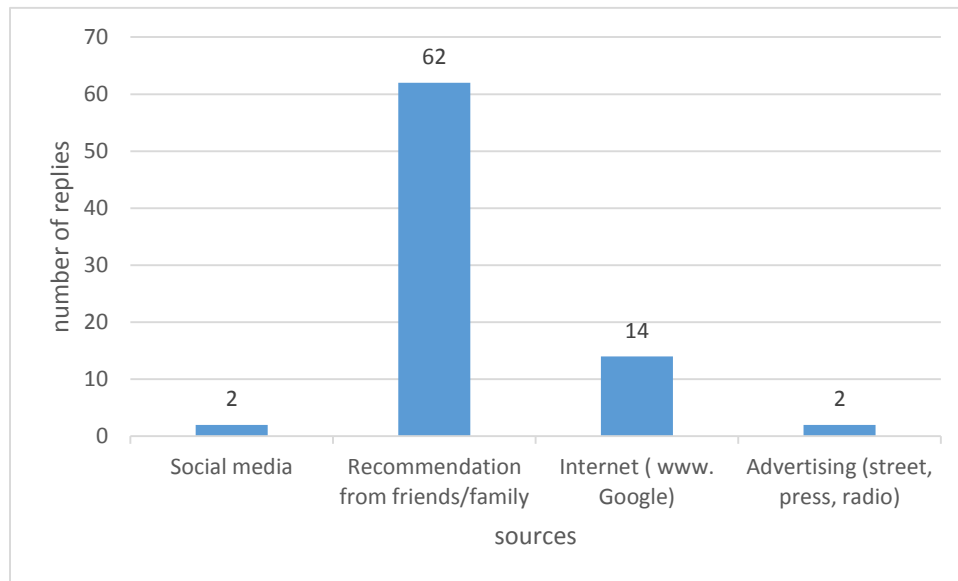


Figure 4. Sources of information for healthcare facilities.

The survey found that most often patients use the opinions of friends to choose a particular facility. Conducting further research, however, made it possible to note a correlation between the choice of media used as a source of information and the age of patients. A chi-square test of independence was examined, which, with a significance level of 0.95 and 9 degrees of freedom, found that the hypothesis of independence of information sources and the age of respondents should be rejected. It shows that the source of information is dependent on the age of respondents with a probability of 95%.

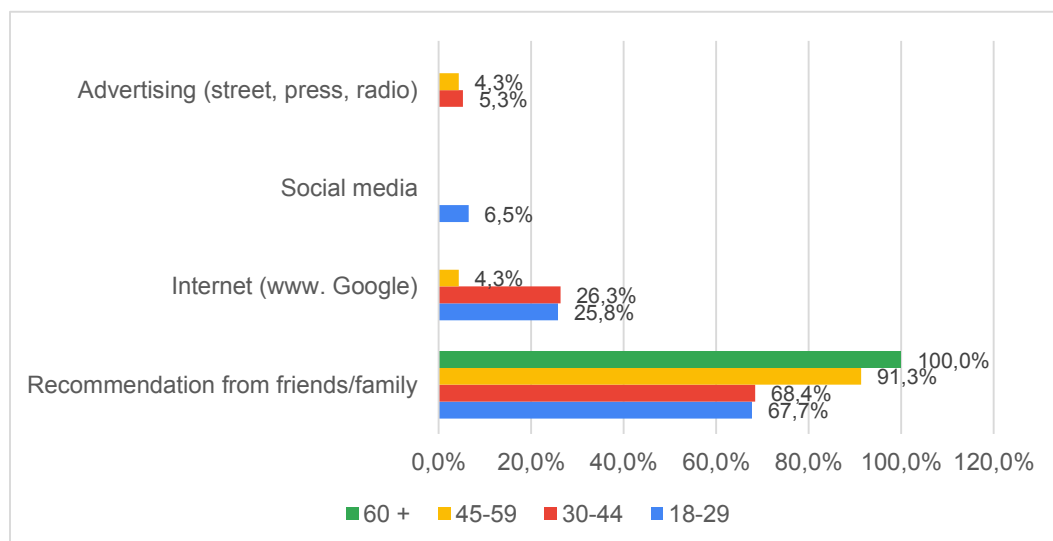


Figure 5. Correlation between age and choice of source of information about NZOZ facility.

It shows that in the group of people over 60, 100% of the information about the establishment came from friends. It also seems interesting that young people in the 18-29 age range did not pay attention to advertising placed on traditional media. Only 18-29 year olds

used social media and 18-29 and 30-44 year olds used websites talking about the establishment. However, these groups were also dominated by information obtained from family and friends.

These results may indicate that such complex services with a high social cost still require creating a good image and building a community of ambassadors, as their opinions are the most important.

The next group of issues concerned patients' subjective feelings about marketing activities.

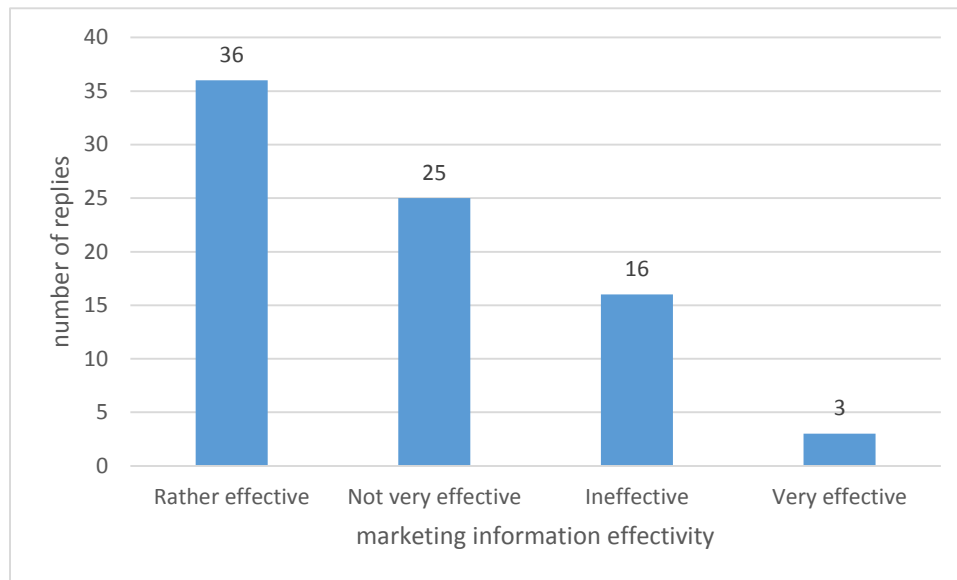


Figure 6. Effectiveness the facility's information activities (subjective scale).

Responses regarding the effectiveness or lack thereof were almost evenly distributed because the corresponding 48.8% to 51.2%. Relating this to the previous chart, it can be seen that it is likely that those who got their information from friends and family do not pay attention to marketing activities posted in public spaces and modern information channels.

This is consistent with the answer to the question "Did the presence of the establishment in social media influence your decision to use the services?" where 58 people or 72.5% answered that it did not.

The same number of respondents or 72.5% do not notice the health promotion campaigns organized by the facility. The implication is that modern communication channels still reach a small number of patients, and these are relatively young patients, whose contact with NZOZ may be mainly based on prevention and emergency measures.

The elements that patients largely pay attention to are shown in the chart below. Patients were able to mark several answers here.

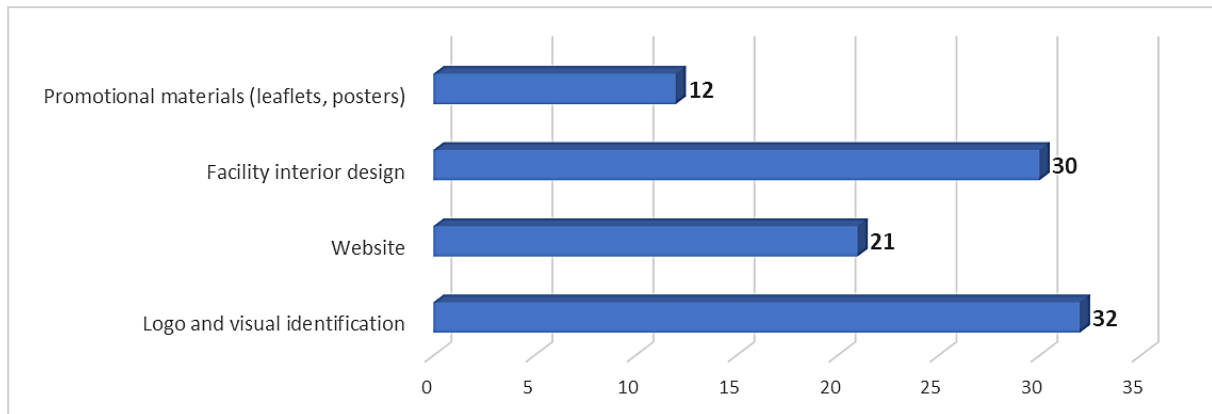


Figure 7. The most memorable marketing elements of healthcare facilities according to respondents.

The clear favorite here is the design of the establishment and therefore the appropriate layout of the offices, registration of seats in the waiting room for patients, equipment in the offices (cf. Krukowska-Miler, 2016). In second place is the logo and visual identity (cf. Krukowska-Miler, 2015). The website is in third place.

Responses regarding the effectiveness of the establishment's communication of its offerings are almost evenly distributed. 53.8% of respondents said they were effective or rather effective. The rest had a different opinion. Which coincides with responses saying that such activities are not perceived by patients. Also, measures regarding the use of e-services are similarly perceived.

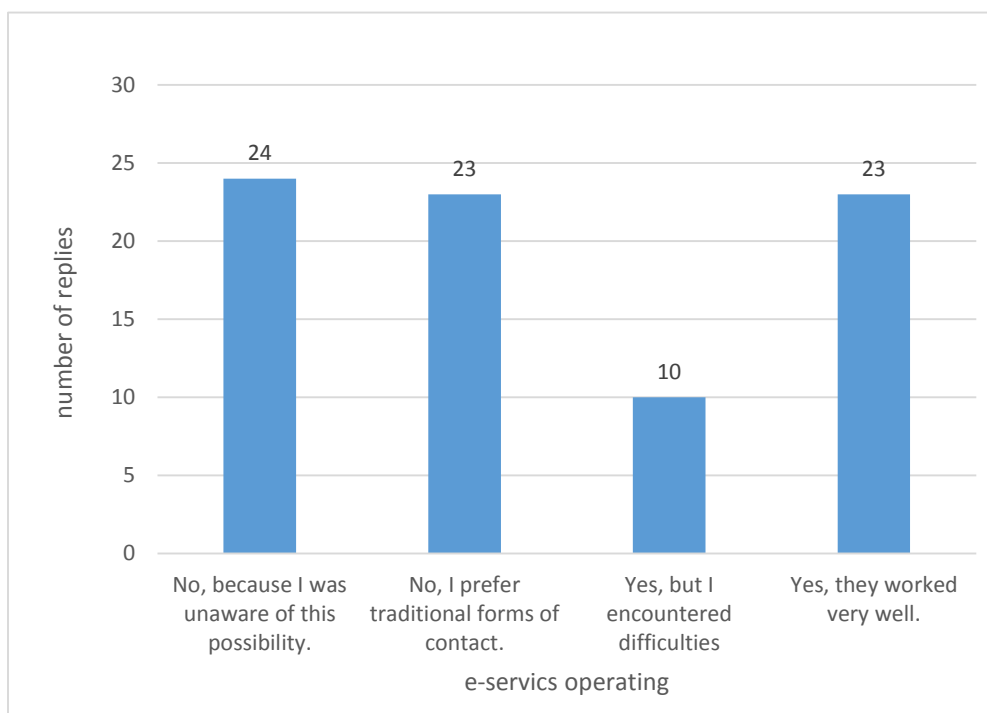


Figure 8. Operation of electronic services offered by a healthcare facility (e.g., online registration).

What may be surprising here are the answers placed in Figure 8. As many as 58.7% did not use the e-services offered by the facility, emphasizing that they prefer traditional forms of contact which contradicts the thesis that modern forms of marketing are perceived

and positively by patients. This corresponds with the answer to the next question in the survey: “To what extent did the promotional activities of the facility affect your confidence in the facility?” 74 people said that promotional activities had no or a moderate effect on trust in the facility. This represents as much as 92.5% of all responses and contradicts the assumption that the promotional activities of the facility are noticed by patients. However, it can be seen, also, that NZOZs do not use modern marketing activities on a large scale, e.g. via email or text message. Only 12.5% of respondents received an e-mail message after a visit and 28.7% received an sms message after a visit. 2 people received a marketing message in another form. According to 48.5% of respondents, there is no personalization of marketing activities at the facilities. Only 11.3% note such activities. The rest of the respondents state a low degree of personalization. This is in opposition to researchers' predictions of personalization processes that also involve healthcare facilities. However, it may also indicate a certain slowness in implementing change in the healthcare sector as captured in the work of Chanchaichujit, Tan, Meng, Eaimkhong, among others, (Chanchaichujit et al., 2019).

As for the application of ethics in the marketing activities of HNWIs, the majority of respondents as much as 87.5% of the answers were positive. The remaining respondents had a different opinion. This issue requires further in-depth research, as it is not known which/what activities influenced these negative opinions.

Figure 9 shows that almost half of the respondents/patients believe that marketing activities did not encourage them to use the services of a particular HCAI again, which was surprising to the researcher as it again contradicted the thesis of positive perception of marketing activities by patients. This may be due, in conjunction with the previous responses, to the fact that modern online marketing activities were not perceived by almost half of the respondents and thus they cannot appeal to them.

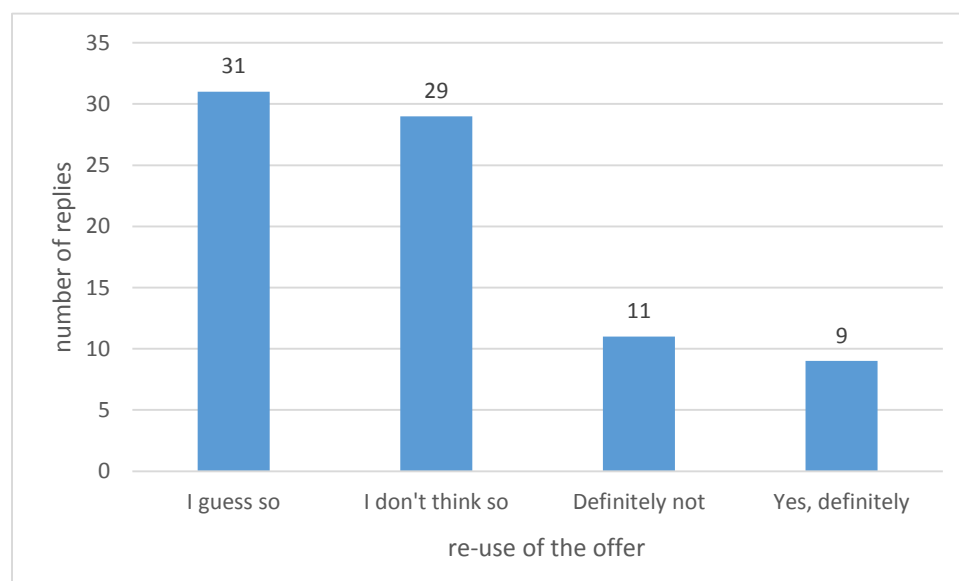


Figure 9. Effectiveness of marketing activities encouraging respondents to use the healthcare facility's services again.

However, additional questions on the general perception of marketing activities undertaken in the health sector are encouraging. The willingness of respondents to accept such activities is evident. When asked, does marketing affect the quality of the patient-provider relationship? 70.1% think it can influence positively, 28.7% have no opinion on this. Among the marketing activities that respondents consider most needed, health education and prevention, as well as information about services and personnel, come to the forefront.

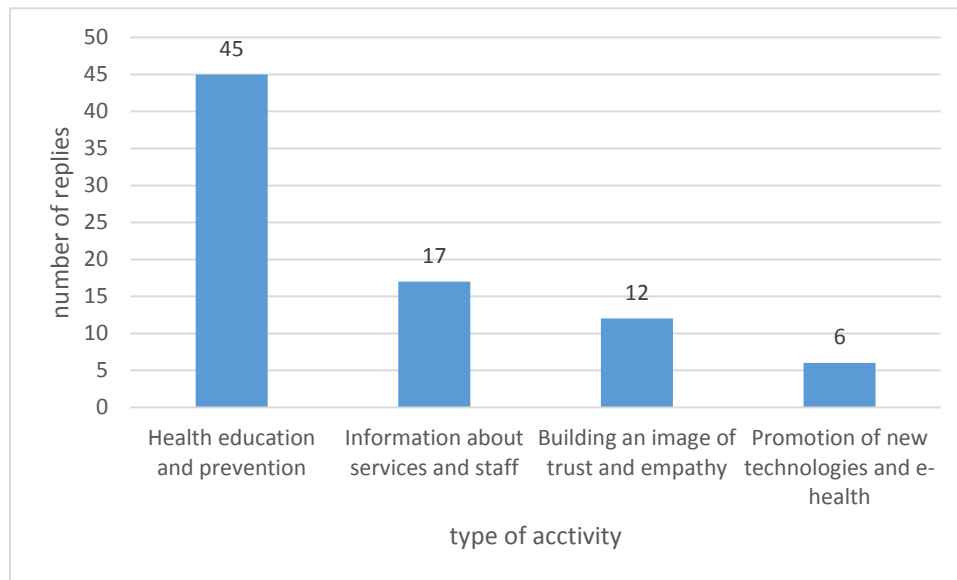


Figure 10. Healthcare activities considered most necessary by patients.

It follows that patients first of all want to take care of their health beforehand and then know what services they can use. Due to the nature of these services, of course, medical personnel and information about them are important to them. The mechanisms that influence this are included, among others, in the publication of A. Mykowska (2002). It should also not be forgotten when undertaking marketing activities that medical services have a number of specific features (Holub, 2001). Hence, the marketing activities one undertakes have a specific form.

4. Discussion

Changing market conditions, the continued development of artificial intelligence, the spread of online tools and, of course, technological developments are undoubtedly affecting changes in the management of non-public health care facilities in Poland. These changes also affect marketing activities. The purpose of this article was to try to look, to a small extent, at the introduction of these changes to the management activities of NZOZs and the perception of patients. The premise of the paper was that modern marketing activities undertaken by NZOZs are noticed and positively evaluated by patients. Unfortunately, this assumption cannot be stated unequivocally on the basis of the research conducted. The willingness of patients to

accept marketing activities is apparent, however, a certain tardiness in learning about and using modern marketing channels is revealed. The correlation study conducted by the chi-square test of independence highlighted the relationship between the use of sources of information about the facility and the age of the person acquiring this information. Therefore, the assumption that ongoing marketing activities influence the patient can only be partially confirmed. Many respondents still use information provided by friends and family, and it is their recommendations that are most important to them. A change in attitude and partial use of information on the Internet can be observed among those under 45 years of age. It can be seen here that what happens at NZOZ-e is most important because the ambassadors are patients who have already used NZOZ-e's services. Therefore, any shortcomings in the activity must be immediately corrected and explained. However, managers must bear in mind that a new generation is coming, familiar with social media and the Internet, which cannot be neglected. This article can therefore be a contribution to making appropriate marketing decisions by NZOZ managers. In a few years, one can try to repeat the research in order to compare today's results with the future.

5. Summary

To summarise the research conducted, it should be noted that it is incomplete, but at the same time it points to elements that may be important in the process of managing the marketing activities of non-public healthcare institutions. This research is definitely of a pilot nature. It may be deepened and expanded at a later date. However, it constitutes a contribution to further research and the expansion of the issues raised. An interesting conclusion from this partial research is that contact via modern marketing channels, such as the Internet, has a greater impact on young people and is not really applicable to older respondents over the age of 60. It is also worth noting that marketing activities introduced into the healthcare sector are accepted, but this is happening slowly and, despite patients' relatively positive attitude towards these activities, they are not fully familiar with their role. The healthcare activities considered most essential by patients are mainly health education and providing information about services and staff. This shows that there is a need for proper health education and prevention of potential diseases, as well as basic information about the range of services available. Typical marketing activities are still seen as an addition. Changes in the approach to marketing in healthcare facilities are visible among younger respondents. This trend may encourage facility managers to manage marketing properly and use it to build a competitive advantage for healthcare facilities in the future.

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INTEGRATING CONTINUOUS AND EPISODIC PERSPECTIVES IN THE CHANGE MANAGEMENT PROCESS IN PUBLIC ORGANIZATIONS

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Purpose: This study aims to explore how Polish public organizations manage change by integrating continuous and episodic approaches.

Design/methodology/approach: The research was conducted in Poland using a structured survey based on original statements derived from change management theory. Data were collected from 576 employees working in various public institutions, including local government administrations, higher education institutions, healthcare services, and central government agencies. The sample comprised 63% women and 37% men, with the majority (86%) holding non-managerial positions. Respondents represented diverse educational backgrounds, with 42% holding technical degrees. A 5-point Likert scale was used, and Spearman's rank correlation coefficient was applied for analysis.

Findings: The results indicate that mechanisms of continuous change-such as communication of stable elements and teamwork-are positively associated with trust ($\rho = 0.449$) and cross-functional collaboration ($\rho = 0.399$). Conversely, features of episodic change-including decision reversals and repeated failed initiatives-are negatively correlated with trust ($\rho = -0.158$) and collaboration ($\rho = -0.156$). A strong correlation between trust and collaboration ($\rho = 0.682$) underscores the importance of social capital. These findings suggest that public organizations operate within hybrid models of change and that balancing both change logics enhances organizational adaptability and effectiveness.

Research limitations/implications: Reliance on self-reports, purposive sampling, and a cross-sectional design limits causal inference and generalizability. The brief scale's moderate internal consistency indicates room for refinement and validation (e.g., subscale development and longitudinal assessment). Future research should examine mediation pathways – specifically, whether communication fosters trust, which in turn facilitates collaboration – and test sector-level moderators.

Practical implications: During organizational change, explicitly communicate which elements will remain stable, establish cross-functional teams, and actively manage the initiative portfolio to avoid symbolic or duplicative efforts – i.e., “change for its own sake”. These practices are associated with higher levels of trust and collaboration and, in turn, support more sustainable implementation.

Social implications: Strengthening trust and collaboration in public organizations can reduce change fatigue, enhance service reliability, and improve stakeholder confidence in public administration.

Originality/value: This study offers an empirically grounded integration of continuous and episodic perspectives on public-sector change, quantifying how specific managerial practices – stability communication and cross-functional teamwork – are associated with social capital outcomes.

Keywords: change management, public organizations, continuous change, episodic change.

Category of the paper: Research paper.

1. Introduction

Organizational change has been a subject of intensive research in the organizational and management sciences for several decades. One of the key approaches to understanding this phenomenon is the distinction between continuous and discontinuous change, a framework thoroughly discussed in the work of Weick and Quinn (1999). These authors argue that the primary criterion distinguishing the two types of change lies in their rhythm and the way they are embedded in organizational practices. Discontinuous (episodic) change is infrequent, radical, and intentional, often triggered by a crisis or significant disruption to the organizational equilibrium. It disrupts the existing order and compels the organization to transition to a new state of balance. This form of change follows the “unfreeze–transition–refreeze” model originally proposed by Lewin (1991), which entails questioning the current state, undergoing a transitional phase, and then solidifying the new order.

In contrast, continuous change is characterized by an ongoing process of adjustments, minor adaptations, and evolutionary modifications that are embedded in everyday organizational practice. It does not require dramatic breakthroughs or formal external interventions but instead emerges from routine activities, improvisation, learning, and local initiatives. Weick and Quinn (1999, p. 366) describe it as a “freeze–rebalance–unfreeze” process, in which the organization continually identifies patterns of action, introduces small corrections, and then reopens itself to further adaptation. This type of change reflects the concept of a learning organization – one that is capable of adapting through a deeply embedded culture of reflection, experimentation, and knowledge sharing.

The literature emphasizes that discontinuous changes are often driven by external factors such as technological advancements, regulatory changes, sudden market shifts, or financial crises. Studies by Tushman and Romanelli (1985) and Romanelli and Tushman (1994, p. 1162) suggest that organizations operate in cycles of long-term stability punctuated by periods of revolutionary transformation, aligning with the “punctuated equilibrium” model. Episodic change becomes necessary when the organizational structure – including entrenched norms, values, and relationships among system components – grows too rigid to respond effectively

to environmental demands. These types of changes are typically costly, provoke resistance, and may lack sustainability unless supported by appropriate reinforcement mechanisms.

In contrast, continuous change is theoretically grounded in concepts of organizations as open and self-learning systems. Research by Orlikowski (1996, pp. 89-90) demonstrates that even small, localized modifications in work processes – when repeated and reinforced through practice – can eventually lead to deep, structural transformations. Brown and Duguid (1991, pp. 11-12) emphasize the role of social practices and “communitas” in shaping and transforming organizational knowledge. This approach views change as an emergent process, difficult to capture within traditional, linear, goal-oriented change management models. From this perspective, managing change is less about designing and implementing formal plans and more about creating conditions that foster experimentation, improvisation, and knowledge sharing.

The aim of the study was to identify and assess how change management processes are perceived in public organizations from the perspective of integrating continuous and episodic change approaches. The analysis examined the extent to which the surveyed organizations employ mechanisms characteristic of both approaches, as well as the role of factors such as trust, collaboration, and communication in shaping perceptions of the effectiveness and sustainability of change processes.

2. Literature review

The differences between continuous and discontinuous change also have important implications for intervention strategies. Episodic change requires “unfreezing” existing structures and patterns, which involves confronting resistance, generating a sense of urgency, and creating a psychologically safe space for change, as described by Schein (1996). Burnes and Bargal (2017) offered a renewed analysis of Lewin’s “unfreezing” model, particularly in the context of episodic change. Continuous change, by contrast, does not necessitate such a dramatic disruption of the status quo. Instead, it focuses on creating space for reflection, sharing experiences, and building awareness of changes occurring at the “margins” of organizational life. The literature suggests that effective organizations are able to integrate both approaches, developing the capacity for everyday adaptation while also being prepared for moments that require more radical, episodic interventions. Brown and Eisenhardt (1997, p. 5) argue that the key to success in dynamic sectors of the economy lies in adopting a “semi-structured” approach – one that combines clearly defined frameworks with the flexibility needed for improvisation. This approach enables organizations not only to respond to change but also to actively shape it, harnessing the potential of both continuous and episodic change.

In the context of continuous and discontinuous change theories, ten statements regarding organizational change were formulated based on the literature. These statements reflect how respondents perceive transformation processes within their organizations and allow their responses to be interpreted through the lens of relevant theories and scholarly literature. The first statement – “S1: Despite changes in the organization, work has remained the same over the past several years” – is interpreted as an indication of organizational inertia and the limited scope of change. This suggests that although the change may have been formal in nature, it did not meaningfully affect day-to-day operations (Adler et al., 2022). This phenomenon aligns with episodic change theory, as supported by references to the works of Weick and Quinn (1999), Romanelli and Tushman (1994), and Gersick (1991).

The second statement – “S2: The management hierarchy has become significantly flatter than it was a few years ago” – points to a structural transformation resulting from an episodic change, though it also reflects elements of continuous adaptation, as the organization’s structure has evolved toward greater flexibility. This interpretation combines features of episodic change with aspects of continuous change, in line with the frameworks proposed by Weick and Quinn (1999), Dunphy (1996), and Tushman and O’Reilly (1996) (Hazelzet et al., 2022). The study by A. Gofen et al. (2023) highlights that minor adaptations in public organizations play a critical role in ensuring the stability and integration of change (Andriopoulos, Lewis, 2009).

The third statement – “S3: Informing employees about what will remain unchanged during the implementation of changes” – emphasizes the communication of stability and the maintenance of balance throughout the change process (Ellis et al., 2023; Hall, 2023; Krukowski et al., 2021). This approach is characteristic of continuous change, which aims to preserve the organization’s identity. This interpretation is supported by the works of Weick and Quinn (1999), Schein (1996), and Kotter and Heskett (1992).

The fourth statement – “S4: Despite declarations of strengthening change, employees are still controlled in the same way as before” – illustrates a situation in which the formal narrative of change does not lead to an actual shift in power relations. This reflects symbolic actions typical of episodic change, where the outcomes remain superficial. This interpretation is based on the analyses of Weick and Quinn (1999, pp. 361-386), Jacobsen et al. (2022), Marshak (1993), and Beer et al. (1990).

The next statement – “S5: Teamwork has significantly improved the effectiveness of implementing change” – emphasizes the role of local, bottom-up adaptations and collaboration. This is an example of continuous change enacted through micro-innovations and learning processes, in line with the concepts developed by Weick and Quinn (1999), Brown and Eisenhardt (1997), and Orlikowski (1996). Teamwork played a crucial role in significantly enhancing change implementation effectiveness (Ward et al., 2022). This can also be linked to an adaptive culture oriented toward innovation (Siemiński, Krukowski, 2011).

The sixth statement – “S6: The need to appear dynamic is more important than implementing real changes” – points to the simulation of change or so-called “change for the sake of change.” This approach is characteristic of certain management practices within episodic change, focusing on visible but superficial transformations (Meneses et al., 2025). This interpretation is supported by the research of Doyle et al. (2008) and Weick and Quinn (1999).

The seventh statement – “S7: It was necessary to reverse some of the radical organizational changes that had been implemented” – reflects a failure to sustain the outcomes of episodic change, which often requires correction. This interpretation is supported by the works of Lewin (1997), Weick and Quinn (1999), and Beer et al. (1990).

The eighth statement – “S8: The changes currently being discussed are similar to previously attempted and abandoned initiatives” – highlights the cyclical nature of change (Cianetti, 2023; Kleizen, MacCarthaigh, 2023). This phenomenon is typical of organizations that undergo repeated episodes of change without fostering continuous learning or accumulating experience. This interpretation is supported by the works of Weick and Quinn (1999), Kotter (1996), and Gersick (1991).

The ninth statement – “S9: There has been an increase in trust between managers and employees compared to a few years ago” – illustrates the process of building relationships and fostering collaboration (Bentzen, 2022). This is characteristic of continuous change, carried out through adaptation and the development of organizational culture, in line with the research of Weick and Quinn (1999), Barrett et al. (1995), and Schein (1993).

The final statement – “S10: There is now more authentic collaboration between managers of different functions than there was a few years ago” – indicates a deepening of cross-functional collaboration and integration. This interpretation points to continuous change (Meneses et al., 2024) and the development of the organization as a learning system, as reflected in the analyses of Weick and Quinn (1999), Brown and Duguid (1991), and Crossan et al. (1996).

In summary, the literature review reveals that organizational change is a multidimensional process, and effective change management requires the ability to discern when an episodic approach is appropriate and when continuous change should be supported. Contemporary organizations operating under conditions of complexity and uncertainty must develop the capability to navigate both logics of change simultaneously, while also strengthening social capital, trust, and organizational learning capacity.

3. Research methodology

Respondents evaluated specific statements they considered important for implementing change in public organizations. The survey questionnaire was directed at employees of public sector institutions. The research sample consisted of 576 individuals employed across various types of public organizations, including central government administration, local government administration, government agencies, the education sector, healthcare services, and higher education institutions. To fulfill the study's objectives, a purposive sampling strategy was adopted. The sample was diverse in terms of gender, length of service, education level, and job position, allowing for comparative analyses based on these variables as potential factors influencing perceptions of change.

Eligibility for participation in the study was based not only on employment in the public sector but also on actual involvement in organizational change processes. The sampling process took into account the need to ensure an adequate level of domain-specific knowledge among respondents to minimize the risk of misinterpreting terms used in the survey. To increase the reliability of the collected data, the survey was designed to capture respondents' evaluations of current experiences, rather than retrospective recollections. A Likert scale was used to assess the factors, with the following response options: 1 – strongly disagree, 2 – somewhat disagree, 3 – neutral, 4 – somewhat agree, 5 – strongly agree.

In terms of educational background, the largest group of respondents held technical higher education degrees, accounting for 41.67% of the sample. This was followed by respondents with degrees in the humanities (28.82%) and social sciences (19.97%), while 9.55% reported having a secondary education. The majority of participants occupied non-managerial positions (85.59%), whereas 14.41% held managerial roles. Analysis of work experience revealed that the largest proportion of respondents (29.17%) had less than five years of professional experience. Additionally, 24.27% had between 11 and 20 years of experience, 9.55% reported 6 to 10 years of experience, and 17.01% had more than 20 years of service.

Women constituted the majority of the sample, representing 63.19% of all respondents, while men accounted for 36.81%. Regarding qualifications in change management – acquired through courses, training programs, or postgraduate studies – 24.83% of respondents reported having such qualifications, while 75.17% did not. A total of 26.39% of participants identified the implementation of organizational change as a key element of their role, whereas 73.61% did not associate it with a core aspect of their job duties.

With respect to the type of public organization, the largest groups of respondents were employed in local government administration (40.97%) and higher education institutions (35.07%). Other groups included healthcare services (7.99%), government agencies (7.47%), the education sector (4.86%), and central government administration (3.65%).

To account for potential common method bias (CMB), the questionnaire design incorporated Brewer's split-sample method (Brewer, 2006). This approach aimed to minimize CMB by using one respondent group to assess the independent variable and another to measure the dependent variable. In the present study, the independent variable – i.e., the type of public organization – was derived from administrative data (Podsakoff et al., 2012; Jakobsen, Jensen, 2015). The survey was distributed to multiple individuals within each organization who were involved in the change management process, which also helped to reduce the risk of bias (MacKenzie, Podsakoff, 2012).

Before conducting the factor analysis, the quality and internal consistency of the measurement instrument were evaluated. The Cronbach's alpha coefficient was 0.601, indicating a moderate level of internal consistency, which nonetheless requires further refinement. Given the exploratory nature of the study and the relatively novel context of analysis (types of change within public organizations), an acceptable threshold for internal consistency was set at 0.5 or above (Nunnally, 1978). The Cronbach's alpha value was partly influenced by the limited number of items, which constrained the potential for achieving higher reliability (Cortina, 1993). Additionally, the alpha level reflects the high heterogeneity of the sample – respondents came from diverse types of public institutions – resulting in natural variation in the perception of the phenomena studied, which may have contributed to the lower consistency coefficient.

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.695, indicating a moderate yet acceptable level for conducting factor analysis (Kaiser, 1974). Bartlett's test of sphericity reached statistical significance ($\chi^2(45) = 1019.452$; $p = 0.00$), allowing the null hypothesis of a homogeneous correlation matrix to be rejected and thus justifying further analysis (Bartlett, 1954). However, the aim of the study was not to establish relationships between variables but rather to identify and assess their presence, as they pertain to a single phenomenon.

To analyze dependencies, Spearman's rank correlation coefficient was used. This choice was justified by the ordinal nature of the data, the lack of need to meet assumptions of normality and linearity, the method's robustness to outliers, and its suitability for detecting monotonic relationships between variables representing complex psychosocial phenomena occurring during organizational change processes. The significance level was set at $\alpha = 0.05$. Statistical analyses were performed using IBM SPSS.

For analytical purposes, the ten statements were categorized according to their theoretical alignment with either continuous or episodic change perspectives. Statements S3, S5, S9, and S10 were identified as indicators of continuous change, reflecting communication of stability, teamwork, and trust-building. Statements S4, S6, S7, and S8 represented episodic change mechanisms, such as reversals, symbolic actions, and repeated initiatives. Statements S1 and S2 captured structural or contextual aspects that could co-occur with either logic, depending on organizational dynamics.

4. Results

Respondents' indications revealed how they perceive changes within their organizations and allowed their responses to be related to established theoretical frameworks. The descriptive statistics for the statements concerning change implementation in public organizations provide a synthesized view of how these processes are perceived by employees (Table 1). An analysis of the median values suggests a moderate perception of change – most statements had a median of 3.00, indicating a predominance of neutral responses and a lack of clear positive or negative evaluations. An exception is the statement, “We talk about strengthening change, but our people are controlled just as much as always,” which had a median of 4.00. This indicates greater agreement among respondents and may reflect a critical view of the effectiveness of change initiatives, as well as a perception of such changes as superficial. The mode supports this interpretation – most statements had a mode of 3.00 or 4.00, with “4” being the most frequently selected response. This may suggest that respondents tend to assess the situation as moderately true or commonly observed.

Table 1.

Descriptive Statistics for Statements on Change Implementation in Public Organizations (n = 576)

Itemization	Median	Mode	Minimum	Maximum
S1 – Despite changes in the organization, my work has remained the same over the past few years.	3.00	4.00	1.00	5.00
S2 – Our management hierarchy is significantly flatter than it was a few years ago.	3.00	3.00	1.00	5.00
S3 – We always inform people about what will remain unchanged when implementing changes.	3.00	4.00	1.00	5.00
S4 – We talk about strengthening change, but our people are still controlled just as much as before.	4.00	4.00	1.00	5.00
S5 – Teamwork has significantly improved the effectiveness of implementing change.	3.00	4.00	1.00	5.00
S6 – The need to appear dynamic is more important than implementing real change.	3.00	4.00	1.00	5.00
S7 – We will likely have to reverse some of the radical organizational changes we implemented.	3.00	3.00	1.00	5.00
S8 – The changes we are currently discussing are similar to initiatives that were tried and abandoned some time ago.	3.00	3.00	1.00	5.00
S9 – There is more trust between managers and employees than there was a few years ago.	3.00	3.00	1.00	5.00
S10 – There is now more genuine collaboration between managers across different functions than there was a few years ago.	3.00	3.00	1.00	5.00

Source: authors' own work based on research results.

The response range, from a minimum of 1.00 to a maximum of 5.00 for all statements, indicates a wide variation in respondents' perceptions – from strong disagreement to full agreement. This suggests that experiences related to change processes in public organizations are heterogeneous and dependent on individual contexts.

It is particularly noteworthy that none of the statements received an unequivocal, extreme rating from respondents – both the median and the mode tend to cluster around mid-scale values. This may indicate either a lack of clear successes or failures in change processes or their limited visibility in day-to-day work. It is also worth noting that statements related to collaboration and trust – such as “There is more trust between managers and employees than there was a few years ago” and “There is now more genuine collaboration between managers across different functions than there was a few years ago” – both recorded a median and mode of 3.00. This may suggest that the processes of relationship-building and collaboration are not clearly perceived as improving.

The analysis of Spearman correlation coefficients revealed several statistically significant relationships between variables describing perceptions of organizational change processes (Table 2). The correlation results illustrate how various aspects of organizational change are interconnected and how they are perceived by respondents. The correlation coefficient values make it possible to assess which relationships are strong or weak, as well as whether they are statistically significant. The strongest correlation was observed between the level of trust between managers and employees (S9) and collaboration among managers across different functions (S10), with a statistically significant correlation coefficient of 0.682. This indicates that an increase in vertical trust is associated with improved horizontal collaboration.

Significant correlations also emerged between informing employees about what will remain unchanged during changes (S3) and both trust (S9) and inter-manager collaboration (S10). This suggests that clear communication during change processes fosters a sense of security and enhances organizational relationships.

Other notable relationships include the link between a flatter management hierarchy (S2) and the likelihood of needing to reverse some radical changes (S7), as well as the emphasis on the need to appear dynamic (S6). These findings imply that more flexible, less hierarchical organizations exhibit greater awareness of the need to adapt to changing conditions and adjust previously implemented measures.

An additional noteworthy result is that teamwork (S5) is correlated with levels of trust and collaboration, reinforcing the notion that a team-based approach is one of the key foundations for effective change implementation.

One of the more pronounced negative correlations was observed between the statement “We always inform people about what will remain unchanged when implementing changes” (S3) and the statement “We will likely have to reverse some of the radical organizational changes we implemented” (S7), with a statistically significant coefficient of -0.128 . This indicates that in cases where communication regarding stable organizational elements is stronger, the perceived need to reverse changes is lower. This may be interpreted as evidence that clearly defined boundaries of stability reduce the sense of organizational chaos and enhance the quality of the change process, thereby limiting the need for subsequent corrective actions.

Table 2.*Correlation Analysis Between Statements Describing Organizational Change*

Specification			Statements									
			S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Statements	S1	Correlation coefficient	1	.133**	.167**	0.075	0.054	0.013	-0.032	.136**	.235**	.159**
		Significance	.	0.001	<.001	0.072	0.199	0.757	0.444	0.001	<.001	<.001
	S2	Correlation coefficient	.133**	1	-0.003	-0.019	0.014	.214**	.291**	.182**	0.019	-0.028
		Significance	0.001	.	0.943	0.642	0.737	<.001	<.001	<.001	0.642	0.504
	S3	Correlation coefficient	.167**	-0.003	1	.256**	.317**	0.044	-.128**	0.075	.449**	.399**
		Significance	<.001	0.943	.	<.001	<.001	0.297	0.002	0.072	<.001	<.001
	S4	Correlation coefficient	0.075	-0.019	.256**	1	-0.005	.143**	.136**	.117**	-0.027	0.033
		Significance	0.072	0.642	<.001	.	0.912	<.001	0.001	0.005	0.513	0.423
	S5	Correlation coefficient	0.054	0.014	.317**	-0.005	1	.116**	-.116**	0.005	.392**	.428**
		Significance	0.199	0.737	<.001	0.912	.	0.005	0.005	0.897	<.001	<.001
	S6	Correlation coefficient	0.013	.214**	0.044	.143**	.116**	1	.272**	.165**	0.018	0.048
		Significance	0.757	<.001	0.297	<.001	0.005	.	<.001	<.001	0.668	0.246
	S7	Correlation coefficient	-0.032	.291**	-.128**	.136**	-.116**	.272**	1	.291**	-.158**	-.156**
		Significance	0.444	<.001	0.002	0.001	0.005	<.001	.	<.001	<.001	<.001
	S8	Correlation coefficient	.136**	.182**	0.075	.117**	0.005	.165**	.291**	1	.082*	0.06
		Significance	0.001	<.001	0.072	0.005	0.897	<.001	<.001	.	0.048	0.152
	S9	Correlation coefficient	.235**	0.019	.449**	-0.027	.392**	0.018	-.158**	.082*	1	.682**
		Significance	<.001	0.642	<.001	0.513	<.001	0.668	<.001	0.048	.	<.001
	S10	Correlation coefficient	.159**	-0.028	.399**	0.033	.428**	0.048	-.156**	0.06	.682**	1
		Significance	<.001	0.504	<.001	0.423	<.001	0.246	<.001	0.152	<.001	.

* Correlation is significant at the 0.05 level (two-tailed).

** Correlation is significant at the 0.01 level (two-tailed).

Source: authors' own work based on research results.

The findings suggest that key elements positively influencing the perception of organizational change include communication about stable aspects, trust-building, and teamwork. In contrast, more flexible and flatter organizational structures may enhance the perception of dynamism but are also associated with a higher risk of overload and the need to retract certain decisions. These results imply that organizations should pay attention not only to the substantive content of change but also to the manner in which it is communicated and to the strengthening of relationships across various levels of management.

5. Discussion

The results confirm the findings of classical literature (Weick, Quinn, 1999; Orlikowski, 1996; Brown, Duguid, 1991) and are consistent with recent research (Khumalo Jackson, 2024; Knies et al., 2018; Bradley, 2020; Bentzen, 2022; Bianchi et al., 2021), which emphasize the pivotal role of trust, collaboration, and transversal leadership in the effective implementation of change within complex and dynamic organizational environments.

The distinction between continuous and episodic practices is empirically supported by the correlation patterns observed. Continuous change indicators (S3, S5, S9, S10) are positively associated with trust and collaboration, confirming their reinforcing role in social capital development. Conversely, episodic change indicators (S4, S6, S7, S8) demonstrate weak or negative correlations with these variables, suggesting that discontinuous, top-down interventions may erode relational foundations when not balanced by continuous learning and communication mechanisms.

The findings indicating statistically significant positive correlations between communicating stability (S3) and both trust (S9) and collaboration (S10) align with the theory of continuous change as articulated by Weick and Quinn (1999), in which minor adaptations, the reinforcement of stability, and the integration of change into routine organizational practices play a central role. D. Lamba (2023) emphasizes that top-level managers in public organizations are instrumental in facilitating incremental adaptations that underscore stability while concurrently embedding change. A. Lambright (2023) similarly demonstrates that effective communication about what remains unchanged fosters individual-level trust, which in turn reinforces collaborative behaviors. These findings are also consistent with Orlikowski's (1996) perspective, which highlights the importance of local, micro-level adaptations as a mechanism for enacting deeper structural transformations (Dries, 2024).

On the other hand, the observed negative correlations between the recurrence of change initiatives (S8) and both trust (S9) and collaboration (S10) ($\rho = -0.158$; $\rho = -0.156$) corroborate concerns raised in the literature regarding the costs and risks associated with episodic change (Vernon-Wilson et al., 2023). Weick and Quinn (1999), along with Beer et al. (1990), emphasized that such change processes may result in "change fatigue" and a gradual erosion of trust – particularly when successive initiatives fail to deliver expected outcomes or are prematurely withdrawn. These findings are also consistent with Marshak's (1993) assertion that episodic change often assumes a symbolic form, without generating genuine transformation of deeper organizational structures. This may help explain the high levels of agreement among respondents with statements indicating that core practices remain unchanged despite formal declarations of change. Recent research has also highlighted the importance of adaptation, innovation within tradition, and the strategic modification of organizational rituals in times of crisis (Kapoor et al., 2022).

The presence of significant correlations between a flattened management hierarchy (S2) and the need to reverse changes (S7) ($\rho = 0.291$), as well as between the repetition of change initiatives (S8) and reversals (S7) ($\rho = 0.291$), aligns with the perspective of Tushman and Romanelli (1985), Hazelzet et al. (2022), and Gersick (1991), who conceptualize organizational change within the framework of the "punctuated equilibrium" model. The findings of this study suggest that public organizations within the examined sample operate in a cycle of alternating periods of stability and abrupt, radical interventions, some of which prove to be unsustainable or problematic in terms of implementation.

Moreover, the strong positive correlation between trust (S9) and collaboration (S10) ($\rho = 0.682$) reinforces the findings of Barrett et al. (1995), Bentzen (2022), and Schein (1993), who argue that trust constitutes a fundamental pillar for cultivating an organizational culture conducive to collaboration, knowledge sharing, and learning – values essential to the logic of continuous change. In the context of this study, it is worth emphasizing that despite the presence of episodic change elements, public organizations also exhibit adaptive characteristics typical of learning organizations. This observation is consistent with the conceptualizations offered by Brown and Duguid (1991), Piubello Orsini et al. (2024), and Crossan et al. (1996).

The interpretation of the findings thus points to the necessity of integrating the theoretical approaches described in the literature. The results suggest that effective change management in public organizations cannot be confined to a single model, but instead requires the simultaneous application of strategies rooted in continuous adaptation – grounded in teamwork, communication, and trust-building – as well as the capacity to plan and implement more radical, episodic interventions when required by environmental conditions. This reinforces the proposition advanced by Brown and Eisenhardt (1997) concerning the value of a “semi-structured” approach that combines structural frameworks with the flexibility needed to make deliberate decisions under conditions of complexity and uncertainty. Theoretical insights further indicate that optimal policy design is inherently complex and demands a nuanced understanding of institutional structures and the preferences of both bureaucratic actors and political overseers (Patty, 2023).

In summary, the findings of this study complement the existing literature by illustrating the complexity of change processes in public organizations and underscoring the need to balance the logics of continuous and episodic change.

The conducted study provided valuable insights into the perception of change processes in public organizations. Still, several important limitations should be noted, as they may affect the interpretation and generalization of the findings. First, a key limitation lies in the use of a questionnaire-based method relying on respondents' self-assessments. Although sampling procedures and instrument validation were applied, participants' responses may have been influenced by subjectivity, as well as by attitudes, concerns, or organizational pressure. It cannot be ruled out that some individuals adjusted their answers to align with perceived norms or the official image of the organization. Second, the moderate value of Cronbach's alpha

coefficient (0.601) indicates limited internal consistency for some scale items. While this level was deemed acceptable due to the exploratory nature of the study, it points to the need for further refinement of the instrument and the potential expansion of the scale with additional indicators that better capture the complexity of the phenomenon. Third, the sampling strategy was purposive, which limits the ability to fully generalize the findings to the entire population of public sector employees. Another limitation lies in the fact that the study focused on participants' perceptions and subjective experiences rather than on objective indicators of change process effectiveness. Therefore, the results should be interpreted as a reflection of the perceived reception of change rather than a direct measure of implementation success. Finally, the study employed a cross-sectional design based on data collected at a single point in time. This limits the ability to capture the dynamics of change and to track the evolution of attitudes and organizational processes over a longer period.

6. Conclusion

The conducted research enabled a multidimensional analysis of change management processes in public organizations from the perspective of integrating continuous and episodic approaches. The findings, including the analysis of Spearman's rank correlation coefficients, indicate the coexistence of both change logics within the surveyed organizations. On the one hand, mechanisms characteristic of continuous change are evident, such as the communication of stable organizational elements, teamwork, and the building of trust and collaboration. On the other hand, symptoms of episodic change also emerge – such as the reversal of radical decisions, the recurrence of unsuccessful initiatives, and the experience of change fatigue.

At the same time, the negative correlations between the recurrence of change initiatives and both trust and collaboration highlight the risks associated with the predominance of episodic change – particularly when successive initiatives fail to deliver the expected outcomes. Based on the research findings, the following conclusions can be drawn:

1. Change management in public organizations requires the integration of continuous and episodic approaches, with an emphasis on their complementarity rather than mutual exclusivity.
2. Building trust and collaboration through transparent communication, teamwork, and the emphasis on stable organizational elements enhances the organization's adaptive capacity and increases acceptance of change.
3. The recurrence of unsuccessful initiatives and the reversal of implemented changes undermine trust in leadership and collaborative relationships; therefore, it is essential to avoid illusory or symbolic changes that do not translate into tangible outcomes.

In conclusion, the study reveals that public organizations operate within a complex landscape of change, where the effectiveness of transformational efforts depends on the ability to balance stabilizing and dynamic actions while simultaneously investing in social capital, trust, and collaboration. The findings offer valuable insights for change management practitioners, highlighting the need for a multidimensional and integrated approach to organizational transformation.

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PROSPECTS AND TRENDS IN THE MANAGEMENT OF SMALL AND MEDIUM-SIZED ENTERPRISES IN LOGISTICS

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Purpose: This paper examines global logistics trends and evaluates their adoption among Polish SMEs. The theoretical part reviews literature on contemporary SME challenges, while the empirical part is based on desk research and four case studies.

Design/methodology/approach: A qualitative approach was applied, combining analysis of international and national reports with case studies.

Findings: The study confirms the growing impact of digitalization, automation, AI, e-commerce, paperless logistics, and ecological transformation on SMEs in Poland. Digital tools, automation, and e-commerce are adopted most rapidly, while AI, IoT, and sustainable fuels face financial and skills-related barriers. Case studies illustrate that innovations enhance efficiency, service quality, and competitiveness.

Research limitations/implications: Due to reliance on a limited set of reports and case studies, the research is exploratory in nature.

Practical implications: Polish SMEs can adopt advanced logistics solutions and trends, but the pace of transformation depends on resources, digital competences, and managerial strategies.

Originality/value: By integrating global trends with local practices, this paper contributes to a deeper understanding of logistics transformation in SMEs.

Keywords: logistics; SMEs; digitalization; automation; AI; e-commerce; sustainability; case study.

Category of the paper: Research paper.

1. Introduction

Small and medium-sized enterprises (SMEs) form the backbone of the Polish economy. According to the *Raport o stanie sektora małych i średnich przedsiębiorstw w Polsce* (PARP), enterprises generate 74.1% of national GDP, with SMEs contributing 46.6% and

microenterprises nearly 28%. SMEs employ 6.9 million people, including over 4.3 million in microenterprises (Zakrzewski et al., 2025). Their scale underscores their central role in value creation and employment, as well as their importance for studies on competitiveness and economic resilience.

Today, SMEs operate in a turbulent environment shaped by globalization, ecological transition, inflationary pressures, and the rapid technological progress of Industry 4.0. In such conditions, firms increasingly search for new sources of competitive advantage (Kozak-Siara, Olak, 2022; Zakrzewska-Bielawska, Piotrowska, 2022). Logistics is widely recognized as one of these sources – not merely an operational function, but a strategic domain of value creation and customer engagement (Christopher, 1993; Matwiejczuk, 2013, 2021; Sandberg, Abrahamsson, 2011).

Globally, logistics is shaped by a dynamic set of emerging concepts and trends (Kovács, Kot, 2016; Malagón-Suárez, Orjuela-Castro, 2023). In this paper, logistics trends are defined as specific technological, organizational, and environmental developments that translate global megatrends such as digitalization, sustainability, and globalization into supply chain practice (Pęciak, 2016). Their diffusion into Polish SMEs, however, is often constrained by financial, organizational, and competence-related barriers. This study explores the extent to which global logistics trends are being adopted in Poland and how they influence SME development opportunities.

The theoretical section outlines the role of SMEs in the economy and highlights logistics as a source of competitive advantage. The empirical section applies desk research and case studies of Polish SMEs to assess the degree of adoption of modern logistics solutions.

2. SMEs: Challenges, opportunities, and threats - A literature review

As highlighted in the literature, SMEs constitute the core of national economies and serve as a vital source of innovation and flexibility in adapting to market change. In most countries, they generate a substantial share of GDP and play a stabilizing role during crises by mitigating the effects of recession and maintaining business continuity (Mardikaningsih et al., 2022; Senin et al., 2024; Nesterowicz, 2020; Odorzyńska, 2000; Reswita et al., 2021). In the Polish context, SMEs account for nearly half of gross value added and employ the majority of the workforce in the enterprise sector (Drożdżyński, 2021). Their centrality makes them an important subject of research, increasingly examined across diverse streams of management literature.

Recent studies emphasize that SMEs, like larger corporations, operate in a dynamic and complex environment shaped by globalization, ecological transition, inflationary pressures, and rapid technological change under the Industry 4.0 paradigm. These megatrends – together with rising consumer expectations and sustainability imperatives – create both opportunities and risks (Capurro et al., 2024; Gajdzik et al., 2021). Opportunities include digitalization and technological transformation, which improve operational efficiency and expand market reach, while barriers involve limited digital skills, financial constraints, and cybersecurity risks (Iyelolu et al., 2024; Rupeika-Apoga et al., 2022). Digital transformation therefore requires not only investment in infrastructure but also the upskilling of employees and managers to integrate both hard and soft competences (Zamani, 2022).

Another theme gaining prominence for SMEs is ESG, encompassing environmental, social, and governance issues (Cahyono et al., 2024; Jin, 2025; Mućko et al., 2021). Scholars note the close link between ESG requirements and digitalization, as digital tools enable more effective monitoring and reporting of sustainability indicators (Chen, Wang, 2024).

The literature identifies several key trends shaping the SME environment. These include digitalization and process automation, particularly in logistics operations, which reduce costs and enhance efficiency (Rupeika-Apoga et al., 2022); the green transition, driven by environmental regulations (Kadłubek et al., 2022); and intersectoral collaboration, which facilitates the exchange of knowledge and resources (Pańka, 2022). Innovation – whether product, process, organizational, or marketing – remains a cornerstone of SME competitiveness (Kott, 2020). Studies during the pandemic further demonstrated that innovation was critical to organizational resilience, enabling firms to adapt business models swiftly to new conditions (Adam, Alarifi, 2021).

Overall, the literature consistently highlights the growing importance of digital and managerial competences as prerequisites for innovation and change management. The SME sector thus emerges as a highly diverse and dynamic research domain, where local and global challenges intersect, and adaptability and innovativeness are decisive for long-term development.

One domain where global trends exert particular influence on SMEs is logistics. As Kovács and Kot (2016) argue, globalization, shorter product life cycles, and rising customer expectations are transforming logistics processes. New supply chain models such as Lean, Agile, and Hybrid Supply Chains enable more flexible responses to environmental shifts. This flexibility is reinforced by Logistics 4.0 – the adaptation of Industry 4.0 principles to supply chain management – through the integration of technologies that shorten reaction times and enhance responsiveness (Malagón-Suárez, Orjuela-Castro, 2023). For SMEs, these developments offer both opportunities to boost efficiency and competitiveness, and risks of marginalization if adaptation does not occur.

3. Research method

As noted in the introduction, the aim of this study is to examine how and to what extent Polish enterprises are adapting global logistics trends and how these processes influence their development. The research employs a mixed-method approach, combining the analysis of secondary data sources (desk research) (Topolski et al., 2023) with a qualitative analysis in the form of case studies of selected Polish firms.

In the first stage, a desk research analysis was conducted, focusing on industry and institutional reports: *DHL Logistics Trend Radar 7.0* (DHL, 2025), *OECD Financing SMEs and Entrepreneurs 2024* (OECD, 2024), *GS1 Poland 2024* (GS1, 2025), *Capgemini Integrated Annual Report 2024* (Capgemini, 2025), and the *Report on the State of the SME Sector in Poland 2025* prepared by PARP (Zakrzewski et al., 2025). This analysis enabled the identification of key trends shaping contemporary logistics at the global level (DHL, OECD, GS1, and Capgemini reports) and the national level (PARP report), as well as the classification of the main categories and types of trends.

In the second stage, a case study analysis was undertaken to illustrate how global trends are being implemented in the practice of Polish SMEs. Four companies representing different industries were selected: BWS Expo (exhibition services), Frisco.pl (online retail, e-grocery), Martex Logistics (distribution of spare parts), and Goliard (food production). Data for the case studies were drawn from industry reports, descriptions of technological implementations published by solution providers, and press and trade publications.

The triangulation of sources – international reports, national reports, and case studies – provided a more comprehensive picture of the phenomenon under investigation and allowed for a comparison of identified trends with actual implementation practices.

4. Emerging Logistics Trends – Evidence from Desk Research

4.1. Global Logistics Trends

The *DHL Logistics Trend Radar*, considered the most influential foresight report in the logistics sector, identifies in its latest edition 7.0 (2024/2025) forty logistics trends grouped into four areas: social and business, technological, environmental, and regulatory (DHL, 2024). The report highlights both entirely new trends and those redefined from earlier editions (DHL, 2025). New entries include *E-commerce Evolution* (multichannel retail, social commerce, parcel lockers, PUDO, and multi-carrier services), *AI Ethics* (responsible AI deployment with emphasis on transparency and data protection), *Green Urban Transformation* (zero-emission zones, micro-hubs, fleet electrification), *Workforce Focus*

(upskilling, reskilling, adapting jobs to automation), and *Audio AI* (voice-based technologies in logistics and warehousing) (DHL, 2024).

Redefined trends include *Generative AI*, which replaces *AI & Analytics* by extending beyond predictive models to scenario generation and customer service content; *Computer Vision*, applied in 2D code scanning, product recognition, and real-time quality control, replacing the broader *IoT* and *Automation* categories; and *Advanced Analytics*, integrating big data, prediction, and decision intelligence to support operations, superseding the earlier *Big Data* focus. Other updated directions include *Sustainable Fuels* (biofuels, hydrogen, synthetics) replacing *Alternative Drives*, and *Renewable Energy Infrastructure* (PV farms, storage systems, charging networks) replacing the more generic *Green/Alternative Energy Sources* (DHL, 2024).

The *GS1 Poland Report 2024* stresses the growing role of 2D codes (QR, DataMatrix) enabling product lifecycle traceability and the *Digital Product Passport* (mandatory from 2027 for batteries, later textiles and steel). It also highlights reusable packaging and deposit systems (DRS), paperless logistics through standardized digital documentation, and enhanced product safety in pharmaceuticals and food, where GS1 tools support expiry control and recalls. ESG reporting remains a key challenge (GS1, 2025).

The OECD Financing SMEs and Entrepreneurs 2024 report points to the green transition as a major direction, requiring investment in low-emission transport, renewable energy, and circular economy models. Firms are urged to electrify fleets, expand charging infrastructure, and adopt sustainable fuels while also leveraging fintech solutions to finance digitalization and automation. Alternative financing models such as factoring and leasing are emphasized as tools for fleet modernization. The report stresses the need to strengthen resilience to geopolitical, energy, and trade crises through financial diversification, while also underlining the role of ERP, IoT, and AI systems in boosting efficiency and meeting ESG requirements (OECD, 2024).

Finally, *the Capgemini Integrated Annual Report 2024* notes that global supply chains are entering a new phase marked by agility, sustainability, and AI adoption. AI applications include predictive analytics, real-time shipment monitoring, resource optimization, and transparency enhancement. Robotics, especially AI-supported cobots, are highlighted as drivers of flexible automation and safety. Cybersecurity is identified as another critical area, where AI supports threat prediction and infrastructure protection. In addition, climate tech – Including renewable energy, e-mobility, energy storage, and carbon-reduction solutions – emerges as a foundation of sustainable logistics (Capgemini, 2025). A synthesis of the main directions emerging from the analyzed reports is presented in Table 1.

Tabele 1.
Contemporary Trends in Logistics: A Comparative Perspective

Category	Trend	Relevance for SMEs
AI and Digitalization	Generative AI	Decision automation, cost reduction, new planning opportunities.
	Advanced Analytics	Support for operational decision-making, better data utilization.
	AI & Agile Supply Chains	Increased flexibility and resilience of supply chains.
	AI in Cybersecurity	Protection of systems and data.
	Digital Financial Services	Access to innovative financing instruments for logistics.
Sustainable Logistics	Sustainable Fuels	Emission reduction, but high fleet transition costs.
	Renewable Energy Infrastructure	Support for RES in logistics, long-term energy cost reduction.
	Green Urban Transformation	Adaptation to zero-emission zones, eco-friendly image.
	Climate Tech	Implementation of low-emission technologies, potential for funding.
	ESG and Reporting	Mandatory reporting, challenging for SMEs but crucial for cooperation with large firms.
Transparency and Data	2D Codes	Digital identification, transparency for customers.
	Digital Product Passport	EU requirement, new opportunities and obligations for firms.
	Computer Vision	Product recognition, quality control.
Automation and Robotics	Robotics and Cobots	Warehouse automation, improved efficiency.
	Audio AI	Voice assistants supporting employees.
Finance and Business Models	Alternative Financing	Factoring, leasing as opportunities for logistics growth.
	Deposit Return Systems (DRS)	Circular economy, new recycling models.
	Reusable Packaging	Waste reduction, long-term savings.
Competences and Workforce	Workforce Focus	Need for training and adapting human resources to automation.

Source: author's own elaboration based on desk research.

The comparison indicates that contemporary logistics trends encompass technological and digital domains as well as environmental, organizational, and financial aspects. For SMEs, this implies the need to simultaneously comply with sustainability requirements, implement digital innovations, and enhance workforce competences. While this poses a significant challenge, it also creates opportunities to strengthen competitiveness.

4.2. SME Logistics in Poland: Trends and Prospects

Global logistics trends are increasingly permeating the practices of Polish SMEs, as confirmed by the latest PARP report (2025). Although logistics is not the main focus of the report, the analysis allows the identification of several trends directly relevant to this domain. A central direction is the digitalization of processes, including the implementation of ERP systems, electronic document circulation, e-commerce solutions, and supply chain integration. Digitalization enhances operational efficiency and enables better alignment of services with customer needs. The report also highlights the importance of artificial intelligence and the Internet of Things, though their adoption in Poland remains limited – only 5.9% of SMEs use AI compared to the EU average of 13.5%, and 18.7% use IoT against the EU

average of 28.7%. This reflects both a technological gap and a significant growth potential in shipment monitoring, demand forecasting, and transport route optimization.

Another noticeable trend is the growing role of paperless logistics and remote work. In 2024, nearly 90% of firms provided employees with access to ICT resources, and an increasing number adopted electronic document workflows, improving information flows and reducing operational costs. Cybersecurity is likewise a critical area: 94.1% of SMEs apply ICT safeguards and over half conduct educational programs, which is particularly important for protecting data and logistics systems.

Eco-innovation and the circular economy also represent key directions. Poland still belongs to the group of “catching-up countries” (EU Eco-Innovation Index: 69.7 points compared to the EU average of 127.5), yet the adoption of circular practices – recycling, reusable packaging, and waste reduction – is gaining importance in logistics. Financial barriers remain the main constraint: rising capital costs and stricter credit requirements limit investments in renewable energy, electromobility, and process automation.

In sum, the PARP report indicates that the future of logistics in Polish SMEs will be shaped by digitalization, AI and IoT adoption, paperless logistics, enhanced cybersecurity, and eco-innovation. At the same time, limited access to finance slows the pace of transformation, leading to gradual and selective implementation of innovations.

To capture the relationship between global logistics trends and the situation of SMEs in Poland, Table 2 presents a comparative overview of the most important trends, their characteristics, and their national perspective.

Table 2.
Comparison of Global and Polish Logistics Trends

Global Trend	Description of the Global Trend	Perspective in Poland (PARP, 2025)
Generative AI	Decision automation, demand forecasting, route planning, customer service.	Low adoption of AI – only 5.9% of SMEs in Poland use AI compared to the EU average of 13.5%.
Advanced Analytics	Decision intelligence and real-time prediction.	ERP systems and process digitalization (e.g., document workflows) increasingly introduced.
E-commerce Evolution	Omnichannel retail models, integration of social commerce, parcel lockers.	Dynamic e-commerce growth, particularly in FMCG and urban logistics.
Green Urban Transformation	Zero-emission zones, micro-hubs, fleet electrification.	Eco-innovation and CE are developing, but Poland remains below the EU average in the eco-innovation index.
Sustainable Fuels	Development of biofuels, hydrogen, and synthetic fuels.	Limited adoption due to investment costs and low infrastructure availability.
Renewable Energy Infrastructure	PV farms, charging stations, energy storage.	Growing interest in RES, but financial constraints slow investment pace.
Paperless Logistics	Digitalization of documents and fully digitized processes.	Wider implementation of e-documents; 90% of firms provide remote access to resources.
Computer Vision	Automated product recognition, 2D code scanning, quality control.	GS1 technologies expanding – 2D codes and Digital Product Passport (DPP).
Cybersecurity	Securing data and systems in digital logistics.	94.1% of SMEs apply ICT safeguards, 57% conduct educational programs.
Climate Tech/ESG	Emission-reducing technologies and ESG reporting.	Low awareness and readiness among SMEs; need for education and reporting support.

Source: author's own elaboration based on desk research.

The comparison shows that although many global trends are reflected in Polish SMEs, their implementation varies in pace and scale. The most evident challenges relate to investment financing and the low adoption of digital and environmentally sustainable technologies.

5. Global Logistics Trends in Polish SMEs: case studies

Case studies of selected Polish enterprises help to illustrate how global logistics trends are reflected in the practice of domestic SMEs. These examples demonstrate that even medium-sized firms operating in diverse industries can successfully implement advanced technological solutions that not only enhance operational efficiency but also strengthen competitive advantage.

The first example is **BWS Expo**, an exhibition industry firm that implemented a Warehouse Management System (WMS) together with Zebra Technologies hardware. The aim was to automate warehouse operations and improve material flow management. The results proved significant – logistics service time was reduced by around 35% and errors decreased by 85%. The company gained greater process transparency and higher service quality through faster order fulfillment (Piskorek, 2025). This case aligns with global trends in automation and robotics, advanced analytics, computer vision, and digital documentation, showing that medium-sized firms can effectively adopt solutions once associated primarily with large corporations.

The second case concerns **Frisco.pl**, one of Poland's largest online supermarkets in the e-grocery segment. In response to growing demand for online shopping, the company invested in logistics automation and AI-based solutions. A particularly innovative project is *Friscoach* – a generative AI shopping assistant that recommends meals based on customer preferences and budget, automatically generating shopping lists. These implementations have enabled the company to maintain order completeness above 97% and on-time delivery at 93.5%, while improving service personalization (Frisco, 2024; Sołowiej, 2025). The Frisco.pl case illustrates global trends such as e-commerce evolution, generative AI, and advanced analytics, highlighting how Polish SMEs in e-commerce can leverage digital solutions to enhance both efficiency and customer experience.

The third case involves **Martex Logistics**, a spare parts distributor. As part of its *Smart Warehouse 2025* program, the company implemented the AutoStore system, enabling fully automated storage and retrieval of goods. Based on a modular grid of racks operated by mobile robots, AutoStore increased operational efficiency fivefold, accelerated order fulfillment, and improved warehouse ergonomics. The investment resulted in faster, more reliable operations with measurable benefits (Element Logic Poland, 2025). This case reflects global trends in automation and robotics, agile supply chains, and green urban logistics transformation,

showing that medium-sized enterprises can adopt enterprise-class solutions and achieve rapid returns on investment.

The final example is **Goliard**, a Polish pasta producer that introduced *Comarch ERP XL* with the *Comarch WMS* module and Business Intelligence tools. The aim was to integrate sales, warehouse, and production processes and transition fully to digital documentation. The system enabled automated process linking, optimization of shipment preparation (time reduced by approx. 25%), and improved inventory control. By eliminating paper-based workflows, the company achieved greater process consistency and management transparency (Comarch S.A., 2019). This case exemplifies global trends in advanced analytics, paperless logistics, and adaptive supply chains, illustrating that digital transformation offers SMEs in manufacturing a tangible pathway to efficiency and competitiveness.

6. Discussion

The analysis of four case studies (BWS Expo, Frisco.pl, Martex Logistics, and Goliard) demonstrates that Polish SMEs are implementing a wide range of logistics solutions aligned with the global trends identified in the desk research. All examples confirm that technological innovations – ranging from WMS systems and automation to robotics and artificial intelligence – are becoming increasingly accessible, enabling firms to improve efficiency, reduce errors, and ultimately enhance competitiveness. Although such implementations often require substantial investment, the cases show that returns can be both tangible and rapid, with additional benefits including improved customer service quality, stronger process control, and compliance with legal and environmental requirements. This suggests that Polish SMEs not only adopt global solutions but also adapt and further develop them to fit local market conditions. A comparative overview of the implementations, their outcomes, links to global trends, and implications for Polish SMEs is presented in Table 3.

The synthesis of global trend analyses (DHL, GS1, OECD, Capgemini) with the conditions of Polish SMEs (PARP, 2025) and case study evidence (BWS Expo, Frisco.pl, Martex Logistics, Goliard) points to a clear convergence of development directions, while also revealing a persistent “implementation gap.” Polish firms increasingly follow global trajectories: digitalization and automation of operations, the spread of AI and advanced analytics, greater transparency in supply chains (2D codes, DPP), paperless logistics, and the integration of environmental objectives into operational practices.

Tabela 3.*Logistics Implementations in SMEs: Links to Global Trends and Implications*

Company	Implementation	Outcomes	Links to Global Trends	Implications for SMEs
BWS Expo	WMS system + Zebra Technologies devices	Process time -35%, errors -85%, improved inventory control	Computer Vision, Advanced Analytics (DHL); Automation (Capgemini); Paperless Logistics (GS1)	Even medium-sized firms can successfully implement WMS-class systems
Frisco.pl	Automation + AI (Friscoach – generative AI)	Order completeness >97%, on-time delivery ~93.5%, personalized shopping	E-commerce Evolution, Generative AI (DHL); Advanced Analytics (Capgemini, OECD)	AI enhances efficiency and customer loyalty in e-commerce
Martex Logistics	AutoStore system (intralogistics robotics)	5x efficiency, faster order processing, improved ergonomics	Automation and Robotics (Capgemini); AI & Agile Supply Chains; Green Urban Transformation (DHL)	Medium-sized firms can invest in enterprise-class robotics
Goliard	Comarch ERP XL + WMS + BI	Shipment preparation time - 25%, greater process consistency	Advanced Analytics (DHL); Paperless Logistics (GS1); AI & Agile Supply Chain (Capgemini)	Digitization of production processes increases control and competitiveness

Source: own elaboration based on case study results.

The case studies show that even medium-sized enterprises are adopting solutions once typical of large corporations: BWS Expo and Goliard integrate WMS and paperless workflows, Frisco.pl combines automation with generative AI in customer service and demand planning, and Martex Logistics improves productivity through AutoStore robotics and redesigned intralogistics processes. These practices correspond closely with the redefined DHL trends (2024/2025), shifting from broad categories such as Big Data/IoT to high-value applications including Generative AI, Computer Vision, Advanced Analytics, Sustainable Fuels, and renewable energy infrastructure.

At the same time, barriers slow the pace of transformation. PARP (2025) highlights the low share of SMEs using AI and limited adoption of IoT, reflecting skills shortages and weak data quality. Rising capital costs and collateral requirements further constrain investments in renewable energy, electromobility, and automation (OECD, 2024). As a result, implementations are often fragmented, while sustainable competitive advantage requires technology integration with processes and data management across the decision cycle.

Regulatory and environmental pressures are also intensifying. ESG requirements, digital product passports, and transparency systems are becoming prerequisites for participation in supply chains (GS1, 2025; OECD, 2024), while in Poland there remains a knowledge and reporting gap among SMEs. Simultaneously, the focus is shifting from generic “green energy” concepts to practical installations such as PV systems, energy storage, and charging infrastructure, aligning with DHL’s redefined trends and delivering tangible operational cost savings.

From a managerial perspective, three conclusions emerge. First, transformation depends on a structured data model (GS1 standards, ERP/WMS/TMS integration), without which AI and analytics cannot deliver lasting value. Second, the greatest benefits stem from process design rather than isolated technology adoption – as shown by Martex Logistics or the ERP/WMS integrations at BWS Expo and Goliard. Third, investment in skills (upskilling/reskilling) and change management is essential for moving from pilots to scaled implementation. Given financial constraints, flexible instruments (leasing, factoring, “as-a-service” models) play a critical role, while public policy support is needed to foster data integration, green infrastructure, and simplified ESG reporting for SMEs.

However, achieving these managerial priorities is far from straightforward, as SMEs must also contend with a wider range of barriers that extend beyond financial limitations and skills gaps. Beyond the financial and skills-related constraints highlighted earlier, SMEs face a broader set of challenges that significantly influence the adoption of technologies such as AI and IoT. Cultural barriers – including organizational inertia, employee resistance to automation, and a lack of trust in algorithmic decision-making – often slow down digital transformation. Organizational factors such as insufficient leadership commitment, fragmented decision-making processes, and inadequate change management structures further exacerbate these issues. Regulatory complexity, including data protection laws, cybersecurity requirements, and evolving ESG standards, also creates uncertainty that discourages investment. Furthermore, the relative importance of individual global logistics trends varies for Polish SMEs: digitalization, automation, and e-commerce represent immediate priorities due to their lower entry barriers and quick returns on investment, whereas advanced analytics and AI, despite their long-term strategic potential, require greater resources and capabilities. Sustainable fuels and IoT, while still emerging, are expected to grow in significance as regulatory pressure intensifies and supply chains become more data-driven. This prioritization provides a more nuanced understanding of transformation pathways and highlights the need for tailored support mechanisms.

7. Conclusions

The analysis indicates that logistics is becoming one of the key areas of transformation for small and medium-sized enterprises in Poland. Global trends such as artificial intelligence, advanced analytics, automation and robotics, digital transparency, and the green transition define the framework for modern supply chain development. Polish SMEs are gradually adopting these solutions, as confirmed by both institutional reports and practical implementation cases.

The case studies demonstrate that technological innovation is not reserved for large corporations – medium-sized enterprises such as BWS Expo, Frisco.pl, Martex Logistics, and Goliard are also able to effectively adapt solutions in automation, generative AI, and process digitalization. The outcomes include substantial improvements in efficiency, error reduction, greater process transparency, and enhanced customer satisfaction.

At the same time, report findings reveal a persistent gap between global development trajectories and their actual implementation in Poland. Low adoption of AI, limited infrastructure for sustainable transport, and difficulties in financing green and digital transformation mean that implementations are often selective and fragmented. This suggests that systemic support will be essential for further development of the sector: standardized data solutions (e.g., 2D codes, digital product passports), improved access to capital, and educational programs aimed at strengthening digital and managerial competences in SMEs.

The overarching conclusion is that the future of logistics in Polish SMEs will be determined by their ability to integrate digitalization and automation with the requirements of sustainable development. Success will be achieved by those enterprises that go beyond ad hoc investments and implement coherent logistics strategies built on data, processes, and people. The integration of these three elements – technology, organization, and competences – will ultimately shape the competitiveness of Polish firms in the global economy.

While this study provides important insights into the transformation of logistics in Polish SMEs, it does not exhaust the topic — on the contrary, it opens up new questions and areas for further exploration. Future research could examine more deeply the interplay between organizational culture, regulatory environments, and technology adoption in SMEs, as well as the long-term impacts of prioritizing specific logistics megatrends on firm performance. Comparative studies across sectors or countries would also offer valuable insights into best practices and context-specific strategies for accelerating digital and green transformation in small and medium-sized enterprises.

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REVERSE LOGISTICS AS A COMPONENT OF THE CIRCULAR ECONOMY: CHALLENGES FOR CORPORATE COMPETITIVE STRATEGIES

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Purpose: This paper explores the role of reverse logistics (RL) as a link between the circular economy (CE) and corporate competitive strategies. It outlines the evolution of RL, the CE as an alternative to the linear model, and their potential to enhance competitiveness. The empirical part draws on a 2025 survey of Polish companies to assess CE and RL adoption and their perceived impact.

Design/methodology/approach: A mixed-methods survey was conducted among 37 companies from various industries in Poland. Data were analyzed using basic statistical techniques and content analysis of open-ended responses.

Findings: Firms mostly implement low-entry CE and RL practices (e.g., waste segregation, cooperation with recycling firms), while advanced measures (e.g., design for recyclability) are rare. Reported benefits include improved reputation, cost reduction, and regulatory compliance; barriers include high investment costs, limited technology, and knowledge gaps. Overall, CE and RL have a moderate but positive impact on competitiveness.

Research limitations/implications: The purposive sample of 37 firms limits generalizability, and self-reported data may involve bias.

Practical implications: Even basic CE and RL actions can yield economic and reputational gains, guiding managers in prioritizing initiatives and addressing barriers.

Social implications: CE and RL practices can reduce environmental impacts, raise stakeholder awareness, and support sustainable development goals.

Originality/value: This study integrates CE, RL, and competitive strategy perspectives, offering empirical evidence from Polish companies and contributing to research on the strategic use of RL for competitive advantage.

Keywords: circular economy; reverse logistics; corporate competitiveness; competitive strategy; sustainable development.

Category of the paper: Research paper.

1. Introduction

In the face of escalating climate and environmental challenges, companies are increasingly seeking ways to operate more sustainably without compromising their business objectives. One of the key directions in the transformation of economic models is the circular economy (CE), which emphasizes maximizing resource use and minimizing waste. Within this context, reverse logistics (RL) is gaining prominence as a practical tool for implementing CE principles in corporate operations.

At the same time, rapid changes in competitive and regulatory environments are forcing companies to redefine the sources of their market advantage. Environmental initiatives are increasingly shifting from being merely a response to legal requirements to becoming integral components of competitive strategies – shaping customer relationships, operational costs, innovation, and corporate reputation.

The aim of this paper is to examine the role of RL as a link between CE practices and the development of competitive business strategies. It seeks to conceptually align these three domains and highlight the need for their integration in today's market conditions. The empirical section presents findings from a study of companies of various sizes and industries, exploring how they implement RL practices and how these practices influence their competitiveness.

2. Reverse logistics: evolution and contemporary relevance

Reverse logistics (RL) is a branch of logistics concerned with managing product flows after their end-of-life, primarily waste (Sadowski, 2008), but it also includes the return of functional products for repairs, recalls, and warranty claims (Huk, 2020; Szołtysek, Twaróg, 2017). Traditionally viewed as a supporting operational function, RL has evolved into a strategic component of supply chain management. It is classically defined as the process of planning, implementing, and controlling flows of products from the point of consumption back to recovery or proper disposal (Rogers, Tibben-Lembke, 1998). RL activities include returns handling, repairs, recycling, remanufacturing, component recovery, and disposal, typically divided into two domains: during-use and post-use flows (Janczewski, 2017).

Over the past two decades, RL has become embedded in closed-loop supply chains, where products are designed and managed to enable reuse or recycling after their use phase (Guide, Van Wassenhove, 2009). This integration positions RL as a key driver of reduced environmental impact and improved resource efficiency (Govindan et al., 2015).

Profitability is a recurring theme in RL research. Montabon et al. (2018) argue that RL should be treated not merely as a technical function but as a strategic tool, noting that many firms adopt compensatory actions rather than achieving true sustainability (Montabon et al., 2016). A literature review by Heydari et al. highlights that while RL operations benefit the environment and society, they often fail to generate sufficient profits for supply chain actors. Thus, regulatory mechanisms - such as incentives and fees – are considered essential to improve RL performance (Heydari et al., 2017). Effective implementation requires technological, economic, and organizational alignment, supported by collaboration across the value chain, process digitalization, and strong managerial commitment.

Recent studies emphasize the growing relevance of RL in the context of digitalization and automation (Romagnoli et al., 2023). Industry 4.0 tools – including the Internet of Things (IoT), artificial intelligence (AI), and big data analytics – enhance operational efficiency and enable real-time decision-making. These technologies support product lifecycle monitoring, returns tracking, and demand forecasting for recovered components (Krstić et al., 2022).

Contemporary approaches increasingly view RL as an integral part of product lifecycle management and a core component of circular economy models. Principles of sustainability and circularity are reshaping RL strategies, with a focus on waste reduction and resource recovery (Che Hassan, Osman, 2025). Rather than a cost factor, RL is now seen as a source of value, innovation, and customer loyalty, helping firms extend product lifecycles, close material loops, and create new value propositions.

3. The Circular Economy: a systemic approach

The concept of the circular economy (CE) emerged as a response to environmental degradation driven by unsustainable resource use and waste generation. It seeks to integrate economic activity with environmental wellbeing in a sustainable manner (Holtzer, 2022; Murray et al., 2017). The origins of CE date back to the 1940s, when ideas such as industrial symbiosis and industrial ecology were first proposed (Rada, 2023). The European Union formally introduced CE in 2015, emphasizing resource efficiency and integrated production-distribution-consumption systems (Rada, 2023). CE is closely linked to the United Nations Sustainable Development Goals, particularly Goal 12 on responsible consumption and production (Sarangi, 2023).

Scholars emphasize that CE is primarily a practical agenda for both policymaking and business, yet no single universally accepted definition exists (Jastrzębska, 2017; Kirchherr et al., 2017). The European Parliament defines CE as a “model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is

extended. In practice, it implies reducing waste to a minimum. When a product reaches the end of its life, its materials are kept within the economy wherever possible thanks to recycling. These can be productively used again and again, thereby creating further value” (“Circular economy: definition, importance and benefits”, 2023). CE is also framed as a development strategy that enables economic growth while optimizing resource use, reshaping production and consumption systems, and redesigning industrial processes (Forum Odpowiedzialnego Biznesu, 2016).

At its core, CE entails a shift from a linear model (extraction–production–consumption–waste) to a circular one, in which materials and products remain in the economic cycle for as long as possible. Instead of maximizing sales and throughput, CE seeks to maximize the value derived from available resources (Dańko et al., 2021; Jaworski, Grochowska, 2017; European Parliament, 2023). This systemic approach involves designing products for repair, disassembly, reuse, and recycling, as well as developing business models based on sharing, leasing, and product-as-a-service solutions. According to Kirchherr et al., transitioning to CE requires not only technological change but also shifts in mindsets, organizational structures, and cross-sector collaboration. CE has become a policy priority for the European Union.

Implementation strategies for CE include reducing resource extraction, promoting regenerative production, and ensuring effective end-of-life management (Sarangi, 2023). However, CE has limitations – most notably the lack of explicit social dimensions inherent in broader sustainable development frameworks (Murray et al., 2017). Despite these challenges, CE remains a promising approach to addressing global sustainability issues. In April 2022, the European Commission proposed a policy package to accelerate the EU’s transition to CE. Yet, as Pinyol Alberich, Pansera, and Hartley (2023) argue, these policies are built on a hybrid mix of often competing visions of a circular future. Dominant narratives reflect a techno-optimistic and centralized “modernist” vision of CE, which may result in a weak version unable to meet the EU’s environmental ambitions.

Within this context, reverse logistics (RL) becomes a critical operational component that enables material recovery and reverse flows within supply chains. RL facilitates the handling of returns, sorting, recovery, and transport to repair or processing facilities, requiring robust informational, technological, and organizational infrastructure. Emerging models such as the sharing economy, biological resource regeneration, urban mining, and circular platforms depend on advanced logistics systems capable of managing goods within closed loops. Effective CE implementation requires aligning environmental and economic objectives, making CE both a challenge and an opportunity for innovative firms (Aguirre Rodríguez et al., 2024).

4. Competitive strategy: classical and contemporary perspectives

A competitive strategy is a long-term plan that guides a firm's efforts to gain and sustain an advantage over its market rivals. It defines how the firm competes, what differentiates its offerings, and which resources and actions will be deployed to attract customers and achieve superior performance. The concept of competitive advantage itself has no single, universally accepted definition. According to Malewska and Sajdak (2014), it can be understood as a situation in which a firm possesses something others do not, does something better than its rivals, or performs activities competitors cannot, thereby generating superior outcomes. A widely adopted perspective is that of Michael E. Porter, who defines competitive advantage as the ability to perform activities better or differently than competitors, leading to superior results (Porter, 2010).

In management literature, strategy is generally viewed as a means of achieving a firm's core objectives as defined in its mission. It provides a framework for market activity, guiding operational and strategic decisions (Kaczmarek-Kalisz, Guliński, 2010). A competitive strategy enables organizations to direct their development, concentrate and allocate resources effectively, and make coherent operational and investment decisions. According to Porter's classical framework, sustainable competitive advantage can be pursued through cost leadership, differentiation, or market focus (Porter, 2010). Traditional sources of competitiveness also include cost, distribution, marketing, technology, market position, product uniqueness, managerial quality, knowledge, information, and time-based management (Kozak-Siara, Olak, 2022).

However, contemporary sources of competitive advantage increasingly extend beyond Porter's classical model and reflect the dynamics of global markets, technological development, and evolving customer expectations. Today, firms compete not only on price and product but also on innovation, relationships, speed, agility, sustainability, and knowledge (Kozak-Siara, Olak, 2022; Zakrzewska-Bielawska, Piotrowska, 2022).

5. Reverse logistics as a link between the Circular Economy and competitive strategy

Research on reverse logistics (RL) and the circular economy (CE), in connection with corporate competitive strategy, shows that both concepts can enhance how firms are perceived by customers, thereby strengthening their competitiveness. Increasingly, companies build competitive advantage on their ability to adopt circular models, manage product life cycles, reduce carbon footprints, and ensure supply chain transparency. The capability to recover

and reuse products is becoming not only a sign of responsibility but also a strategic market lever. In this context, RL serves as a tool for implementing sustainable strategies and building innovation- and relationship-based advantages (Gao, 2018; Ivanova et al., 2022; Voigt et al., 2019).

Similar links are observed between competitive advantage and CE. CE is gaining traction in both academic and business discourse as an alternative to the dominant linear “take–make–dispose” model (Pichlak, 2018). Unlike the linear model, CE aims to extend the life cycle of products and materials, reduce the consumption of virgin resources, and regenerate natural systems (Szczech-Pietkiewicz, Czerniak, 2024). Its implementation can strengthen firms’ competitive positions by improving resource efficiency, reducing operating costs, fostering innovation, and enhancing stakeholder reputation (Kwiecień, Wawrowski, 2019; Zupok, 2021). CE principles also support competitiveness through product and process innovation, supply chain optimization, and new business models such as product-as-a-service or closed-loop material systems (Kwiecień, 2018, 2021). Firms adopting such solutions often gain better access to new markets and customers and improve their relationships with business partners (Zupok, 2021). CE is further seen as a way to mitigate risks related to rising resource prices, regulatory changes, and environmental pressures (Kwiecień, 2018).

However, empirical studies show that many Polish firms do not yet view CE as a genuine source of competitive advantage. Many apply only selected elements—such as waste segregation and recycling—without integrating circular principles across the entire value chain (Kachniewska, 2018; Szczech-Pietkiewicz, Czerniak, 2024). Reported barriers include high upfront costs, lack of short-term returns, limited financing, insufficient institutional support, and low awareness among managers and consumers (Kachniewska, 2018; Kwiecień, 2018; Szczech-Pietkiewicz, Czerniak, 2024).

Approaches to CE implementation vary by industry and firm size. In manufacturing, efforts focus on eco-design, process optimization to minimize material losses, and closing resource loops through recycling and component reuse (Kwiecień, 2018). In services, such as hospitality, opportunities are more limited due to complex supplier networks, subcontracting relationships, and less flexibility in material and technology choices (Kachniewska, 2018). From an economic perspective, CE can be profitable in the long term through resource and energy savings and improved corporate reputation (Kwiecień, 2018). Nevertheless, high initial investment thresholds and uncertainty about payback periods remain major obstacles. The literature thus reveals a clear gap between the declared benefits and the actual level of implementation – indicating that the competitive potential of CE in Polish enterprises remains largely untapped (Kwiecień, 2021).

Contemporary management approaches increasingly call for viewing RL not as an isolated function but as a critical link between the operational implementation of CE and a firm’s strategic objectives. Concepts such as closed-loop supply chains and circular value creation underscore RL’s role in fostering organizational flexibility, resilience, and innovation.

Effective integration of CE, RL, and corporate strategy requires not only operational transformation but also a rethinking of business models and strategic orientations. This highlights the need for in-depth empirical studies to explore how firms actually implement RL practices, how they evaluate them, and what barriers and opportunities they face in linking these practices to market competitiveness and circularity.

While both circular economy (CE) and reverse logistics (RL) have been widely studied, most existing research treats them as separate operational or environmental practices rather than as interconnected elements of competitive business strategies. Prior studies typically focus on technical, environmental, or cost aspects of RL and CE, offering limited insight into their strategic integration and their combined impact on firm competitiveness. Moreover, empirical evidence remains scarce – particularly cross-sectoral studies at the firm level – that would reveal how companies actually adopt CE and RL practices, how they assess their effects, and what barriers they face in linking these practices to long-term competitive advantage.

This paper seeks to address this gap by conceptually framing CE and RL within a competitiveness-oriented perspective and by providing empirical evidence from diverse Polish enterprises. The study contributes by examining not only the extent of CE and RL implementation, but also their perceived strategic value, offering a multidimensional view of how operational practices can support competitive positioning and business model transformation.

6. Methods

The study employed a mixed-methods design and was conducted using a standardized questionnaire survey targeting companies operating in Poland. Its aim was to identify the scope of reverse logistics (RL) and circular economy (CE) implementation and to assess their perceived impact on firms' competitiveness.

The questionnaire was structured into several thematic sections:

- section B – CE practices and activities (8 items, 5-point Likert scale),
- section C – RL practices (14 items, 5-point scale),
- section D – perceived impact of RL and CE on competitiveness (7 items, 5-point scale),
- section E – barriers to RL and CE implementation (8 items, 5-point scale),
- section F – quantitative performance data (e.g., recovery costs, share of recycled materials; optional),
- section G – development plans in RL and CE (5 items, 5-point scale),
- section H – open-ended questions for qualitative insights (11 questions).

Closed-ended questions used a five-point Likert scale (1 = “strongly disagree”, 5 = “strongly agree”). The open-ended questions collected examples of good practices, key barriers, and proposals for measures supporting RL and CE development in Polish enterprises.

Data were analyzed using descriptive statistics (means, medians, standard deviations) and preliminary dependency tests. Qualitative responses were thematically coded into recurring categories (e.g., technical barriers, legal barriers, cost-related benefits, reputational effects).

The study covered 37 companies from various industries:

- manufacturing – 29.7% (n = 11),
- transport and logistics – 27.0% (n = 10),
- waste/recycling – 21.6% (n = 8),
- services – 16.2% (n = 6),
- trade – 5.4% (n = 2).

In terms of size, the sample consisted of small and medium-sized enterprises. The sample was purposively selected to ensure sectoral diversity and varying levels of RL and CE implementation. Not all invited companies agreed to participate, so the analysis included only those that consented. Participation was voluntary, and responses were anonymous. Some questions, mainly those concerning economic data, allowed non-responses to reflect practical limitations in accessing sensitive business information. Given the small and purposive nature of the sample and the exploratory scope of the research, the study should be regarded as preliminary. Its results offer indicative insights into the relationship between reverse logistics, the circular economy, and competitiveness, but they do not allow for broad generalizations.

6. Results

6.1. Results of the quantitative analysis

The quantitative analysis was conducted using three composite indexes: I_CE, reflecting the level of circular economy implementation; I_RL, indicating the degree of reverse logistics implementation; and I_COMP, measuring the respondents' subjective assessment of the impact of CE and RL activities on their company's competitiveness.

Index values were calculated from the mean scores in the relevant questionnaire sections and rescaled to a 0-100 range. The table 1. presents the means, medians, and standard deviations for each index, both by industry sector and for the total sample.

Tabele 1.*Synthetic Indexes of CE, RL and Competitiveness: Descriptive Results by Sector*

Sector	I_CE_Mean	I_CE_Median	I_CE_SD	I_RL_Mean	I_RL_Median	I_RL_SD	I_COMP_Mean	I_COMP_Median	I_COMP_SD
Trade	48.4	48.4	11.0	44.6	44.6	7.6	53.6	53.6	15.2
Waste/Recycling	57.4	57.8	10.7	63.2	61.6	7.0	60.7	64.3	9.2
Manufacturing	54.3	56.2	10.3	53.2	51.8	7.5	56.5	60.7	14.0
Transport/Logistics	52.2	53.1	9.8	54.6	54.5	7.3	50.4	50.0	15.9
Services	41.7	43.8	10.4	48.2	50.9	7.9	50.0	48.2	7.8
Overall	52.0	53.1	11.0	54.5	53.6	8.8	54.5	53.6	12.9

Source: own elaboration based on survey results.

The results indicate that the overall levels of circular economy (I_CE) and reverse logistics (I_RL) implementation in the surveyed companies are moderate, and their perceived impact on competitiveness (I_COMP) is at a similar level. The highest index values were observed in the waste and recycling sector (I_CE = 57.4; I_RL = 63.2; I_COMP = 60.7), confirming that the nature of this sector facilitates the adoption of CE and RL solutions, which are closely integrated into its business models and competitive positioning.

High I_CE scores were also recorded in manufacturing (54.3), accompanied by a relatively strong competitiveness rating (56.5), suggesting that CE implementation can bring tangible benefits in production processes. In the transport and logistics sector, the three indexes are close to the sample average, which may reflect partial adoption but also indicate substantial growth potential, particularly in linking RL practices more directly to market advantage.

The trade sector shows lower I_CE (48.4) and I_RL (44.6) scores, likely due to fewer return and recovery processes compared with manufacturing and processing. The lowest values of I_CE (41.7) and I_RL (48.2) were recorded in services, where opportunities to implement closed-loop material processes are limited by the intangible nature of the activities provided.

Overall, the analysis reveals a clear relationship between sector-specific characteristics and the level of circular economy (I_CE) and reverse logistics (I_RL) implementation, as well as their perceived impact on competitiveness (I_COMP). In sectors where CE and RL are embedded in the business model, the index values are higher and align more closely with competitiveness assessments. By contrast, sectors with lower material intensity show considerable potential for further development in this area.

To gain a deeper understanding of the nature of the initiatives undertaken by the surveyed companies, the most commonly implemented CE and RL practices were also analyzed. The table 2. below summarizes these practices, including the number and percentage of firms applying them.

Table 2.*Overview of Common CE and RL Practices Implemented by Enterprises*

Practice	Area	Number of enterprises	% of enterprises
Waste segregation at the source	CE	33	89.2
Recovery of secondary materials in production processes	CE	24	64.9
Product design for recycling	CE	17	45.9
Waste minimization through process optimization	CE	22	59.5
Customer return and take-back systems	RL	19	51.4
Cooperation with recycling companies	RL	26	70.3
Monitoring and analysis of return causes	RL	21	56.8
Use of recovered materials in new products	CE/RL	20	54.1
Reuse of packaging	CE/RL	25	67.6
Incentive programs for customers to return products	RL	15	40.5

Source: own elaboration based on survey results.

As shown in the table, the most common practice is waste segregation at the source, implemented by 89.2% of the surveyed enterprises. A substantial share of firms also report cooperating with recycling companies (70.3%) and reusing packaging (67.6%). Practices directly linked to reverse logistics – such as customer return and take-back systems (51.4%) and the monitoring and analysis of return causes (56.8%)—are also widely adopted.

In contrast, practices requiring greater investment or design changes, such as designing products for recyclability (45.9%) or offering customer incentives for product returns (40.5%), are less common. These results suggest that firms tend to prioritize practices that are relatively easy to organize, while initiatives requiring fundamental business model changes are adopted less frequently.

6.2. Results of the qualitative analysis

Section H of the questionnaire contained open-ended questions designed to complement the quantitative results by exploring the perceived benefits, barriers, and suggested measures for further developing circular economy (CE) and reverse logistics (RL) practices. The aggregated results are presented in Table 3.

Responses from 37 companies show that the most frequently reported benefit was improved corporate image and customer relationships (68%). Many respondents emphasized that CE- and RL-related activities enhance company reputation and credibility in the market. The second most common benefit was reduced operating costs achieved through the reuse of materials and packaging (54%). Some firms (41%) indicated improved compliance with legal regulations and avoidance of potential sanctions, while a smaller share (27%) mentioned the development of innovative products and services.

The most frequently cited barrier was the high investment cost associated with new technologies and process upgrades (62%). Lack of access to suitable technological solutions was reported by 49% of respondents, and insufficient knowledge and competencies in CE and RL by 46%. Additionally, 24% highlighted difficulties in integrating new practices with existing logistics processes and the lack of business partners willing to cooperate in this area.

As for recommendations, respondents most often suggested expanding financial support programs for CE and RL investments (59%) and offering training and educational campaigns for managers and employees (51%). Furthermore, 38% called for the creation of inter-company collaboration platforms to exchange resources, materials, and information. A smaller share (19%) pointed to the need for stronger regulatory pressure to accelerate CE and RL adoption at the economy-wide level. The results are summarised in Table 3.

Tabele 3.

Benefits, barriers, and recommendations for implementing CE and RL in the surveyed firms

Category	Description	% of firms
Improved corporate image and customer relationships	Perceived as strengthening the firm's reputation and credibility	68%
Reduced operating costs	Savings through the reuse of materials and packaging	54%
Regulatory compliance	Avoiding sanctions and aligning with legal requirements	41%
Innovation development	Creating new products and services	27%
High investment costs	Expenditures on technologies and process upgrades	62%
Lack of technologies	Limited access to appropriate technological solutions	49%
Lack of knowledge and competencies	Shortage of CE and RL-related skills	46%
Integration challenges	Difficulties aligning new practices with existing processes	24%
Lack of business partners	Insufficient collaboration within the supply chain	24%
Financial support	Need for subsidies and tax incentives	59%
Training and education	Raising awareness and developing managerial and employee competencies	51%
Collaboration platforms	Sharing resources, materials, and information	38%
Regulatory pressure	Strengthening legal requirements to accelerate adoption	19%

Source: own elaboration based on survey results.

These findings highlight the dual nature of CE and RL adoption: while firms recognize clear reputational and cost-related benefits, they also face substantial financial, technological, and knowledge-related barriers. This contrast sets the stage for a broader discussion of how these practices can be more effectively integrated into competitive strategies.

7. Discussion

This study, combining both quantitative and qualitative analyses, offers insights into the complex relationships between the circular economy (CE), reverse logistics (RL), and firms' competitiveness. The quantitative findings show a generally moderate level of implementation in both areas, with notable differences across sectors. Industries characterized by high material intensity, such as manufacturing and waste/recycling, achieved the highest I_CE and I_RL scores, alongside relatively strong assessments of their impact on competitiveness (I_COMP). This suggests that circular practices and reverse flows are more easily embedded in the core business models of these sectors, directly contributing to operational efficiency and competitive

positioning. By contrast, service-oriented firms reported the lowest index values, reflecting the limited opportunities to introduce closed-loop material flows in less material-intensive contexts.

The qualitative results enrich this picture by revealing managerial and practitioner perspectives. The most frequently cited benefit of CE and RL adoption was improved corporate image and customer relationships, indicating an indirect competitive effect rooted in intangible factors. Reduced operating costs and enhanced regulatory compliance were also highlighted as key advantages, while innovation was mentioned less often and primarily by companies more advanced in circular implementation. At the same time, persistent barriers – particularly high investment costs, limited access to modern technologies, and a lack of knowledge and competencies – constrain the scale of adoption. These challenges help explain why more demanding initiatives, such as designing products for recyclability or implementing customer return systems, are still relatively rare.

The findings are also consistent with observations presented in international research on CE and RL adoption. Rogers and Tibben-Lembke (1998) as well as Guide and Van Wassenhove (2009) emphasize that reverse logistics activities are frequently implemented at a basic operational level, while their integration into strategic business processes remains limited – a tendency that is likewise visible in the analysed sample. Govindan et al. (2015) and Heydari et al. (2017) identify economic and technological barriers as key obstacles to the effective functioning of reverse flows, which corresponds to the reported challenges, particularly high investment costs and insufficient technological capabilities.

The results also reflect conclusions reached by Voigt et al. (2019) and Ivanova et al. (2022), who argue that the main competitive benefits associated with CE and RL – such as enhanced corporate image, improved stakeholder relationships, and regulatory compliance – tend to be indirect and long-term rather than immediate. At the same time, while research by Romagnoli et al. (2023) and Krstić et al. (2022) points to the growing application of digital technologies (IoT, AI, big data) in supporting reverse flows, such solutions remain relatively uncommon among Polish enterprises. Similarly, in contrast to findings from Pinyol Alberich et al. (2023), where strong institutional support significantly accelerates CE adoption in Scandinavian countries, companies operating in Poland face a less favourable policy and market environment. These contrasts highlight the decisive role of contextual factors – including regulatory frameworks, technology maturity, and institutional incentives – in shaping the pace and scale of CE and RL implementation.

Taken together, the findings suggest that the effective integration of CE and RL requires coordinated efforts across four dimensions: technological (investments in innovation and infrastructure), organizational (embedding circular processes into business models), educational (building managerial and employee awareness and competencies), and institutional (developing stable regulatory frameworks, financial incentives, and collaboration platforms). Importantly, the competitive advantages associated with CE and RL are no longer primarily cost-based. They increasingly derive from reputational, relational, and innovation-oriented

factors that enhance stakeholder trust and strengthen firms' long-term resilience in sustainability-driven markets.

Overall, the study confirms that many Polish firms continue to perceive CE and RL mainly as sets of operational practices, even though their strategic potential is becoming more widely recognized. Unlocking this potential will require comprehensive business model transformation supported by an enabling institutional environment.

8. Conclusions

The study on the implementation of the circular economy (CE) and reverse logistics (RL) in Polish enterprises provides a multidimensional picture of the practices adopted across different sectors and their perceived impact on competitiveness. The quantitative analysis revealed that companies tend to implement practices that are organizationally and technically simple, such as waste segregation, cooperation with recycling firms, and packaging reuse. These measures are attractive due to their low entry barriers, relatively quick cost effects, and regulatory compliance. In contrast, more advanced practices, such as designing products for recyclability or establishing customer return systems, are implemented far less frequently, primarily due to financial, technological, and organizational barriers.

The qualitative part of the study helped identify both key benefits (enhanced reputation and customer relationships, cost reduction, regulatory compliance) and major constraints (high investment costs, lack of suitable technologies, insufficient knowledge and competencies, integration challenges). These findings suggest that while companies recognize the strategic potential of CE and RL, they currently implement mostly operational-level activities, postponing full transformation to later stages of development.

Several key insights emerge from this research. First, the adoption of CE and RL can have a tangible impact on competitiveness, largely through indirect effects, such as reputation, customer relationships, and compliance, that may evolve into lasting market advantages over time. Second, there is a clear relationship between sectoral characteristics and the degree of implementation, indicating that support strategies and policy tools should be tailored to the diverse needs of different industries. Third, the effective integration of CE and RL into corporate strategies requires coordinated efforts across multiple dimensions: technological, organizational, educational, and institutional.

In sum, the implementation of CE and RL practices can significantly enhance firms' competitiveness, but their full potential in Poland remains largely untapped. Further progress will require both strategic commitment from companies and consistent institutional support

to reduce implementation barriers and create favorable conditions for a broader transition toward a circular economy.

The results of the study also provide several important theoretical and practical implications. From a theoretical perspective, the findings confirm observations made in the international literature that reverse logistics and circular economy practices tend to generate competitive benefits primarily through indirect, long-term effects, such as improved corporate reputation, stakeholder relations, and regulatory compliance, rather than immediate cost reductions. The research additionally indicates that contextual factors – including regulatory frameworks, technological maturity, and institutional support — significantly shape the scale and pace of CE and RL implementation, which helps explain differences between Polish enterprises and firms operating in more advanced economic environments.

From a practical standpoint, the study highlights the necessity of integrating circular processes into strategic business planning rather than limiting them to isolated operational activities. This requires coordinated actions in technological, organizational, educational, and institutional areas, as well as targeted public policies and financial instruments to support corporate transformation. These insights may serve as a reference point for both companies seeking to strengthen their competitive position and policymakers designing instruments to accelerate the transition toward a circular economy. Furthermore, the results underline the need for future research exploring sector-specific pathways and the role of emerging technologies in enhancing the strategic potential of CE and RL.

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ORGANIZATIONAL DEPENDENCE, WORK CHARACTERISTICS AND EMPLOYEE WORK ENGAGEMENT IN THE DIGITAL ERA

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Purpose: In order for enterprises to effectively operate within the unpredictable dynamics of digital development and achieve above-average outcomes in terms of innovativeness, it is essential to build teams characterized by creativity and the ability to generate innovation. The present study examines whether specific configurations of organizational dependence, encompassing four dimensions: technological, relational, emotional, and benefit dependence in combination with work characteristics in the digital era, may foster a high level of employee work engagement. The aim of the study is therefore to identify key configurations of factors that determine work engagement in the context of ongoing digitalization.

Design/methodology/approach: The study employed fuzzy-set qualitative comparative analysis (fs/QCA) to examine the interdependencies among six factors: job complexity, career prospects, technological dependence, relational dependence, emotional dependence, and benefit dependence. This methodological approach addresses the limitations of prior research by accounting for the co-occurrence and non-linear nature of relationships among these factors. The research was conducted on a sample of 56 small and medium-sized enterprises (SMEs).

Findings: The findings of our study indicate the existence of diverse configurations of factors shaping employee work engagement. The application of fs/QCA enabled the identification of multiple pathways through which the examined determinants interact to influence engagement, thereby providing a deeper and multidimensional understanding of the conditions that foster employee involvement in the context of digital transformation.

Originality/value: From a theoretical perspective, this study contributes to the literature by identifying diverse configurations that determine employee work engagement. The applied methodology makes it possible to capture the complex interdependencies among the examined variables and their combined impact on engagement, thereby providing a more in-depth understanding of this phenomenon. Furthermore, the findings offer practical value by delivering empirical insights that can inform the design of managerial interventions aimed at enhancing employee engagement in the context of ongoing digitalization.

Keywords: organizational dependence, work engagement, digital transformation, fs/QCA.

Category of the paper: Research paper.

1. Introduction

The advancement of information and communication technologies (ICT), accompanying the fourth industrial revolution-particularly solutions such as blockchain, the Internet of Things, artificial intelligence, and big data analytics-has contributed to the emergence of new business formats, thereby transforming organizational structures, production processes, and business models (Nambisan et al., 2019). Many enterprises have undertaken digital transformation to gain a competitive advantage. However, this process is inherently risky and presents considerable challenges, with the majority of difficulties arising at the organizational and employee levels.

In this regard, enhancing the professional status of employees deserves particular attention, as they constitute both the core of the enterprise and a critical factor in the success of digital transformation. Technological progress imposes significant demands on employees, and prior research highlights that work characteristics play a crucial role in shaping employee attitudes and engagement (Kuratko et al., 2005; Wales et al., 2011). Specifically, attributes such as job complexity and career prospects can be understood as elements of the broader social context within which human resource management systems operate.

Moreover, employees' attitudes toward new technologies, their learning capacity, as well as organizational dependence, defined as the degree to which individuals or entities rely on the organization for resources and support, represent additional factors that must be considered in the course of digital transformation. These dimensions critically influence work engagement under the pressures associated with rapid technological change.

Work engagement is defined as a positive, work-related state of fulfillment and well-being that translates into favorable organizational outcomes, such as improved performance, customer satisfaction, and competitive advantage (Bakker et al., 2008). The present study focuses on examining the antecedents of work engagement from the perspective of the organizational environment and job characteristics. Prior research has emphasized the importance of conceptualizing organizational environments as multidimensional structures, understood as configurations of various factors shaping employee behavior and engagement (e.g., Douglas et al., 2020; Fiss, 2011; Misangyi, Acharya, 2014). This approach allows for a more comprehensive reflection of the complexity of organizational contexts and their impact on employee behavior.

However, traditional analytical methods, primarily regression-based approaches, often prove insufficient for studying the complex causal mechanisms underlying employee engagement. Work engagement is inherently multifactorial, and classical statistical techniques struggle to adequately capture both the co-occurrence of multiple determinants and the causal asymmetry typically present in complex organizational settings (Fiss, 2011). To address these limitations, this study employs fuzzy-set qualitative comparative analysis (fs/QCA; Ragin,

2008; Rihoux, Ragin, 2008), which conceptualizes the organizational environment as a set of interrelated profiles rather than isolated attributes. The application of this method enables the identification of multiple alternative configurations of factors, particularly different dimensions of organizational dependence and job characteristics, that may lead to high levels of work engagement.

The central assumption of this study is that analyzing factors such as job characteristics and organizational dependence from the perspective of a supportive ecosystem enables a more comprehensive understanding of the complexity involved in fostering employee engagement. This approach makes it possible to capture the interdependencies among variables and their combined influence on work engagement, thus providing a more accurate and in-depth account of the phenomenon. Adopting such a perspective may also support employees in effectively coping with dynamic changes, particularly in light of the profound transformations driven by digitalization in the workplace.

Based on the literature on work engagement, six categories of factors within the supportive ecosystem have been identified as influencing employee engagement (see Figure 1): job complexity (LePine, 2005), career prospects (Akerlind, 2015), technological dependence, relational dependence, emotional dependence, and benefit dependence (Luo, Chen, 2024).

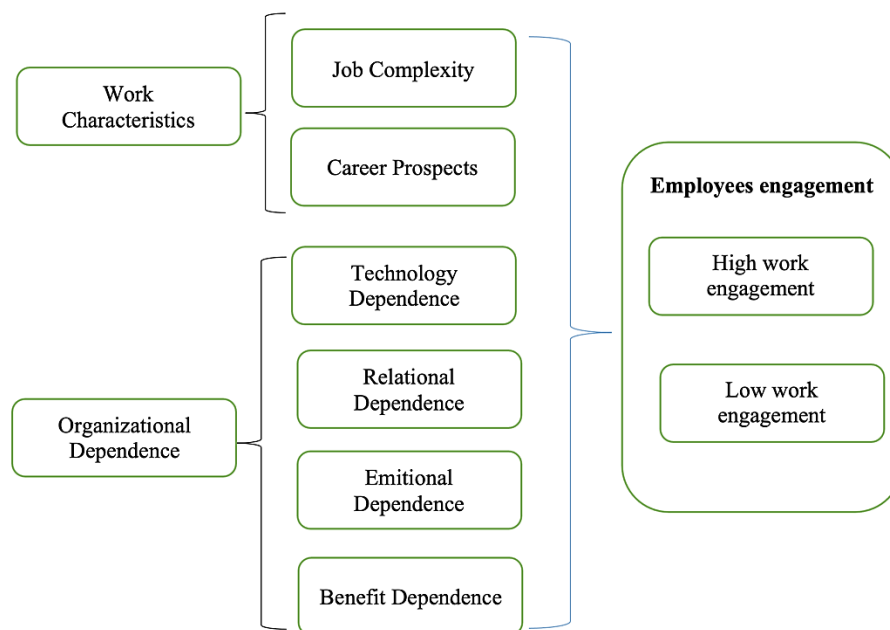


Figure 1. Research model.

Source: own study.

This article addresses at least two limitations of previous studies. Most prior analyses were based on the assumption that factors operate independently and do not interact with one another (Knight et al., 2017). Such an approach often led to the identification of a single optimal pathway and equilibrium point, while overlooking the interdependencies among variables as well as the issue of causal equifinality in outcome analysis. Moreover, earlier research predominantly relied on quantitative methods, such as correlation and regression analyses,

which typically accounted only for linear and symmetric relationships between determinants and work engagement. This perspective neglected the possibility of non-linear and asymmetric dependencies, as well as the role of configurational effects in shaping employee engagement.

The objective of this study is to identify equifinal configurations of factors influencing employee work engagement and to formulate relevant managerial recommendations. The research is based on the assumption that employee attitudes and behaviors play a pivotal role in the process of organizational digital transformation. Accordingly, work engagement has been designated as the outcome variable, in line with the terminology of fs/QCA.

The remainder of this paper is organized as follows: the next section introduces the theoretical background, after which the data and research methodology are presented in detail. This is followed by a discussion of the empirical results and their interpretation. Finally, the paper closes with a summary of the key contributions, practical implications, and suggestions for future research avenues.

2. Literature review

Work engagement is defined as a positive, fulfilling, and work-related psychological state (Van Wingerden et al., 2017). It is recognized as a key factor contributing to the effectiveness of organizational performance (Wibawa, Takahashi, 2021). Kahn (1990) argues that a high level of employee engagement leads to stronger integration between the individual and their professional role. Previous studies further demonstrate that the compatibility between employee characteristics and the work environment significantly enhances engagement (Fu et al., 2022; Srimulyani, Hermanto, 2022). The literature emphasizes that social information influences job characteristics, which in turn shape employee attitudes and determine various behaviors (Kuratko et al., 2005; Wales et al., 2011). In particular, job features such as task complexity and career development opportunities can be viewed as elements of the social context in which employees operate. The existence and modification of these job characteristics may be affected by the transmission and interpretation of social information within the organization.

In today's digital technological environment, marked by constant change, employees face increasingly complex and continuously evolving working conditions. This requires them to adapt to new responsibilities and procedures arising from technological advancement, which consequently intensifies the complexity of work dynamics (LePine, 2005). A substantial body of research highlights that job complexity plays a critical role by influencing problem-solving abilities, knowledge of work methodologies, and skills development. Empirical studies further show that job complexity generates both stress and developmental opportunities, including prospects for advancement (Podsakoff et al., 2007).

When established work paradigms are disrupted and job complexity reaches unprecedented levels, employees are compelled to adopt innovative behaviors as a means of responding to the growing demands of their roles (Janssen, 2000). Consequently, within enterprises operating in the digital era, the complexity of the work environment becomes of fundamental importance, significantly shaping individual tendencies toward work engagement and innovative behaviors (Zacher, Frese, 2011).

According to the assumptions of social information processing theory, social factors significantly shape the way individuals perceive their needs and values (Benjamini, Hochberg, 1995). In the context of digital transformation, effective communication and information exchange are crucial, as they enable employees to develop a shared understanding of organizational strategies (Zhang et al., 2022). In the digital economy, employees' aspirations—particularly among younger generations—are becoming increasingly complex, with motivation extending beyond financial rewards toward purpose and meaningful work. In this regard, career prospects, understood as opportunities for advancement and growth, constitute a key motivational factor (Akerlind, 2015).

Consistent with social information processing theory employees draw upon various sources of information, which they utilize in processes of interaction and communication with other members of the organization. This mechanism fosters the formation of career aspirations and values aligned with individual development (Bhave et al., 2010). Consequently, organizational leadership has the ability to influence how employees perceive their career prospects by effectively communicating the organization's vision and strategic goals. When employees gain confidence in the organization's future direction, they are more willing to engage in innovative activities and adopt proactive behaviors. Furthermore, research on career prospects indicates that internal promotion enhances an individual's status and recognition within the organization, thereby increasing motivation to support and leverage one's innovative potential.

In contrast, the technological uncertainties characteristic of the digital age, particularly those linked to external information originating from other organizations, tend to generate anxiety among employees, prompting responses aimed at regaining control or avoiding perceived risks (Hogg, 2000). Within such a context, employees are more inclined to display confidence and motivation toward engaging in innovative activities when they recognize meaningful opportunities for career advancement within their organization. A sense of security regarding professional development prospects provides them with both the drive and the confidence required to pursue innovation despite the challenges posed by digital disruption.

As highlighted in the literature, organizational dependence emerges as a particularly important factor in this context. This concept refers to the extent to which individuals or entities rely on the organization for access to resources, support, and developmental opportunities. It encompasses the interdependencies between individuals or groups and the organization, where both parties rely on one another to accomplish their objectives and tasks.

According to Luo et al. (2021), organizational dependence can be examined across four dimensions: technological, relational, emotional, and benefit-based.

In the context of digital transformation, various forms of organizational dependence emerge as significant drivers of work engagement. One such form is technology dependence, which reflects employees' reliance on advanced digital tools, platforms, and infrastructures. This reliance enhances operational efficiency, reduces repetitive workload, and allows employees to focus on higher-order tasks requiring critical thinking and creativity (Molino et al., 2020). As a result, technology becomes a motivating factor rather than a source of resistance, contributing to heightened interest, involvement, and engagement in work processes.

Relational dependence also plays a pivotal role in shaping employee engagement. Strong interpersonal relationships and supportive workplace networks create a sense of belonging and psychological safety, both of which are critical during periods of technological change. These social connections not only provide emotional support but also enable the sharing of knowledge and collaborative problem-solving (Wood et al., 2016). In digital environments, where change is rapid and often complex, collective adaptation supported by team cohesion significantly enhances engagement by reinforcing communication, shared responsibility, and mutual trust.

Another key factor is emotional dependence, which refers to employees' psychological attachment to the organization's mission, values, and culture. In the digital era, this attachment fosters resilience, loyalty, and proactive behavior in the face of continuous change. Emotional bonds with the organization promote a sense of meaning and purpose in employees' roles, encouraging them to remain engaged despite external pressures. Supportive leadership and a strong organizational culture further reinforce this emotional connection, increasing confidence and long-term commitment (Shin et al., 2020).

Finally, dependence on organizational rewards and benefits, such as fair compensation, opportunities for career advancement, and professional development also significantly influences employee engagement. When employees perceive these benefits as a fair exchange for their contribution, their motivation and identification with the organization increase (Eldor, 2016). Particularly in the context of digital transformation, access to training programs, upskilling initiatives, and clear career paths boosts employees' self-efficacy and readiness to embrace change, resulting in deeper engagement and performance improvement.

In sum, technological, relational, emotional, and reward-based dependencies collectively foster a strong foundation for employee engagement in digitally transforming organizations. These interrelated forms of dependence enhance adaptability, motivation, and organizational commitment, enabling employees to actively contribute to innovation and long-term success.

In summary, the existing literature has extensively examined the predictors of employee work engagement, with particular emphasis on the impact of individual factors on such behaviors. However, it remains insufficiently understood how complex interactions among

multiple determinants contribute to work engagement in a nonlinear manner. Enhancing employee engagement should therefore be conceptualized as a multidimensional process, shaped by the synergistic interplay of interrelated variables. In this regard, the fs/QCA approach provides a valuable methodological framework for analyzing the intricate relationships between antecedent conditions and outcomes (Du et al., 2017).

This study integrates six key factors: job complexity, career prospects, technology dependence, relational dependence, emotional dependence, and benefit dependence. The integration aims to address two research questions through the fs/QCA approach:

1. Can any single condition independently lead to a high level of employee work engagement?
2. How do these six conditions interact synergistically to form configurations that result in high levels of employee engagement?

By addressing these questions, the study seeks to advance the understanding of employee work engagement as a multifaceted phenomenon shaped by the interdependence of organizational and individual factors. This perspective not only extends existing theoretical frameworks but also provides a foundation for empirical investigation into how specific configurations of workplace conditions foster or hinder engagement in the digital era.

3. Methods

A structured questionnaire was employed to investigate the key determinants of employee work engagement. At the preliminary stage, the reliability of the instrument was assessed through a pilot study involving 39 respondents representing ten Polish SMEs. To examine six critical factors influencing employee work engagement in the context of digital transformation, data were collected from Polish SMEs undergoing such transformation and possessing relevant experience. The automotive industry was selected as the focal sector due to its pioneering role in implementing innovative digital technologies and its comparatively advanced technological infrastructure relative to other industries (Schuh et al., 2017).

The data collection was conducted in 2024 and targeted middle- and senior-level managers from 56 small and medium-sized enterprises in Poland. In total, 113 completed questionnaires were initially obtained. However, to ensure data quality, incomplete or blank responses were excluded from the final dataset. Consequently, 73 fully completed questionnaires were retained for analysis.

The data collection was conducted in 2024 and targeted middle- and senior-level managers from 56 small and medium-sized enterprises in Poland. A purposive sampling approach was adopted, focusing on companies actively involved in digital transformation processes and managers with relevant decision-making responsibilities. Participation in the survey was

anonymous. In total, 113 completed questionnaires were initially obtained. However, to ensure data quality, incomplete or blank responses were excluded from the final dataset. Consequently, 73 fully completed questionnaires were retained for analysis

A frequency analysis of demographic variables was conducted using the collected questionnaires. Among the respondents, 85.7% were male and 14.3% female. The majority were under the age of 46, with 37.2% aged 25 years or younger, 35.8% between 26 and 35 years, and 27% between 36 and 46 years. Respondents demonstrated a relatively high level of education, with more than 65% holding at least a bachelor's degree. With regard to organizational positions, the sample consisted primarily of middle-level managers (59%) and senior-level managers (41%). In terms of professional experience, 13.9% reported less than two years, 18.6% had between two and four years, 33.7% between five and seven years, 22.8% between eight and ten years, and 11% more than ten years.

For the fs/QCA, all conditions and the outcome were calibrated into fuzzy sets with values ranging from 0 to 1 (Ragin, 2000). In accordance with established procedures (Campbell et al., 2016; Fiss, 2011; Ragin, 2008), cases were anchored at full membership (90th percentile), full non-membership (10th percentile), and the crossover point (50th percentile). As the variables were measured on a seven-point Likert scale with distributions diverging from theoretical anchors, direct calibration was applied to minimize measurement error. To ensure precise crossover assignment, a minor constant (0.001) was added, consistent with prior studies (Fiss, 2011; Ragin, 2008).

Job complexity was measured using four items adapted from Zacher and Frese (2011), aligned with Morgeson and Stephen's (2006) definition, capturing task difficulty, decision-making demands, and cognitive requirements. Responses were recorded on a 7-point Likert scale (1 = strongly disagree; 7 = strongly agree). Cronbach's $\alpha = 0.85$.

Career prospects were assessed with ten items based on Wan et al. (2014), reflecting perceptions of compensation, advancement, promotion, and long-term career opportunities (e.g., "promotion possibilities in the industry are satisfactory"). Responses were recorded on the same 7-point Likert scale. Cronbach's $\alpha = 0.88$.

Organizational dependence was assessed using the multidimensional scale developed by Luo, Chen (2024), which captures four dimensions: technology, relational, emotional, and benefit dependence. Each dimension was measured with multiple items reflecting distinct aspects of organizational reliance (e.g., "my skills and talents are fully utilized in my work"; "the company performs well in signing and fulfilling labor contracts"; "the relationships between colleagues in the department are quite harmonious"; "the company offers generous salary and benefits"). Cronbach's α values were 0.87, 0.90, 0.86, and 0.87, respectively.

Employees' work engagement was assessed using the UWES-9 scale developed by Schaufeli et al. (2006). A representative item is "At my work, I feel bursting with energy." The scale demonstrated high internal consistency (Cronbach's $\alpha = 0.93$). Table 1 reports the conditions, calibration anchors, and descriptive statistics.

Table 1.*Sets, calibrations and descriptive statistics*

Sets	Fuzzy-set calibrations			Descriptive statistics			
	Full in (90%)	Crossover (50%)	Full out (10%)	Mean	SD	Min	Max
Employee work engagement	6.1	5.3	3.7	5.52	1.28	1.5	7
Job complexity	6.3	5.2	3.2	4.8	1.2	1.4	7
Career prospects	6.7	5.5	2.5	5.8	0.8	1.8	6.3
Technology dependence	7	5.4	3.1	4.4	1.2	1	7
Relational dependence	6.8	5	3.7	4.3	1	1	7
Emotional dependence	6.7	4.5	3.3	5	1.1	1.5	7
Benefit dependence	6.9	5.2	2.9	5.5	1.2	1.5	7

Source: own study.

4. Results

As a first step, an analysis of necessary conditions was conducted for all six conditions included in the study. The objective of this analysis was to determine whether any of the conditions were indispensable for achieving high or low levels of work engagement in the model. Following prior research (Kwiatkowska, 2024; Du, Kim, 2021; Greckhamer et al., 2018), a fuzzy-set analysis of necessary conditions was performed, applying a consistency threshold of 0.90. The results of this analysis are presented in Table 2. The findings indicate that neither the presence nor the absence of any of the six conditions constitutes a necessary requirement for attaining high or low work engagement. This outcome reinforces the expectation of causal complexity within the model.

Table 2.*Results of necessary condition analysis*

Conditions	High work engagement		Low work engagement	
	consistency	coverage	consistency	coverage
Job complexity	0.72	0.39	0.77	0.38
~ Job complexity	0.37	0.78	0.37	0.72
Career prospects	0.84	0.83	0.81	0.38
~ Career prospects	0.33	0.39	0.38	0.41
Technology dependence	0.76	0.74	0.71	0.38
~ Technology dependence	0.79	0.77	0.41	0.74
Relational dependence	0.41	0.43	0.76	0.33
~ Relational dependence	0.75	0.40	0.73	0.73
Emotional dependence	0.52	0.83	0.44	0.37
~ Emotional dependence	0.76	0.51	0.76	0.42
Benefit dependence	0.36	0.4	0.34	0.43
~ Benefit dependence	0.71	0.79	0.38	0.71

Source: own study.

Following the analysis of necessity, a sufficiency analysis was performed. The frequency threshold for sufficiency analysis is generally determined by sample size (Schneider, Wagemann, 2012). For studies based on small- or medium-sized samples, this threshold is

typically set at 1. In line with the recommendations of Du et al. (2017), the PRI consistency threshold was set at 0.80, while the consistency threshold for the truth table was established at 0.85.

Consistent with prior research practices, this study reports both the intermediate and parsimonious solutions generated using fsQCA 3.0 software. According to the guidelines proposed by Ragin (2008), conditions that appear in both the intermediate and parsimonious solutions were classified as core conditions, whereas those present only in the intermediate solution were designated as peripheral conditions. Consequently, the subsequent statistical interpretation focused exclusively on the parsimonious and intermediate pathways.

Table 3 reports the sufficiency analysis, identifying two sets of pathways associated with high work engagement (configurations HC1a/HC1b and HC2a/HC2b). Considering the causal asymmetry of fs/QCA, additional analysis was performed for low work engagement outcomes. The corresponding configurations (LC1, LC2a, LC2b) are presented in Table 4. Consistent with prior research, “●” was used to indicate the presence of a core condition, “⊗” to indicate its absence, “●” to represent the presence of a peripheral condition, and “⊗” to represent its absence (Fiss, 2011). A blank space was applied to denote an “irrelevant” condition.

According to the results presented in Table 3, both configurations HC1a and HC1b demonstrated identical core conditions, namely the presence of emotional and benefit dependence alongside the absence of job complexity, which jointly served as the primary drivers of elevated work engagement. Nevertheless, the peripheral conditions differentiated the two configurations. In configuration HC1a, relational dependence was absent, technology dependence was present, and career prospects were classified as irrelevant. In contrast, in configuration HC1b, career prospects functioned as a peripheral condition, technology dependence was low, while relational dependence was considered irrelevant.

Table 3.
Configurations related to high work engagement

Conditions	High work engagement			
	HC1a	HC1b	HC2a	HC2b
Job complexity	⊗	⊗	●	●
Career prospects		●		
Technology dependence	●	⊗	●	●
Relational dependence	⊗			●
Emotional dependence	●	●	●	
Benefit dependence	●	●	●	
Raw coverage	0.281	0.294	0.407	0.257
Unique coverage	0.198	0.034	0.035	0.071
Consistency	0.921	0.958	0.946	0.891
Overall solution coverage	0.666			
Overall solution consistency	0.903			

Source: own study.

Table 4.
Configurations related to low work engagement

Conditions	Low work engagement		
	LC1	LC2a	LC2b
Job complexity	⊗		
Career prospects	●	●	
Technology dependence		⊗	⊗
Relational dependence	⊗		●
Emotional dependence		⊗	⊗
Benefit dependence	⊗	⊗	⊗
Raw coverage	0.387	0.421	0.388
Unique coverage	0.054	0.029	0.063
Consistency	0.985	0.934	0.899
Overall solution coverage	0.509		
Overall solution consistency	0.912		

Source: own study.

Taken together, these findings suggest that the presence or absence of technology dependence did not alter the explanatory power of the core conditions-emotional and benefit dependence combined with the absence of job complexity-in fostering high levels of work engagement.

For configurations HC2a and HC2b, technology dependence and job complexity emerged as the core conditions driving high levels of work engagement, while the peripheral conditions distinguished the two configurations. In HC2a, the presence of emotional dependence and benefit dependence functioned as supportive factors, whereas in HC2b, relational dependence fulfilled this role. The difference between HC2a and HC2b thus lies in the peripheral conditions associated with high work engagement. Specifically, these results indicate a substitution effect, whereby emotional and benefit dependence in HC2a can be replaced by relational dependence in HC2b without altering the outcome of elevated work engagement.

The sufficiency analysis for low levels of work engagement, as presented in Table 4, identifies two broad categories of causal configurations (LC1 and LC2a/LC2b). Configuration LC1 is characterized by the core absence of job complexity, relational dependence, and benefit dependence, suggesting that insufficient task challenges, weak interpersonal ties, and inadequate organizational rewards jointly undermine employees' engagement with their work. In contrast, configurations LC2a and LC2b highlight a different causal pathway, wherein the core absence of technology dependence and emotional dependence, combined with the core presence of job complexity, is central to explaining reduced engagement. This indicates that when employees perceive their work as cognitively demanding but lack both emotional connection to the organization and reliance on technological resources, their engagement tends to diminish. Taken together, these findings demonstrate that low levels of work engagement may emerge through multiple and non-equivalent pathways, underscoring the principle of causal asymmetry in fs/QCA. They also reveal that both the absence of supportive

organizational dependencies (relational, emotional, and benefit-related) and the misalignment between job demands and technological reliance can serve as critical barriers to sustaining work engagement.

To evaluate the robustness of the fs/QCA findings, sensitivity analyses were conducted by modifying the calibration and consistency parameters. First, the cross-over point was shifted from the 50th to the 55th percentile, and the results indicated no changes to the complex, intermediate, or parsimonious solutions. In addition, calibration anchors were adjusted by defining full membership and full non-membership at the 90th and 10th percentiles of the distribution, respectively, while the consistency cutoff was systematically varied by ± 0.5 . The evaluation focused on potential alterations in the number and composition of configurations, as well as in their consistency and coverage values. Across all specifications, no substantive differences were detected, thereby reinforcing the reliability and validity of the results.

5. Discussion

In line with the principle of equifinality, the analysis identified four distinct configurations leading to high levels of work engagement and three configurations associated with low work engagement. Importantly, due to causal asymmetry, the conditions that prevent high engagement are not identical to those that generate low engagement. This empirical finding highlights that the drivers of engagement differ fundamentally from the factors that fail to support it. Such an observation constitutes a significant theoretical contribution, as it provides a more nuanced understanding of both the enabling and constraining mechanisms of employee work engagement. Notably, the overall solution coverage for high engagement was greater than for low engagement, suggesting that employees are more likely to experience conditions conducive to strong engagement. This finding underscores the predominance of positive drivers of engagement in organizational contexts, indicating that fostering supportive configurations is more impactful than merely eliminating unfavorable ones. Although the findings suggest that certain factors are pivotal for achieving specific outcomes - for instance, the combination of emotional dependence and benefit dependence or the interplay of job complexity and technology dependence appear in configurations leading to high work engagement, while the absence of job complexity, relational and benefit dependence or the absence of technology and emotional dependence emerge in configurations leading to low engagement - most results are considerably more nuanced. This complexity reinforces the importance of examining interaction effects holistically rather than focusing solely on individual variables, thereby highlighting the configurational nature of employee work engagement.

Configurations HC1a and HC1b highlight, based on their core conditions, a pathways that fosters high levels of employee work engagement in the digital era. When organizations address emotional dependence and benefit dependence, while simultaneously addressing job complexity, they create a supportive environment in which employees feel valued, understood, and secure in their roles. Emotional support, manifested through effective communication and opportunities for collaboration, plays a crucial role in strengthening employees' sense of belonging and mitigating anxieties associated with technological change (Ahmed et al., 2016). Such support enhances employees' psychological resilience, providing a foundation for managing uncertainty and the challenges that accompany technological advancement.

At the same time, the provision of tangible benefits, such as fair compensation, career development opportunities, and job security, reinforces employees' trust in the organization's commitment to their well-being. These benefits foster a sense of stability and confidence in the future, enabling employees to embrace change, acquire new skills, and pursue growth opportunities. By integrating both emotional and benefit dependence, organizations enhance employees' adaptive capacity, thereby enabling them to navigate technological transformations more effectively.

Configurations HC2a and HC2b indicate that high levels of employee work engagement are primarily driven by job complexity and technology dependence. The implementation of advanced digital technologies not only enhances production efficiency, reduces costs, and improves product quality (Tang et al., 2022), but also creates conditions that require greater flexibility and adaptive capacity from employees. Within this context, job complexity emerges as a critical determinant of organizational behavior. On the one hand, it fosters the development of analytical skills and problem-solving capabilities; on the other, it stimulates employees to adopt innovative behaviors as a means of responding to the increasing demands of the technological environment (Zacher, Frese, 2011). Task complexity therefore contributes to a work setting in which innovativeness becomes a natural mechanism for addressing emerging challenges. Simultaneously, technology dependence intensifies the necessity for continuous professional development. Employees are compelled to systematically expand their competencies in order to keep pace with technological change and to utilize new tools and work methods effectively. In this sense, commitment to ongoing learning and development becomes a prerequisite for maintaining both individual and organizational performance and competitiveness. Taken together, the interplay between job complexity and technology dependence not only enhances employee engagement but also promotes the cultivation of pro-innovative attitudes, which are essential for the effective implementation of digital transformation initiatives.

Based on the sufficiency analysis for low levels of work engagement, the findings indicate the existence of two principal pathways, defined by core conditions, that lead to reduced employee engagement in the era of digital transformation. Configuration LC1 indicates that the lack of relational dependence, benefit dependence, and job complexity may lead to a decline

in employee work engagement. Insufficient relational dependence fosters feelings of isolation and limits access to the support and resources necessary for effective performance within the organization (Wood et al., 2016). Similarly, benefit dependence plays a crucial role in sustaining engagement by providing employees with a sense of appreciation and adequate rewards for their contributions. Elements such as fair compensation, job security, and opportunities for advancement represent fundamental aspects of this dependence. The absence of these benefits can result in feelings of underappreciation and diminished motivation to actively participate in organizational life. Furthermore, low job complexity restricts the development of cognitive processes and reduces the need for engagement in diverse activities, thereby weakening employees' willingness to take on challenges and fully commit to their work (Ahmed et al., 2018). Consequently, the absence of these conditions creates an environment in which employees feel disconnected, undervalued, and deprived of developmental opportunities, ultimately leading to reduced levels of work engagement.

The configurations LC2a and LC2b indicate that job complexity, when combined with the absence of technology dependence and benefit dependence, can lead to low levels of work engagement during digital transformation. This finding highlights that job complexity, although often regarded as a driver of problem-solving, innovation, and adaptive behavior (Zacher, Frese, 2011; LePine, 2005), requires adequate technological and organizational support to function as a motivating factor. In the absence of technology dependence, employees lack access to digital tools that could help them manage complexity more effectively, transforming job complexity from a developmental challenge into a source of strain and overload. Similarly, the lack of benefit dependence signals insufficient organizational rewards, such as fair compensation, job security, and career opportunities, which reduces employees' motivation to invest effort in demanding tasks.

In summary, traditional approaches to studying work engagement often assume linear and symmetrical relationships between variables (Knight et al., 2017), thereby overlooking the potential for nonlinearity and causal asymmetry. By employing the fs/QCA method, this study extends the scope of inquiry beyond conventional models, allowing for a more nuanced understanding of the complex interdependencies among conditions. For example, Configuration LC1 demonstrates that the simultaneous absence of relational dependence, benefit dependence, and job complexity is associated with reduced work engagement. This finding underscores the inherently nonlinear and asymmetric nature of the pathways leading to work engagement outcomes. By accounting for equifinality and nonlinear dynamics, this study uncovers diverse configurations that shape work engagement, offering deeper insights into the underlying mechanisms. This methodological approach allows organizations to recognize and respond to distinct constellations of factors that undermine work engagement, thereby strengthening their capacity to cultivate committed and productive work environments in the digital era.

Moreover, this study contributes to the literature on employee behavior. It expands the body of research on employee behavior by addressing the call for studies examining the role of the digital environment in fostering employee behaviors (Nambisan et al., 2019). By incorporating organizational dependence and job characteristics, this research systematically investigates the causal relationships shaping employee work engagement from a configurational perspective. The findings provide practical implications for organizations seeking to motivate employees toward work engagement under diverse conditions and demonstrate that the key distinction in these configurational outcomes lies in employees' heterogeneous understanding of organizational dependence and job characteristics. From an integrated perspective, this study examined the impact of the organizational environment on employee behavior, with a specific focus on work engagement in organizations undergoing digital transformation. At the micro level, prior empirical research analyzing such influences has been limited. Addressing this gap, the present study explored how organizational contexts shape work engagement within a single research design, thereby contributing to the growing body of literature on the interplay between organizational factors and employee engagement.

The study also provides empirical insights that can assist managers in designing targeted interventions aimed at enhancing employee work engagement. By identifying specific pathways and critical determinants of engagement, the findings offer actionable guidance for organizations. In particular, organizations should foster a combination of employees' emotional dependence and benefit dependence. While digital technologies enhance efficiency, they cannot replace meaningful interpersonal connections. Managers should therefore foster open communication, empathy, and collaboration to create a supportive and human-centered culture. At the same time, fair compensation, recognition of contributions, and career development opportunities are essential for maintaining trust and long-term engagement.

In addition to this relational and benefit-oriented pathway, the findings highlight a second complementary mechanism: the interplay between job complexity and technology dependence as a critical driver of employee engagement in the digital era. On the one hand, complex tasks stimulate the development of analytical skills, foster innovativeness, and encourage employees to adopt more creative approaches. On the other hand, increasing reliance on technology necessitates continuous competence development and a commitment to lifelong learning. The synergy of these two factors not only promotes higher levels of engagement but also cultivates pro-innovative attitudes, which are essential for the successful implementation of digital transformation processes.

Together, these insights emphasize the necessity of balancing supportive, human-centered practices with the strategic use of task complexity and technological advancements in order to sustain employee engagement in the digital era.

Although this study sheds light on important aspects of employee work engagement, it is important to recognize that many other factors may also shape these dynamics in the digital era. The scope of the research, the size and composition of the sample, as well as the chosen methodological approach, inevitably place certain limits on the generalizability of the findings. To build on these results, future research should broaden its lens by incorporating additional variables that may play a role in shaping engagement. Larger and more diverse samples, spanning different sectors and organizational contexts, would allow for more robust conclusions. Furthermore, investigating elements such as cultural settings, leadership approaches, and organizational design could offer a richer and more nuanced understanding of how engagement is fostered and sustained in environments increasingly shaped by digital transformation.

6. Conclusion

The conducted study, based on the application of fuzzy-set Qualitative Comparative Analysis (fs/QCA), enabled the identification of complex configurations of factors determining employee work engagement in the digital era. The findings reveal both mechanisms that foster and hinder engagement, highlighting the importance of a configurational perspective in the analysis of organizational behavior. The conclusions drawn have significant practical implications, they can support organizations in designing strategies tailored to the specific characteristics of their environment and the needs of their employees. A better understanding of the interactions between organizational and technological factors facilitates the creation of work environments that promote innovation, motivation, and long-term engagement in the context of dynamic digital transformation.

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THE PARTICIPATION OF WOMEN ON SUPERVISORY BOARDS OF COMPANIES IN WHICH THE STATE IS A SHAREHOLDER IN THE CONTEXT OF THE CHANGE OF POWER IN POLAND IN 2023

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Purpose: The article aims to examine whether the change of power in Poland that took place in 2023 led to an increase in the participation of women in state-owned companies.

Design/methodology/approach: In order to achieve such a formulated objective, the composition of supervisory boards of companies under the administration of the Minister of The Treasury as of December 31, 2023, and June 30, 2025, was examined. A comparison of the composition of these boards was made, taking into account the participation of women serving on them.

Findings: The change of power that took place in 2023 had its impact on the gender structure of supervisory boards of companies under the administration of the Ministry of The Treasury. This is consistent with the pre-election declarations of the winning parties concerning the defence of women's rights. Not only did the share of women on the supervisory boards of the examined companies increase, but also their share in the position of chair of the supervisory board. Despite these positive changes, however, men still dominate the supervisory boards of state-owned companies.

Research limitations/implications: Only the composition of supervisory boards of companies under the administration of the Ministry of The Treasury was analysed. In the future, research should also encompass all state-owned companies, as well as those in which local government units hold shares.

Social implications: The study revealed that a shift in power can positively impact the gender composition of supervisory boards in state-owned companies. This increases the chances of reducing the dominance of men in the governing bodies of these companies and, in the future, may also translate into a change in women's representation in TMT positions in companies with different ownership structures.

Originality/value: In the literature, it is challenging to find studies examining the impact of political changes on women's participation in the governing bodies of state-owned companies. This paper fills that gap for the Polish market, taking into account the most recent parliamentary elections.

Keywords: corporate governance, board of directors, gender, women.

Category of the paper: Research paper.

1. Introduction

The literature frequently highlights the low representation of women in both corporate management boards and supervisory boards. Historically, women have been under-represented in senior management positions across almost all industries. (Calinaud, Gebbels, Kokkranikal, 2021).

It turns out that the low proportion of women is not only the result of institutional, organisational, and individual factors influencing women's career choices, but also of industry norms and practices that collectively restrict their ability to engage and advance. (Cooper et al., 2021). The lower number of women in senior positions, both in Poland and in many other countries, is a result of prevailing stereotypes about the role of women in the family and society, which act as barriers to their professional development (Błaszczuk, 2021).

The literature on the subject not only points to factors that limit the number of women in corporate bodies (including supervisory boards) but also highlights the benefits of greater gender diversity in these bodies. One of them is that gender diversity is associated with a lower likelihood of financial manipulation, even after controlling for firm-specific factors (firm fixed effects) (Wahid, 2019). Another factor highlighted in the literature is that the presence of women on boards is positively associated with financial performance as well as ethical and social compliance, which in turn are positively linked to firm value (Isidro, Sobral, 2015). Gender discrimination is associated with poorer firm outcomes, as evidenced by higher levels of earnings management (Lara et al., 2017), therefore, increasing the representation of women in corporate bodies is a desirable phenomenon.

Board diversity significantly increases CSR performance by increasing CSR strengths and reducing CSR concerns for firms producing consumer-oriented products and firms operating in more competitive industries (Harjoto, Laksmana, Lee, 2015). By increasing the representation of women in corporate bodies, it is expected that women will contribute different backgrounds, competencies, values, and personalities compared to men (Huse, Gabrielsson, 2012). A gender-diverse workforce provides a firm with a competitive advantage, which is expected to lead to higher performance (Ali, 2016). Gender diversity in management teams is positively associated with performance in labour and human rights, and the presence of women in management teams serves as a driving force for enhanced social responsibility (Monteiro, García-Sánchez, Aibar-Guzmán, 2022). Additionally, having a female lead entrepreneur positively moderates the relationships between a firm's human and financial capital indicators and high growth (Devine, 2019).

Furthermore, there are calls for firms to place greater emphasis on supporting women in entry-level and lower managerial positions (Stainback, Roberts, Biswas, 2024). Unfortunately, progress in terms of female representation at the board level has been painfully slow (Chow, Petrou, Procopiou, 2023).

Also, in the field of innovation, the importance of increasing the representation of women in management teams has been recognised. This may affect innovation because leadership styles more common among female managers positively impact it (Foss et al., 2022). Thus, gender diversity is positively associated with corporate innovation (Attah-Boakye et al., 2022). Moreover, men and women tend to bring different knowledge, experiences, and values to the boardroom (Byron, Post, 2016) and females tend to seek out more comprehensive information in their decision-making and use all available information (Lonkani, 2019). Gender diversity contributes to firm competitiveness by improving decision-making processes, fostering innovation and creativity, and bringing different perspectives and cognitive structures to the firm, may provide a sustainable competitive advantage by being a valuable, rare, imperfectly imitable, and non-substitutable resource (Ferrary, Déo, 2023).

The problem is not only the low representation of women in top management teams (TMT), but also that female TMT members are said to be paid less than their male colleagues (Yanadori, Kulik, Gould, 2021).

In Poland, the proportion of women in corporate bodies is also significantly lower than that of men. Research conducted at the Department of Business Management at the University of Economics in Katowice confirmed that, in the case of listed companies (as of March 7, 2025), men predominate in both management boards and supervisory boards. In the case of company management boards, women accounted for 14.3%, while their representation on supervisory boards was just over 20%. Similarly, at the end of 2023, the share of women on the supervisory boards of state-owned companies on December 31, 2023, was low and significantly lagged behind the representation of men in these bodies (Samborski, 2024). This situation changed during the first 18 months of the new government's term; however, as of now (June 30, 2025), men still dominate state-owned companies.

In the case of companies in which the State is a shareholder, the authorities have, to a large extent, a direct influence on who will sit on their management boards or supervisory boards. Policymakers can establish various political and regulatory pressures on companies to promote the presence of women on boards (López-Cabarcos et al., 2023). France and Spain, and earlier Norway, introduced regulations stipulating that 40% of the members of public company boards should be women (Bohdanowicz, 2011). With Norway being the first country in the world to legally guarantee this (Półtorak, 2014).

The impact of politically driven actions can influence the composition of supervisory boards not only in state-owned companies but may also extend to private entities. Moreover, it has been observed that some female directors actively seek to promote gender equality within their organisations (Kirsch, 2022). Research on the Polish market has also indicated that entrusting women with the position of chairperson of the supervisory board is associated with a higher representation of women on supervisory boards. Increasing the representation of women in corporate bodies is therefore a way to reduce the dominance of men in the management

of various entities (Samborski, 2024), because women will appoint more female executives who may someday become management board directors (Tyrowicz et al., 2020).

Firms should also introduce various diversity practices to increase the proportion of women and minorities at the top, because the more diversity management and family-friendly practices that are implemented, the higher is the proportion of women in management positions (Schoen, Rost, 2021).

Before the 2023 elections, the then-opposition parties' emphasised the need to increase women's rights, including access to professions and positions that had so far been dominated by men. This can also be understood as increasing access to corporate bodies over which the ruling parties have influence. If the current government were to act in line with its earlier declarations, there should be an increase in the representation of women in companies in which the State holds shares (and thus has influence).

It is therefore worth examining whether the change of power in 2023 actually led to an increase in the representation of women on the supervisory boards of these companies. Of course, as a candidate for a supervisory board member, the entity entitled to exercise the rights attached to shares held by the State proposes a person who has received a positive opinion from the Council for Companies with State Participation and State Legal Entities (Act on The Principles of State Property Management, 2016), who must also meet additional conditions specified by law. The provisions of the law thus serve as the basis for the selection of specific individuals.

The contemporary literature offers limited research on changes in the representation of women on supervisory boards during the first eighteen months of the new government's term, within the group of companies supervised by the Ministry of The Treasury in Poland. Previous studies have primarily focused on factors influencing board composition (such as the gender of the chairperson or the company's headquarters location). However, they have typically analysed data at a single point in time rather than adopting a dynamic perspective that captures changes occurring over a longer period.

2. Methods

The subject of the study for the purposes of this article is the representation of women on the supervisory boards of state-owned companies. The change of power in Poland that occurred at the end of 2023 also influenced changes not only in the management boards of entities subordinate to the State but also in their supervisory boards. This situation occurs not only at the central level but also at various levels of local government. It is therefore not surprising that such changes also took place following the inauguration of the new government led by Donald Tusk at the end of 2023. The following changes in societies are causing the share of women

in on corporate boards to increase systematically. Studies conducted on large listed firms in Europe (EU-27, Iceland, Norway, and the UK) showed that between 2012 and 2022, the share of women decreased in only two countries (with the largest decline recorded in Latvia: -9.2 percentage points). In 28 countries, the share of women on boards of directors increased, with the largest rise observed in Italy: +31.8 percentage points (Martínez, Gómez, 2023).

The following research hypotheses were adopted in this study:

1. From the inauguration of the new government on December 13, 2023, until June 30, 2025, the representation of women on the supervisory boards of state-owned companies under the supervision of the The Treasury Minister (MAP) increased.
2. During the studied period, the share of women serving as Chairpersons of the Supervisory Boards of state-owned companies under the supervision of MAP increased.
3. The increase in the representation of women on the Supervisory Boards of companies in which the State holds a majority stake (under MAP supervision) was greater than in the case of companies with minority state participation.
4. In the case of a person serving as Chairperson of the Supervisory Board, the increase in the representation of women was greater in companies in which the State holds a majority stake.
5. During the studied period, the increase in the representation of women on the supervisory boards of the examined companies representing the State was greater than in the case of women representing other groups of entities.

The study selected companies in which the State was a shareholder, and were under the supervision of the Treasury Minister on both December 31, 2023 (MAP, 2023), and June 30, 2025 (MAP, 2025). All data regarding the composition of supervisory boards for the specified dates (and additionally for three individuals on December 13, 2023) were obtained from the website of the Ministry of The Treasury. Consequently, the study covered ninety-five companies that were under the supervision of the Treasury Minister on both dates.

Materials regarding the composition of supervisory boards on the Ministry's website indicate that, in the period from December 13 to December 31, 2023, only three individuals were appointed to supervisory boards. However, this concerns an entity that was not included in further analyses because it did not meet the previously established criteria for being under the supervision of the Treasury Minister in both studied periods.

For the purpose of testing the third and fourth hypotheses, the companies in both periods were divided into two groups. The first group consisted of companies in which the State holds at least a 50% stake, while the second group consisted of companies with a minority stake held by the State. For the purpose of testing the third and fourth hypotheses, the companies in both periods were divided into two groups. The first group consisted of companies in which the State holds at least a 50% stake, while the second group consisted of companies with a minority stake held by the State.

It should be noted that the number of members serving on the supervisory boards of the companies examined increased. Between December 31, 2023, and June 30, 2025, this number grew by six members. This change was due to modifications in forty-one companies. In twenty-one companies, the number of supervisory board members increased, while in twenty companies, the number of members on the board decreased.

3. Results

In the first hypothesis, it was assumed that the change of power on December 13, 2023, influenced an increase in the representation of women on the supervisory boards of state-owned companies (under MAP supervision). The basis for formulating this hypothesis (as well as the other research hypotheses) was the stance of the then-opposition before the parliamentary elections regarding women and the fight for their rights (including in the context of professional self-realisation). A study conducted on ninety-five state-owned companies under the supervision of the Treasury Minister indicated that the representation of women on the supervisory boards of these companies increased during the examined period, as shown in Figure 1.

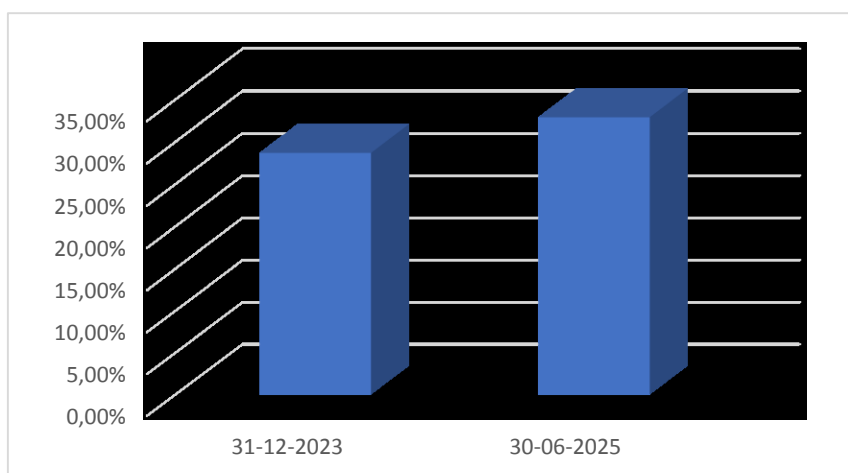


Figure 1. The representation of women on the supervisory boards of companies under the administration of MAP on 31.12.2023 and 30.06.2025.

Source: own elaboration.

As shown in Figure 1, the representation of women on supervisory boards stood at 28.66% at the end of 2023. Over the course of 18 months, it increased to 32.87%. This was not only the result of an increase in the number of women in the companies under study, but also a decrease in the number of men on the supervisory boards of the examined companies. This indicates that the new government, during its first 18 months in office, already introduced favourable changes to increase the representation of women on the supervisory boards of the companies studied. Therefore, there is no reason to reject the first hypothesis.

In the second hypothesis, it was assumed that there would be an increase in the representation of women serving as Chairpersons of the Supervisory Boards of state-owned companies under the supervision of the Treasury Minister (MAP). This hypothesis was formulated to examine whether any potential increase in the representation of women in the studied entities was merely symbolic-by appointing them as board members while overlooking them for the position of Chairperson of the Supervisory Board. The results of the study for both periods are presented in Figure 2.

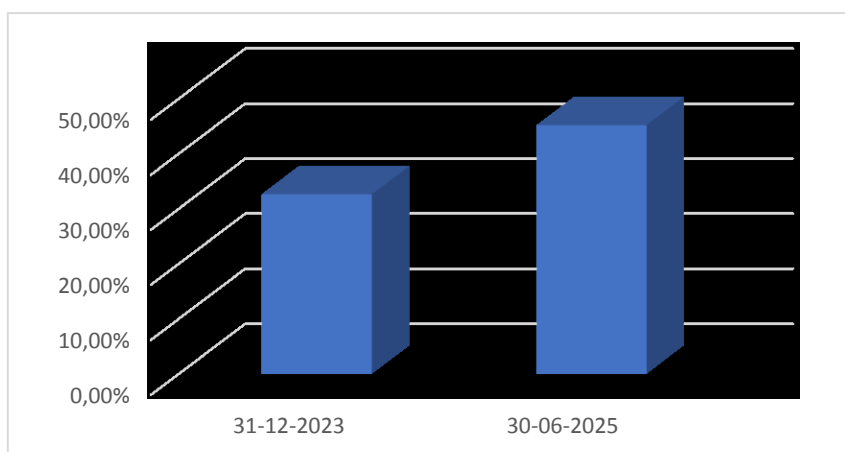


Figure 2. The representation of women as Chairpersons of the Supervisory Boards of companies under the administration of MAP on 31.12.2023 and 30.06.2025.

Source: own elaboration.

In the case of the position of Chairperson of the Supervisory Board, the representation of women holding this role also increased. Moreover, this change was more pronounced than for the overall composition of the supervisory boards of the companies under study. On December 31, 2023, women held the position of Chairperson in 32.56% of cases, while by June 2025, this share had risen to 45.12%. Thus, there was an increase of 12.56 percentage points, while the rise in the representation of women on the supervisory boards of the studied companies was only 4.21 percentage points. Therefore, there are no grounds to reject this hypothesis.

In the third hypothesis, it was assumed that the representation of women on the supervisory boards of state-owned companies with majority ownership increased more than in companies where the State holds a minority stake. When formulating this hypothesis, it was assumed that central authorities have greater decision-making power in companies in which they hold a majority stake. Out of the ninety-five companies considered, the State held less than 50% in 42 companies, while in fifty-three companies, the State's share was above 50%. In the first group, at the end of 2023, women accounted for 27.04% of the composition of the supervisory boards in the forty-two companies with minority State ownership. By June 2025, this share had risen to 28.15%. In the case of companies with majority State ownership, the change in gender structure is more pronounced. At the end of 2023, women represented 30.08% of the supervisory boards, and by June 2025, their share in this group of companies had reached 37.08%. This situation is illustrated in Figure 3.

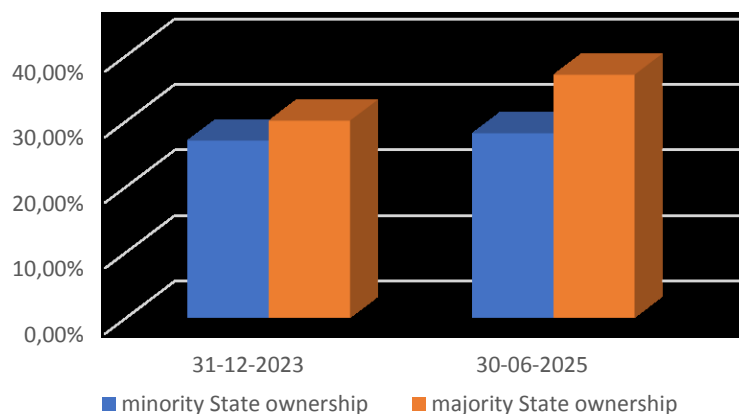


Figure 3. The representation of women on the supervisory boards of companies under the administration of the Treasury Minister (MAP) on 31.12.2023 and 30.06.2025, with a breakdown between companies with majority and minority State ownership.

Source: own elaboration.

This indicates that in companies where the decisive voice belongs to the government, changes in the composition of supervisory boards that increased the representation of women occurred on a larger scale than in companies with minority State ownership (although an increase was also observed there). Therefore, the hypothesis formulated at the outset was confirmed. The fourth hypothesis assumed that, similarly, in companies with majority State ownership, the proportion of women holding the position of chairperson of the supervisory board increased to a greater extent compared to companies with minority State ownership. It is worth recalling that among all ninety-five companies studied, there was an increase of 12.56 percentage points. The changes in representation over the period examined for the position of chairperson of the supervisory board, broken down by companies with minority and majority State ownership, are presented in Figure 4.

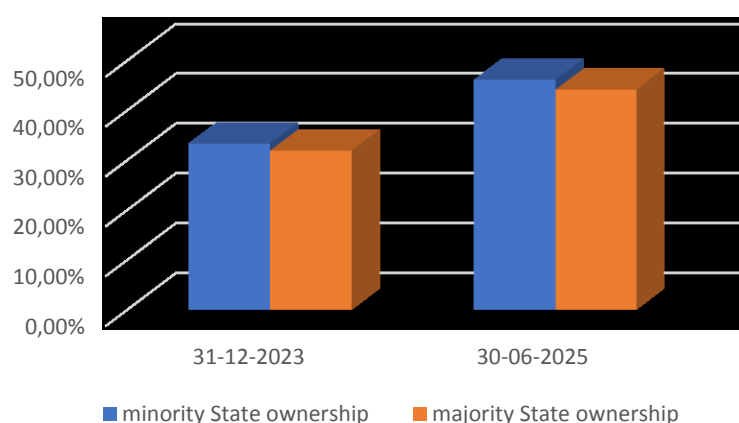


Figure 4. The share of women in the position of chairperson of the supervisory boards of companies under the administration of the MAP on 31.12.2023 and 30.06.2025, broken down by companies with majority and minority State ownership.

Source: own elaboration.

In the group of companies with minority State ownership, the increase in the share of women in the position of chairperson of the supervisory board was higher than in the overall sample, amounting to 12.82 percentage points. In companies with majority State ownership, the increase was at a similar level, reaching 12.27 percentage points. Since the change in the chairperson's position in companies with minority State ownership is slightly higher, hypothesis four should be rejected.

In the fifth hypothesis, it was assumed that the increase in the share of women among individuals representing the State in supervisory boards (regardless of the State's ownership stake in particular companies or the positions held) was greater than in the case of women representing other groups. In this part of the study, the gender composition of individuals appointed to supervisory boards by the State was compared between the reports from December 31, 2023, and June 30, 2025. These data were then compared with the changes in the composition of supervisory boards for individuals appointed by other entities. The comparison of the structures for these two groups is shown in Figure 5.

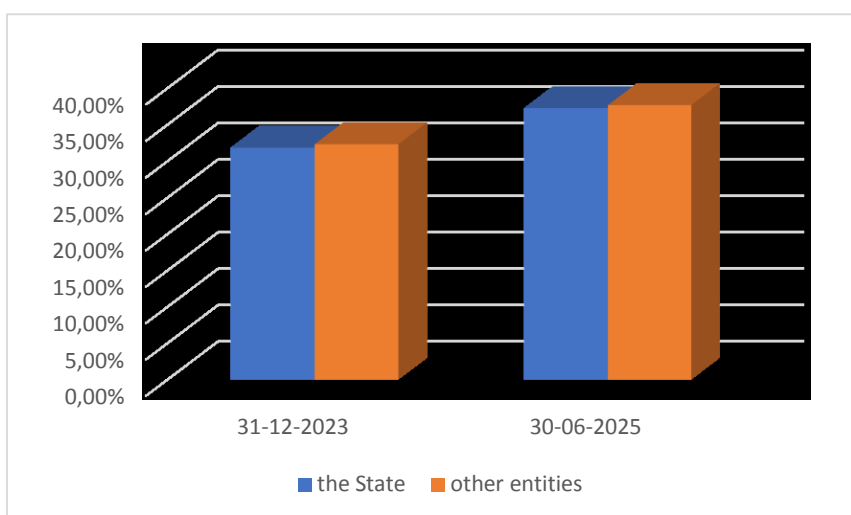


Figure 5. The share of women on the supervisory boards of companies under the administration of MAP on 31.12.2023 and 30.06.2025, broken down by individuals representing the State and other entities.

Source: own elaboration.

Among the individuals representing the State on supervisory boards at the end of 2023, 31.82% were women and 68.18% were men. By June 30, 2025, the share of women in this group had increased to 37.23%. For other entities represented on the supervisory boards of the examined companies (indicated in the MAP documentation as other entities, employees, independents, and farmers/orchardists), the share of women at the end of 2023 was 32.30%. Over the following 18 months, the share of women in this group also increased to 37.65%, which, as at the end of 2023, was higher than that of women representing the State. However, the research hypothesis focused not on the absolute shares of women on supervisory boards but on the change in these shares. For board members representing the State, the share of women increased by 5.42 percentage points, whereas for other entities the increase was 5.36 percentage points. Therefore, research hypothesis five was confirmed.

4. Discussion

In the supervisory boards of companies under the administration of MAP, men continue to dominate. This was the case both before the change of government in 2023 and after 18 months of Donald Tusk's government in office.

However, the research process aimed to answer five specific questions:

1. Has the representation of women on the supervisory boards of state-owned companies under the administration of the Treasury Minister (MAP) increased from the swearing-in of the new government on December 13, 2023, to June 30, 2025?
2. During the studied period, has there been an increase in the proportion of women serving as chairpersons of supervisory boards in state-owned companies under MAP oversight?
3. In the period studied, was the increase in women's representation on the supervisory boards of companies where the State holds a majority stake (MAP) greater than in companies with minority-state ownership?
4. For the position of chairperson of the supervisory board, was the increase in female representation greater in companies where the State holds a majority stake compared to other companies under MAP supervision?
5. Was the growth in female representation on the supervisory boards of the studied companies, appointed by the State, greater than that of women appointed by other entities?

To answer the first question, the participation of women on the supervisory boards of the studied companies was examined on December 31, 2023, and June 30, 2025. It was found that over the 18 months of the new government's term, their representation increased from 28.66% to 32.87%. Women also accounted for a larger share of chairpersons of supervisory boards in the studied companies (question 2). At the end of 2023, this share was 32.56%, rising to 45.12% by June 2025. This situation indicates not only a quantitative increase in the presence of women in the companies under study but also recognition of their knowledge, skills, and competencies, as evidenced by entrusting them with the position of Chairperson of the Supervisory Board. In response to question 3, the study showed that in companies with majority state ownership, women's representation on supervisory boards increased by seven percentage points, while in other companies the increase was only 1.11 percentage points. The answer to question 4 indicated that the increase in female representation in the position of chairperson of the supervisory board occurred to a greater extent in minority-state-owned companies. As for the participation of women on supervisory boards, broken down into representatives of the State and other groups, the increase in the share of women in the first group was slightly higher than in companies with minority State participation.

The results of this study – showing an increase in the share of women on supervisory boards in state-owned companies after the political change in 2023 – are consistent with evidence from other European countries where public policy interventions have influenced board gender diversity. In Norway, which was the first country to introduce legislation mandating a 40% gender quota for women on the boards of public companies, the share of women on supervisory boards increased rapidly (Ahern, Dittmar, 2012).

An additional factor contributing to the increase in the number of women on the supervisory boards of the largest publicly listed companies will be the implementation in Poland of the provisions set out in Directive (EU) 2022/2381 of the European Parliament and of the Council of 23 November 2022 on improving the gender balance among directors of listed companies and related measures.

The analyses show an increase in the presence of women on boards of directors from the early 2000s to nowadays, with greater board presence in countries that enacted gender diversity on board regulations, whether quotas and/or recommendations in codes of good governance (Martínez, Gómez, 2023).

5. Conclusions

The change of government, whose representatives advocated for greater women's rights, influenced the composition of supervisory boards of companies under the administration of the Treasury Minister (MAP). Not only did the proportion of women on these boards increase, but their representation in the position of chairperson of the supervisory board also rose. The political change in 2023 led to an enhanced role for women in the studied companies, aligning with the campaign promises made during the elections. The study therefore confirmed that the change of political power in Poland in 2023 was associated with a measurable increase in the participation of women on the supervisory boards of state-owned companies – both as members and as chairpersons. The results show that political and institutional decisions can serve as an effective mechanism for increasing the participation of women in decision-making bodies. The study confirms the importance of non-market factors, such as public policy and government actions, in shaping corporate governance and gender balance within supervisory structures. The changes initiated in 2023 should be continued, as the literature indicates that increasing the participation of women in corporate bodies (including supervisory boards) positively impacts the functioning of the organisation. Based on the study's results, it can be assumed that if political parties declaring support for women (including in the professional sphere) win future elections, a further increase in women's participation in economic life can be expected, ultimately leading to the reduction of male dominance on supervisory boards – not only in state-owned companies but also in other entities.

The theoretical implications of this study relate to the broader debate on the effectiveness of public policies in promoting gender equality. The results are consistent with observations from countries such as Portugal, Belgium and Italy, where legally or politically supported gender quotas have led to structural changes in the composition of supervisory boards. The conducted research may also serve as a starting point for further discussion on the effectiveness of gender equality policies in Poland and as a reference point for future comparative analyses, both at the national and European levels. It contributes to a deeper understanding of the impact of political changes on gender diversity in corporate bodies, particularly in entities in which the State is a shareholder. Moreover, it complements the existing literature by providing the perspective of Central and Eastern European countries, which have so far been less frequently analysed in this context. The findings may also be used in designing legal and institutional solutions aimed at increasing gender diversity within corporate bodies, as men still continue to dominate supervisory boards of state-owned companies.

The study has certain limitations, as it only examined companies under the administration of MAP. Therefore, the observed trends cannot be directly applied to all companies in which the State holds shares. For a more comprehensive picture, similar research should be conducted on a broader scale, including all state-owned companies. An additional limitation was the geographical scope, as the study focused solely on the situation in Poland. Future research should examine whether a change of government at the national level in other countries also affects the gender structure of state-owned companies. Future research should also focus on companies that underwent personnel changes following the local elections in 2024. It would be valuable to examine changes in the context of women's participation in the management boards of individual local government units after the 2024 elections.

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THE LEVEL OF DIGITAL SKILLS AND DIGITAL AWARENESS AMONG WOMEN AND MEN OF GENERATION Z – RESEARCH RESULTS

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Purpose: The aim of this paper is to assess the level of digital awareness and digital skills among Generation Z women and men.

Design/methodology/approach: The analysis focuses on the results of a 2024 study conducted on 361 randomly selected Generation Z representatives. A proprietary survey questionnaire was used. Responses were answered on a 5-point Likert scale. Cronbach's alpha was used to test the reliability of the research tool. The data were then subjected to appropriate statistical analysis.

Findings: Data analysis showed that the average level of digital skills and digital awareness among Generation Z representatives in Poland is 3.74 on a 5-point scale. All areas of digital skills and awareness scored above 3.00, indicating a relatively high rating from respondents. It turned out that the variable values for women and men are very similar, suggesting a similar perception or assessment of the aspects studied by women and men. Analysis of gender differences in digital competences revealed statistically significant differences in the areas of Hardware, Network, AI, and Interest-Knowledge. The results confirm trends in the European Union, where there is no significant difference in the level of digital skills between the genders in the Generation Z group. Moreover, the level of digital awareness is high, and digital skills are well-developed.

Research limitations: Quantitative research has limitations, including the regional nature of the research group. At the same time, qualitative research could complement and expand the conclusions.

Practical implications: The findings from the analysis help us understand how media practices shape skill development, offering practical advice for policymakers who want to equip the younger generation with the skills they need to succeed. Educational programs should focus on fostering key information literacy and safety skills among generations raised in the digital age. Generation Z should embrace interactive tools, and advanced competencies should enable data management and ethical internet use.

Originality/value: This paper contributes to scholarship by identifying the levels of digital awareness and skills among Generation Z individuals and comparing these levels by gender.

Keywords: digital awareness, digital skills, digital competences, Generation Z, women, men.

Category of the paper: Research paper.

1. Introduction

Nowadays, digital skills and competencies are no longer an asset but are necessary for effective functioning in an increasingly digitalized society and economy. They are important not only in the professional sphere but in virtually every aspect of life. Implementing and using digital technologies determines organizational aspects, learning, environments, and everyday life (Van Laar et al., 2017). As the literature on the subject indicates, the concept of digital literacy is extremely broad. It encompasses a rich set of skills and abilities necessary for continuous learning and functioning in digital environments in a critical, creative, and responsible manner (Vishnu et al., 2022). Digital literacy is a key skill that allows for leveraging the benefits of technological progress and a communication tool that enables access, organization, evaluation, and sharing of information across various social groups (Purnama et al. 2021). This is becoming particularly important and compelling in the digital economy, where generations born in the digital age, including Generation Z, play an increasingly important role in the labor market and in building organizational entrepreneurship.

The aim of this paper is to assess the level of digital awareness and digital skills among Generation Z women and men. The article is based on a 2024 survey of 361 respondents. It contributes to science by identifying the level of digital skills and digital awareness among Generation Z individuals and comparing these levels by gender.

2. Literature review

In the digital economy and society, individuals' ability to adapt to new trends and requirements largely depends on attitudes, habits, and knowledge related to digital skills. The process of acquiring such skills and their outcomes is called digital competences (Pongrac, Alić, Cafuta, 2025). According to Rubach and Lazarides (2021), digital competences can be defined as a set of knowledge, skills, abilities, and other characteristics that enable individuals to perform their jobs effectively. These tasks are securing digital resources for information and data processing, communication and collaboration, and problem-solving. This definition can be expanded to state that digital skills are the foundation of success in today's digital society. They are one of the three key competences for lifelong learning, alongside civic and social competences, cultural awareness, and creative competences, defined by the outcomes of safe and critical use of technology (Giurgiu et al., 2008; Haddon et al., 2020). Digital awareness, competence, and digital skills are multifaceted, multithreaded, and linked to the sociocultural context (Olofsson, Fransson, Lindberg, 2019; Caputa et al., 2023). The role and importance

of skills related to digital technologies are frequently discussed in the literature, as they currently affect almost every aspect of life (Falloon, 2020; Haleem et al., 2022).

As indicated by the PARP Report (2023), the youngest generation in the labor market is Generation Z, born after 1990. This group has initial professional experience but is familiar with digital technologies. They are characterized by volatility and a demanding nature (Cho, Lee, 2018). However, their digital skills are high due to their education in the digital era and the constant use of digital technologies and social networks for social interactions (Persada et al., 2019; Gui, Argentin, 2011). Being born and living in an environment heavily dependent on technology shapes Generation Z representatives in a completely different way and influences their behavior in social interactions and acquiring new knowledge (Bullen et al., 2011). There is research available that indicates that factors such as gender, level of education, and geographical location have a decisive impact on digital skills (Hadjiristic, 2017; Litt, 2013), and what is more, the level of these skills and awareness in the generation Z group is constantly increasing (Haddock et al., 2022; Surian, Andrea, 2019).

The measurement of digital skills and competences is widely discussed in the literature, partly due to its importance. This concerns implementing digital activities in the contemporary world, including using digital technologies and ICT tools for work, participation in social life, social interactions, leisure, and learning (Vuorikari et al., 2025). In general, digital skills assessment tools have two main characteristics: the measurement of procedural knowledge, i.e., the measurement of operational digital skills, and the measurement of knowledge about digital tools and their use. Recently, however, new elements of measurement tools have been added, offering definitions of digital competence attributes (knowledge, skills, and attitudes), as well as a set of terms that allow for the creation of a common understanding of what digital competences mean (Clifford et al., 2020; Ulfert-Blank, Schmidt, 2022). It can be argued that combining new attributes with measurement tools better accounts for the multi-layered nature of digital competences and their constructs, thus enriching self-assessment tools. Further literature analysis reveals a framework identifying four dimensions that constitute digital skills that can be measured. The areas assessed include:

1. Technical and operational skills.
2. Navigation and information processing skills.
3. Communication and interaction skills.
4. Content creation and production skills.

In this case, a distinction should be made between using the functionality of information and communication technologies (ICTs) and leveraging knowledge to manage interactions in digital spaces (Helsper et al., 2020). The growing importance of digital competences in various aspects of life, from education and work to social interactions and leisure, highlights the need for effective assessment tools. However, existing tools can sometimes be too long or complex (Vuorikari et al., 2025).

To achieve the study's aim, the approach adopted by Aydınlar et al. (2024) was adopted, which identifies a model distinguishing seven domains of digital competences, measuring which a total of 24 competencies and skills were used. Within each of the seven variables, subvariables were identified, defining the scope of skills and competencies in each area:

- 1) Software and Multimedia, including ease of learning technology, the ability to communicate via simple online platforms, and knowledge of computer languages.
- 2) Hardware, including the ability to solve technical problems, and technical computer knowledge.
- 3) Networking, including the ability to communicate online and work via online platforms.
- 4) Ethics, including knowledge of copyright, licensing, and the provisions of the Personal Data Protection Act.
- 5) Security, related to cybersecurity and security.
- 6) AI, related to knowledge of artificial intelligence and its application areas.
- 7) Interest-Knowledge, related to knowledge of technology, skills, and willingness to learn.

Regardless of the approach to assessing digital awareness and digital skills, they are currently among the most important competencies for every individual, influencing their ability to participate effectively in social and economic life. Therefore, to achieve the study's objective, the following research questions were posed:

1. What is the level of digital awareness among Generation Z?
2. What is the level of digital literacy among Generation Z?
3. In what areas are Generation Z's digital literacy levels higher and lower?
4. Do digital literacy levels differ among Generation Z women and men?

3. Methodology

The paper aims to assess the level of digital awareness and skills among Generation Z women and men. The results presented in this study are part of a larger study. The main study, conducted in 2024, was preceded by a pilot study with 20 respondents. The main study involved 370 randomly selected respondents, including 193 women, 168 men, and nine gender-neutral individuals. Therefore, data for 361 respondents were used for analysis.

The results of the pilot study and a literature review allowed for the development of a research tool: a survey questionnaire. The original questionnaire consisted of a questionnaire and closed-ended questions, including those assessing the level of digital skills and abilities. Respondents' responses were based on a 5-point Likert scale (Sheng, Zhou, Li, 2011).

The identification of digital skills and digital awareness in the study group was based on findings from Aydınlar et al. (2024). Digital awareness and skill levels were divided into seven domains, each of which respondents assess their skills. The following domains of digital literacy were distinguished: Software and Multimedia (DL1), Hardware (DL2), Network (DL3), Ethics (DL4), Security (DL5), AI (DL6), and Interest-Knowledge (DL7).

Table 1.
Reliability and validity (Cronbach's α)

Variables	Cronbach's α
Software and Multimedia (DL1)	0.922
Hardware (DL2)	0.921
Network (DL3)	0.923
Ethics (DL4)	0.919
Security (DL5)	0.919
AI (DL6)	0.923
Interest-Knowledge (DL7)	0.918

Source: own research.

Cronbach's alpha was used to test the reliability of the research tool (Taber, 2018; Christmann, Van Aelst, 2006). The results of the analysis (Table 1) showed that the digital skills and awareness scale has excellent reliability in each of its domains, with Cronbach's alpha ranging from 0.918 to 0.923. The research scales constructed within the tool meet the requirements, and their use in quantitative research is justified based on the classification scheme established by George and Mallery (2016, p. 240).

4. Results

The analysis showed that the average level of digital skills and awareness among Generation Z representatives is 3.74, while the median is slightly higher at 3.92 on a 5-point scale. This difference suggests a slightly left-skewed distribution – meaning that most respondents have scores on the higher side of the rating scale, indicating relatively good digital competencies and skills in the study group. The standard deviation is 0.795, indicating moderate dispersion of results around the mean. Most scores fall within ± 1 SD of the mean, ranging from 2.94 ($3.74 - 0.80$) to 4.54 ($3.74 + 0.80$). The score range is from 1.33 (min) to 5.00 (max), indicating the full spectrum of ratings on the adopted Likert scale. The lowest value indicates a respondent with very low digital skills, while the maximum value suggests that some respondents rate their digital competencies as the highest possible. Interestingly, the quartile analysis indicates that only 25% of respondents scored below 3.13 ($Q1 = 3.13$), while 25% of respondents scored above 4.36 ($Q3 = 4.36$). Half of the sample (50% of the results) fell within the range of 3.13 to 4.36, suggesting moderate variation in scores and a concentration around average and higher values.

The analysis also indicates that all areas of digital skills and awareness (DL1-DL7) achieved scores above 3.00 on a 5-point Likert scale, indicating a relatively high assessment of respondents' digital skills and awareness. The highest mean score was indicated by respondents for DL5, at 4.078, and for DL2, at 3.862, on a 5-point scale. Conversely, the lowest digital skills and awareness were reported for DL1, at 3.419. The standard deviation for the DL1-DL7 areas ranges between 0.89 and 0.98, indicating moderate response variability (Figure 1).

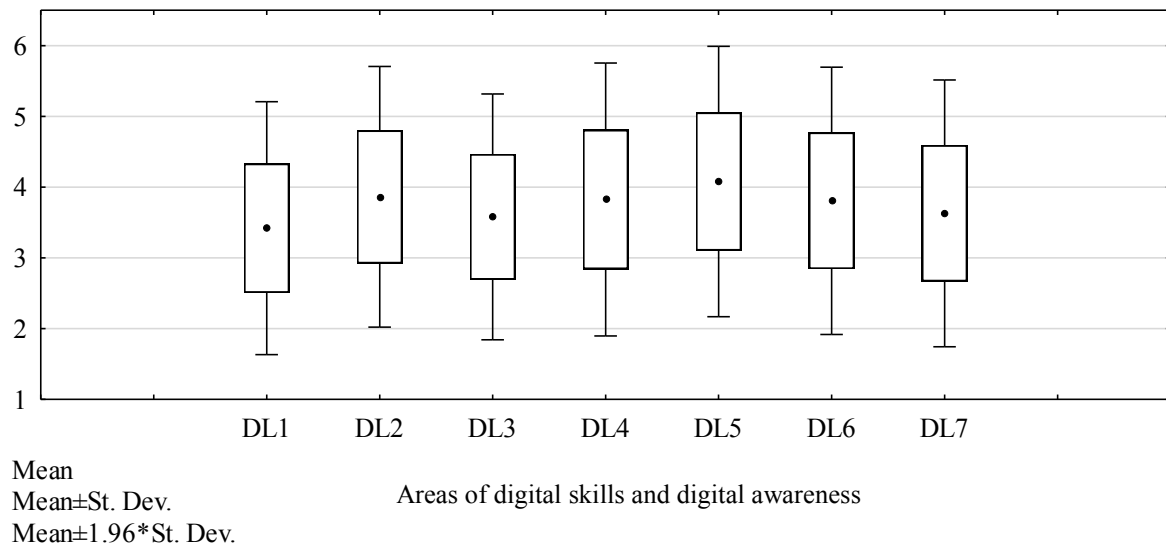


Figure 1. Level of digital awareness and skills of Generation Z (N = 361).

Source: own research.

Further analysis revealed differences between the responses of the surveyed women and men belonging to Generation Z. It turned out that the values for the studied variables (DL1-DL7) for women and men were very similar. The highest ratings (for both genders) occurred in the area of digital skills and awareness DL5, where women declared a level of 4.11, and men a level of 4.05 on a 5-point Likert scale. Women declared the lowest ratings for digital skills and awareness in area DL1, at a level of 3.38, while men declared a level of 3.44 on a 5-point scale in area DL2. In areas DL3, DL5, and DL 6, women have slightly higher ratings of their digital skills and awareness than men. In areas DL1, DL2, and DL7, men have slightly higher ratings of their digital skills and awareness than women. It can be indicated that the differences between genders are minor in each category, DL1-DL7. This indicates that women and men perceive or evaluate the aspects studied very similarly. Figure 2 shows high consistency between the study groups.

Next, the Student's t-test was used to determine whether there were statistically significant differences in the areas of digital skills and digital awareness between women and men. The analysis of gender differences in digital competences revealed statistically significant differences in the areas of DL2 ($t(359) = -3.55$, $p < 0.001$), DL3 ($t(359) = 2.89$, $p = 0.004$), DL6 ($t(359) = 2.53$, $p = 0.012$), and DL7 ($t(359) = -1.98$, $p = 0.048$).

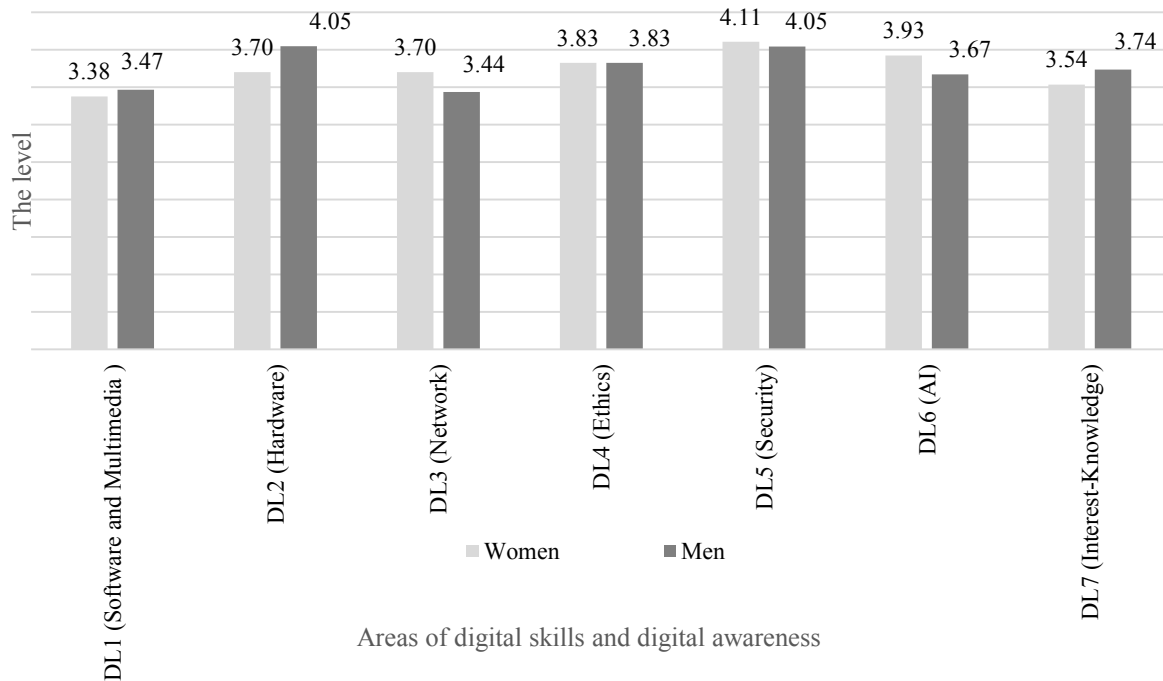


Figure 2. The level of digital literacy and awareness among Generation Z women and men (N = 361).

Source: own research.

No significant differences were found for the remaining variables, i.e., DL1, DL4, and DL5. Additionally, Levene's test (F ratio) showed that for most variables (DL1, DL2, DL3, DL4, DL6, DL7), $p > 0.05$, which means that equality of variances is assumed (the t-test result for equal variances is correct). The exception is the value for the DL5 area ($p = 0.047$), but the result is statistically insignificant.

5. Discussions and Conclusion

The results confirm trends in the European Union, where there is no significant gender difference in digital literacy levels within Generation Z. Generation Z is highly technically proficient (using tools, using social media, communicating), meaning their digital awareness is high. Their digital skills are well-developed (Stjepic, Vukšić, Suša Vugec, 2019), a finding confirmed by research. Research shows that the information-searching abilities of people born in the digital age can improve, among other things, their academic performance, and that better technical and operational communication skills are associated with positive behavior, coping with online threats, and overall life satisfaction (Eynon, Malmberg, 2012). As individuals raised in the digital age enter the labor market and become active members of society, they will play a key role in shaping future policy. The importance of developing and improving digital skills is therefore undeniable. Both individual habits and systematic educational processes significantly influence the acquisition and development of these skills. It should be noted that

digital awareness, although high according to our own research and literature review, often does not extend to critical awareness, digital safety, and digital hygiene, which are often at a lower level.

The literature review also indicates that educational programs should focus on fostering key information and safety skills among generations raised in the digital age. These social groups should utilize interactive tools and age-appropriate content, and advanced competencies should enable data management and ethical use of the internet to prepare for the challenges of a digital society (Buchan et al., 2024). As Gołaszewska-Kaczan and Kuzionko-Ochrymiuk (2023) emphasize, the development of the digital economy forces all members of society to improve their digital skills. These skills are essential not only in professional work but also in everyday life. A lack of competencies in this area may soon contribute to digital exclusion, as limited opportunities to participate in modern forms of culture or the inability to access the expanding range of digital public services.

The quantitative research conducted has its limitations, including the regional sample size. Expanding the geographic scope and including participants with diverse socioeconomic statuses and educational backgrounds would enhance the inferences and generalizability of the results. Furthermore, extending the research to include qualitative methods and incorporating objective assessments of digital competences into the self-assessment data would reduce the impact of potential response biases and provide a more comprehensive understanding of digital competence levels.

Despite the limited sample size and scope of the study, as well as the narrow focus on digital competence dimensions, the study provides valuable insights into the differences in digital awareness and skills between two distinct groups of individuals raised in the digital age. The findings from the analysis contribute to our understanding of how media habits influence competence development, offering practical guidance for policymakers who strive to equip individuals raised in the digital age with the skills necessary to succeed in a rapidly changing technological world.

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MINIMIZING PERSONNEL COSTS USING LINEAR PROGRAMMING TOOLS ON THE EXAMPLE OF A SERVICE BUSINESS

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Purpose: The aim of this article is to apply theories concerning the optimization of employment levels using linear programming methods based on the assignment problem.

Design/methodology/approach: The research was based on a review of literature on business management and the problem of assignment. In the author's opinion, studies showing the practical possibilities of this type of algorithm fill a cognitive and application gap in the field of management sciences. The research part of the thesis formulates a linear programming model for service activities, concerning the assignment of employees to projects, taking into account their specializations.

Findings: The article expresses the view that the optimal allocation of labor resources has a beneficial impact not only on employment costs but also on strengthening the flexibility of enterprises. Currently, companies must strive for a well-thought-out and rapid allocation of their resources in order to be able to effectively take advantage of market opportunities. The assignment problem can partially support these processes.

The article develops a linear programming model for the allocation of employees to projects, taking into account their specializations. As a result, a combination of allocations was found that generates the lowest employment costs, taking into account other constraints, i.e., employee working time and task duration, employee availability, and required completion dates.

Research limitations/implications: Developing optimization models requires understanding and formulating mathematical functions. For many decision-makers, this is a demotivating factor in exploring the implementation of processes with the support of available programming tools.

Practical implications: The model can be adapted to the conditions of the decision-making task. It can serve as a starting point for various forms of activity in which the individual characteristics of objects and their preferences for the tasks to be performed are known.

Originality/value: It should be emphasized that this article can be a valuable source of knowledge on optimal resource allocation. The proposed algorithm in its presented form can be used in many areas of management. It can also be modified depending on changing input parameters.

Keywords: assignment problem, resource allocation, personnel cost minimization, linear programming.

Category of the paper: Research paper.

1. Introduction

The dynamics of globalization processes, linked to the disappearance of market entry barriers and intensified by the development of advanced technologies, cause turbulence in the functioning of economic entities. The still relevant response to these processes is the flexibility of the enterprise, which allows for effective management in conditions of uncertainty (Eapen, 2010). Companies participating in intense market competition are looking for new ways to redefine the sources of competitive advantage. The proper allocation of labor resources within a company is an important element in achieving organizational flexibility, and when supported by the optimization of these resources aimed at minimizing employment costs, it constitutes an important link in building the company's competitive position.

The aim of this article is to apply theories concerning the optimization of employment levels using linear programming methods, in particular the issue of allocation. The article uses the allocation problem, which in the classical sense boils down to assigning a specific number of objects to tasks (projects) (Krawczyk, 2001). The criterion of optimality can be maximization or minimization of the objective function, depending on the measure of efficiency (time, number of elements, costs, profits, etc.). The article describes the use of the assignment problem in optimizing employment levels and thus reducing personnel costs.

Employment levels, understood as the number of employees, are an important component of total costs in both manufacturing and service companies. The simplest way to reduce them is to decrease the number of employees.

The simplest way to reduce these costs is to reduce the size of the workforce, which leads to a reduction in wages, overheads, and other related costs.

Current and future human resources are a key aspect of management decision-making and the ability to achieve the company's strategic goals. In this context, it is necessary to actively shape and optimally use them (Bień, 2013).

Contemporary organizations face the problem of adapting to constantly changing market conditions. It is necessary to build an organization that uses its resources to respond quickly to changing conditions. This is only possible if the organization has a high degree of flexibility. The ability of a company to adapt to external conditions or internal needs can make the organization more resilient to shocks caused by the dynamics of technological progress, the blurring of boundaries between companies and industries, the reduction of formal barriers to market entry, or the separation of financial flows from the production of material goods and services (Moroz, 2011, following Obłój, 2002). In the area of employment, flexibility usually takes the following form (Beardwell et al., 2004):

- quantitative flexibility – refers to adjusting the level of labor input to the requirements related to the scale of production or the scope of the project,
- task flexibility – involves investing in existing employment resources to develop the ability to perform specific tasks, e.g. through employee training,
- outsourcing – involves moving employment outside the company and contracting external labor resources to perform specific tasks or services,
- wage flexibility – the desired employment structure is achieved through an appropriate salary system.

Optimal use of the potential inherent in human resources means shaping them in a way that allows for the multiplication of the company's value. Rational planning of human resource requirements becomes essential in the process of estimating personnel costs and their derivatives, by avoiding the phenomenon of over-employment. One of the key factors in building a flexible organization capable of continuously responding to the changing needs of the environment and the market seems to be, among other things, efficiency in the process of planning human resources, including the size and structure of employment. In the literature on the subject, employment flexibility refers in particular to the rapid adjustment of the number and profile of employees, who constitute the resources of a given enterprise, to changing conditions and needs.

The article focuses primarily on demonstrating the possibilities of rational management of human resources in terms of assigning personnel to tasks, using linear programming tools. Building and solving linear models allows for the streamlining of the employee selection process based on a defined goal (which varies for different decision-making processes). The developed tool is always available and significantly reduces the time-consuming nature of planning processes. In addition, based on mathematical functions, it helps to avoid mistakes in developing the task assignment structure, which could result in an unnecessary increase in project employment costs. It also allows for quick consideration of changing external parameters, such as hourly rates.

2. Literature review

In the literature, the algorithm for the assignment problem was described in the 1950s in the works of H. Kuhn (1955) and J. Munkers (1957). Since then, the problem has gained popularity and has become the subject of consideration by many scientists. The Web of Science database (WoS) contains over 42,546 scientific articles on this topic, the vast majority of which (over 91%) were written after 2000. Over the last twenty years, an average of 2500 articles on this topic have been added to the database each year. Between 1955 and 2025, the issue of allocation was most frequently described in the categories of Operations Research Management

Science (16.81% of all articles), Engineering Electrical Electronic (16.33%), and Telecommunication (11.03%). The number of articles on the subject of allocation categorized in the 20 most numerous WoS fields is presented in Figure 1.

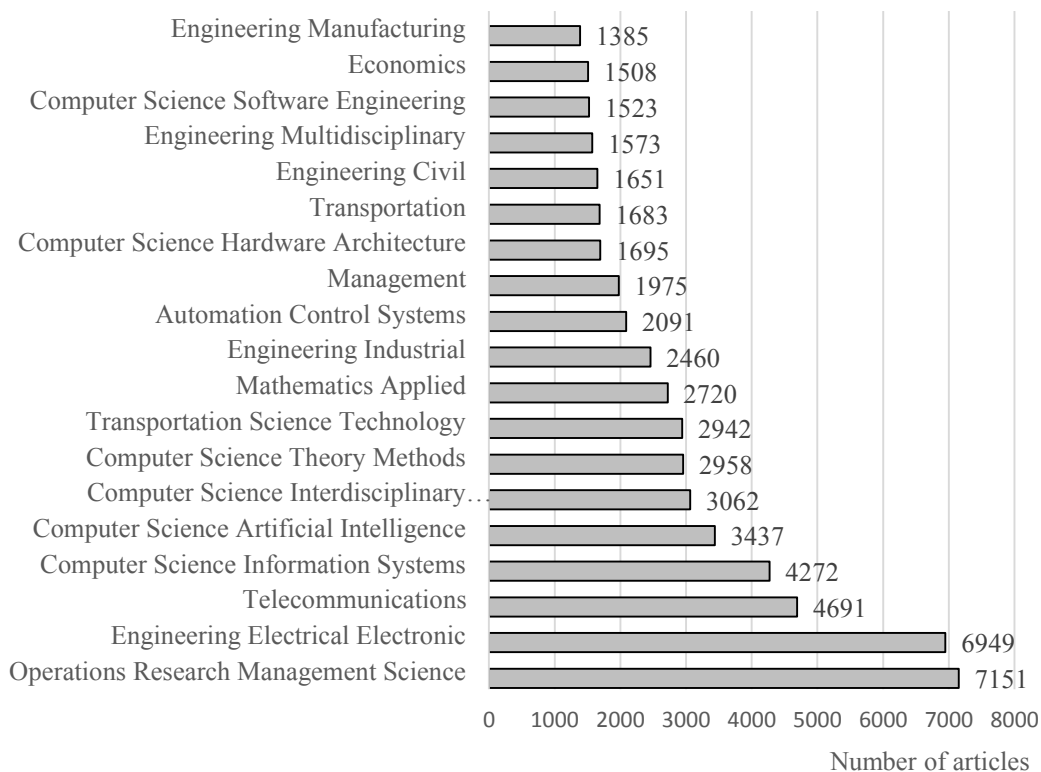


Figure 1. Number of articles published in the WoS database concerning the assignment problem by category (20 most popular).

Source: own study based on data from the WoS database.

Among the numerous applications of the assignment algorithm, there are also those in the fields of management and economics. It is considered as a support in logistics processes, decision-making, resource allocation, and personnel planning. It can apply to decisions made within any company. This is because it refers to improving the process of assigning objects to tasks.

In the literature on the subject, one can find publications referring to many different types of assignment algorithms, such as: the bottleneck AP (Ravindran, Ramaswami, 1977), the generalized AP (Cattrysse, Van Wassenhove, 1992), the quadratic AP (Lawler, 1963), the semi-AP (Kennington, Wang, 1992) and many others. There are also those that are a combination of two or more basic versions (Geetha, Nair, 1993).

Manually assigning employees to tasks without the support of an IT system is a time-consuming task and can generate additional costs related to, for example, delays in starting tasks. Sometimes, manual assignment of tasks to employees, due to its predictability, may give rise to the risk of negative phenomena, such as the risk of corruption (Klimek, Lebkowski, 2012). Assignment issues can be resolved using various methods, including:

The Hungarian algorithm, also known as the Kuhn-Munkres algorithm, is a method for solving assignment problems by finding a matching using several algorithm steps involving the modification of the cost matrix (cf. Kuhn, 1955; Munkers, 1957). The algorithm runs in polynomial time, making it an effective method for many practical applications, including resource management, transportation, production planning, and others;

- linear programming, by formulating the assignment problem as a linear programming problem and solving it using available tools, e.g., the Simplex method (cf. Pamuła, Król, 2013, p. 88; Jędrzejczyk et al., 1996). It is then referred to as a linear assignment problem (LAP).

For advanced decision-making problems, algorithms are used that constitute an individual set of mathematical tools created for the needs of a specific problem. Their complexity and form depend on the constraints and parameters that constitute the input data for a given decision-making problem. Depending on the problem adopted, a multitude of modifications of assignment problems can be observed in the literature (see, among others, Konarzewska, 2020; Duvignau et al., 2026; Cattrysse, Van Wassenhove, 1992; Loiola et al., 2007; Patel, Doshi, 2019). It should be acknowledged that the extensive range of solutions based on the allocation algorithm has several common limitations. These result from the main objection raised against generalized assignment algorithms (GAP), which is the NP-hard nature of the problem. This algorithm poses a fundamental challenge in optimization applied to logistics, resource allocation, and planning. Despite its practical importance, effective GAP solving faces significant limitations due to its inherent computational complexity and the lack of standardized evaluation tools. Furthermore, the time required to find an exact solution grows exponentially with the size of the problem. Exact methods become computationally infeasible for problems of high complexity. Furthermore, it must be acknowledged that many algorithms encounter problems when extended to a larger number of tasks and agents. Implementing an algorithm in two similar decision problems, differing only in the size of the decision variables, may prove impossible due to tool limitations. This may force decision-makers to use increasingly advanced optimization tools, thus generating additional costs for solving such problems.

Several groups of decision-making problems can be identified, the subject of which is the allocation of broadly understood resources. The article uses the problem of allocating labor resources (employees), which can be broadly formulated as follows: m employees must be assigned to complete n orders so that the total allocation costs are as low as possible. The matrix of employee labor costs $C = [c_{ij}]$ is known. In this case, the elements of matrix C represent the cost of the i -th employee in completing the j -th order. The solution (assignment) matrix $X = [x_{ij}]$ will consist of $m \times n$ elements specifying the assignment of a given employee to an order.

Decision variables take a binary form, so each element of the matrix $X = [x_{ij}]$ must belong to the set $\{0, 1\}$, i.e. $x_{ij} \in \{0, 1\}$, where $x_{ij} = 1$ when the i -th employee is assigned the j -th task and $x_{ij} = 0$ in other cases. Assuming that a given employee can only be assigned to one order

(task) and each task can only be performed by one employee, the mathematical notation of the model will look as follows (formulas 1-4) (Pentico, 2007):

$$\sum_{i=1}^m \sum_{j=1}^n x_{ij} c_{ij} \rightarrow \min \quad (1)$$

$$\sum_{i=1}^m x_{ij} = 1 \quad (2)$$

$$\sum_{j=1}^n x_{ij} = 1 \quad (3)$$

$$x_{ij} \in \{0,1\} \quad (4)$$

The specific form of the model depends on the nature of the parameters provided, resulting from the constraints that must be taken into account in the decision-making process.

3. Methods and results

3.1. Input data

Below is an example of how the work assignment algorithm is used in a company providing small-scale gardening services in the Wielkopolska region.

The decision-making problem consists in assigning 10 employees ($i = 1, \dots, 10$) to complete 14 orders ($j = 1, 2, 3, 4$) scheduled for 10 consecutive days. The company has a base of 10 employees at its disposal, whose services it uses by hiring them on a contract basis. Each of them has specific key competencies (specializations). Employees should be assigned to orders in such a way that the total cost of employment is as low as possible. Data on the hourly rate (in PLN/h), hourly workload limit (in h), and key competencies of employees are presented in Table 1.

The key competencies required for the specific profile of services provided by the company include: work related to the felling of trees and larger shrubs (chainsaw), work related to cleaning paving stones, facades, etc., requiring the use of a specialized pressure washer (pressure washer), work related to the installation of electrical systems (electricity) and work related to the installation of irrigation systems (irrigation). Other work included in the scope of services provided can be performed interchangeably by employees. In Table 1, the given qualifications are assigned a value of 1 (if the employee has the given skill) or 0 (if the employee does not have the skill).

Table 1.
Characteristics of workers

Worker	Rate (r _i) [PLN/h]	Max_load (T _i) [h]	Core competencies			
			Chainsaw (c _i)	Pressure washer (p _i)	Electricity (e _i)	Irrigation (i _i)
W1	49	80	1	1	0	0
W2	55	60	0	0	1	1
W3	50	55	1	0	1	0
W4	56	70	1	0	0	1
W5	49	20	0	1	0	0
W6	53	30	1	1	1	0
W7	56	50	0	0	1	1
W8	55	80	0	0	1	1
W9	51	40	1	1	0	0
W10	56	23	1	1	1	1

Source: own elaboration.

Table 2 shows the details of individual orders accepted for the next 10 days. They include the order number, place of execution, deadline for completion, and the number of hours needed to complete the order, estimated on the basis of the accepted scope of work. Some orders are delivered on the same day.

Table 2.
Orders details

Order	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14
Place	Poznań	Kórnik	Komorniki	Swarzędz	Mosina	Luboń	Luboń	Komorniki	Poznań	Mosina	Leszno	Mosina	Kostrzyn	Środa Wlkp.
Day	1	2	2	3	3	4	5	6	6	7	7	8	9	10
Time (t _j) [h]	8	12	5	10	10	8	9	10	12	11	10	8	7	9

Source: own elaboration.

A list of required qualifications was specified for each order (Table 3). The required qualifications were assigned a value of 1 (if required) or 0 (if not required).

Table 3.
Qualifications required for the order

Order	Chainsaw (c _j)	Pressure washer (p _j)	Electricity (e _j)	Irrigation (i _j)
O1	0	0	1	0
O2	1	0	0	1
O3	0	1	0	0
O4	0	1	1	0
O5	0	0	1	1
O6	1	0	1	0
O7	0	1	0	1
O8	1	1	1	0
O9	0	0	1	1
O10	0	0	1	1
O11	0	1	1	0
O12	1	1	1	1
O13	0	1	0	1
O14	0	0	1	1

Source: own elaboration.

In addition, the availability declared by each employee for specific order dates is known. Below are the orders in which the employee cannot be involved:

- employee W1 – unavailable for orders O1-O5,
- employee W2 – unavailable for orders O7, O12-O14,
- employee W4 – unavailable for orders O1, O2,
- employee W5 – unavailable for orders O4, O5,
- employee W6 – unavailable for orders O2, O3, O12,
- employee W7 – unavailable for orders O1,
- employee W8 – unavailable for order O6,
- employee W9 – unavailable for order O11,
- employee W10 – unavailable for order O1, O5.

In addition, it is known that each order must be carried out by at least two employees.

3.2. Solution of the model

The decision variables are presented in the form of a matrix $X = [x_{ij}]$ (Table 4). The variables take the form x_{ij} , where i denotes the employee number and j denotes the order number. In accordance with the assumptions of the assignment problem, they take a binary form, i.e., 1 if the i -th employee is involved in the j -th order and 0 if there is no such involvement.

Table 4.
Symbols of decision variables

	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14
W1	X ₁₁	X ₁₂	X ₁₃	X ₁₄	X ₁₅	X ₁₆	X ₁₇	X ₁₈	X ₁₉	X _{1,10}	X _{1,11}	X _{1,12}	X _{1,13}	X _{1,14}
W2	X ₂₁	X ₂₂	X ₂₃	X ₂₄	X ₂₅	X ₂₆	X ₂₇	X ₂₈	X ₂₉	X _{2,10}	X _{2,11}	X _{2,12}	X _{2,13}	X _{2,14}
W3	X ₃₁	X ₃₂	X ₃₃	X ₃₄	X ₃₅	X ₃₆	X ₃₇	X ₃₈	X ₃₉	X _{3,10}	X _{3,11}	X _{3,12}	X _{3,13}	X _{3,14}
W4	X ₄₁	X ₄₂	X ₄₃	X ₄₄	X ₄₅	X ₄₆	X ₄₇	X ₄₈	X ₄₉	X _{4,10}	X _{4,11}	X _{4,12}	X _{4,13}	X _{4,14}
W5	X ₅₁	X ₅₂	X ₅₃	X ₅₄	X ₅₅	X ₅₆	X ₅₇	X ₅₈	X ₅₉	X _{5,10}	X _{5,11}	X _{5,12}	X _{5,13}	X _{5,14}
W6	X ₆₁	X ₆₂	X ₆₃	X ₆₄	X ₆₅	X ₆₆	X ₆₇	X ₆₈	X ₆₉	X _{6,10}	X _{6,11}	X _{6,12}	X _{6,13}	X _{6,14}
W7	X ₇₁	X ₇₂	X ₇₃	X ₇₄	X ₇₅	X ₇₆	X ₇₇	X ₇₈	X ₇₉	X _{7,10}	X _{7,11}	X _{7,12}	X _{7,13}	X _{7,14}
W8	X ₈₁	X ₈₂	X ₈₃	X ₈₄	X ₈₅	X ₈₆	X ₈₇	X ₈₈	X ₈₉	X _{8,10}	X _{8,11}	X _{8,12}	X _{8,13}	X _{8,14}
W9	X ₉₁	X ₉₂	X ₉₃	X ₉₄	X ₉₅	X ₉₆	X ₉₇	X ₉₈	X ₉₉	X _{9,10}	X _{9,11}	X _{9,12}	X _{9,13}	X _{9,14}
W10	X _{10,1}	X _{10,2}	X _{10,3}	X _{10,4}	X _{10,5}	X _{10,6}	X _{10,7}	X _{10,8}	X _{10,9}	X _{10,10}	X _{10,11}	X _{10,12}	X _{10,13}	X _{10,14}

Source: own elaboration.

The objective of the decision problem presented will be to minimize the function representing the sum of the products of the hourly rate of employees (r_i), the duration of individual orders (t_j), and the matrix of decision variables X . Finally, it will take the form as formula 5:

$$\sum_{i=1}^m \sum_{j=1}^n r_i t_j x_{ij} \rightarrow \min \quad (5)$$

Based on the list of key competencies for a given task (c_j , p_j , e_j , i_j) and the list of key competencies for each employee (c_i , p_i , e_i , i_i), a summary of key competencies for each employee and task (c_{ij} , p_{ij} , e_{ij} , i_{ij}) was developed according to the following notation (see formulas 6-9):

$$c_{ij} = \begin{cases} 0, c_i \cdot c_j = 0 \\ 1, c_i \cdot c_j = 1 \end{cases} \quad (6)$$

$$p_{ij} = \begin{cases} 0, p_i \cdot p_j = 0 \\ 1, p_i \cdot p_j = 1 \end{cases} \quad (7)$$

$$e_{ij} = \begin{cases} 0, e_i \cdot e_j = 0 \\ 1, e_i \cdot e_j = 1 \end{cases} \quad (8)$$

$$i_{ij} = \begin{cases} 0, i_i \cdot i_j = 0 \\ 1, i_i \cdot i_j = 1 \end{cases} \quad (9)$$

The results are presented in Table 5, but due to the complex structure of the data, only the results for key competencies for the execution of a given order have been included, i.e. those that meet the following conditions: $c_j = 1$, $p_j = 1$, $e_j = 1$, $i_j = 1$. This means that if an employee has the required qualification for a given order, the assigned value is 1. They are therefore suitable for the work assignment for a given order and can be taken into account in the assignment. If an employee does not have the required qualification for a given order, then a value of 0 is entered in the appropriate place in the table. This means that the value assigned to the employee's key competence in Table 1 does not match the value assigned to the key competence for the order (Table 2).

The values shown in Table 5 were obtained using the "IF" formula in a spreadsheet. For each competency, an assessment was made of the degree of alignment between the employee's skills and the requirements of the job. If both answers were affirmative, the value 1 was entered, in other cases the value 0 was entered, e.g. $c_{16} = 1$, because the value c_i for $i = 1$ is 1 (Table 1) and the value c_j for $j = 6$ is 1 (Table 3); $p_{28} = 0$, because the value of c_i for $i = 2$ is 0 (Table 1), and the value of c_j for $j = 8$ is 1 (Table 3); $e_{2,12} = 1$, because the value of c_i for $i = 2$ is 1 (Table 1), and the value of c_j for $j = 12$ is 1 (Table 3), etc. The "IF" formula in the spreadsheet was used to calculate the values in Table 5. For the purposes of further calculations, the existence of matrix K is assumed, to which belong those elements c_{ij} , p_{ij} , e_{ij} and i_{ij} for which $c_j = 1$, $p_j = 1$, $e_j = 1$, $i_j = 1$.

Table 5.*The key competence for the order $(c_{ij}, p_{ij}, e_{ij}, i_{ij})$*

	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14															
	electricity (e _{i1})	chainsaw (c _{i2})	irrigation (i _{i2})	pressure washer(p _{i3})	pressure washer (p _{i4})	electricity (e _{i4})	electricity (e _{i5})	irrigation (i _{i2})	chainsaw (c _{i6})	electricity (e _{i6})	pressure washer(p _{i7})	irrigation (i _{i7})	chainsaw (c _{i8})	pressure washer (p _{i8})	electricity (e _{i8})	electricity (c _{i9})	irrigation (i _{i9})	electricity (e _{i,10})	irrigation (i _{i,10})	pressure washer (p _{i,11})	electricity (e _{i,11})	chainsaw (c _{i,12})	pressure washer (p _{i,12})	electricity (e _{i,12})	irrigation (i _{i,12})	pressure washer (p _{i,13})	irrigation (i _{i,13})	electricity (e _{i,14})	irrigation (i _{i,14})
W1	0	1	0	1	1	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0
W2	1	0	1	0	0	1	1	1	0	1	0	1	0	0	1	1	1	1	1	0	1	0	0	1	1	0	1	1	1
W3	1	1	0	0	0	1	1	0	1	1	0	0	1	0	1	1	0	1	0	0	1	1	0	1	0	0	0	1	0
W4	0	1	1	0	0	0	0	1	1	0	0	1	1	0	0	0	1	0	1	0	0	1	0	0	1	0	1	0	1
W5	0	0	0	1	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1	0	0	0
W6	1	1	0	1	1	1	1	0	1	1	1	0	1	1	1	1	0	1	0	1	1	1	1	1	1	0	1	0	1
W7	1	0	1	0	0	1	1	1	0	1	0	1	0	0	1	1	1	1	1	1	0	1	0	0	1	1	0	1	1
W8	1	0	1	0	0	1	1	1	0	1	0	1	0	0	1	1	1	1	1	0	1	0	0	1	1	0	1	1	1
W9	0	1	0	1	1	0	0	0	1	0	1	0	1	1	0	0	0	0	0	1	0	1	1	0	0	1	0	0	0
W10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Source: own elaboration.

We begin formulating the functions related to the constraints of the decision-making problem by assigning tasks according to the qualifications possessed and required by employees. The data contained in Table 5 (matrix K) was used for this purpose. It should be noted that the final solution will require at least one employee with the competence required for the order. For each key competence, at least one employee who possesses it must be assigned. This group of conditions will take the form shown in formulas 10-13.

$$\bigwedge_{j \in K} \sum_{i=1}^{14} c_{ij} x_{ij} \geq 1 \quad (10)$$

$$\bigwedge_{j \in K} \sum_{i=1}^{14} p_{ij} x_{ij} \geq 1 \quad (11)$$

$$\bigwedge_{j \in K} \sum_{i=1}^{14} e_{ij} x_{ij} \geq 1 \quad (12)$$

$$\bigwedge_{j \in K} \sum_{i=1}^{14} i_{ij} x_{ij} \geq 1 \quad (13)$$

It follows that for each key competence required for the order, listed in Table 5, the sum of the products of its individual columns and the corresponding column of decision variables (for the appropriate order number) will be at least 1. Let us take the first column of Table 5 as an example. The limiting condition here will take the form $\sum_{i=1}^{14} e_{i1} x_{i1} \geq 1$, more precisely

$$0x_{11} + 1x_{21} + 1x_{31} + 0x_{41} + 0x_{51} + 1x_{61} + 1x_{71} + 1x_{81} + 0x_{91} + 1x_{10,1} \geq 1$$

Using the appropriate spreadsheet formula, we proceed in the same way for the remaining columns of Table 5.

Taking into account other constraints resulting from the availability of employees on specific dates, regarding the maximum permissible workload of employees (formulas 14-17), the number of employees to be assigned (formula 18), overlapping order dates (formula 19), employee availability for orders (formula 20), and the binary nature of the variables in matrix X (formula 21), the rest of the problem will take the following mathematical form:

$$x_{i2} + x_{i3} \leq 1 \quad (14)$$

$$x_{i4} + x_{i5} \leq 1 \quad (15)$$

$$x_{i8} + x_{i9} \leq 1 \quad (16)$$

$$x_{i,10} + x_{i,11} \leq 1 \quad (17)$$

$$\sum_{i=1}^{14} x_{ij} \geq 2 \quad (18)$$

$$\sum_{j=1}^{10} x_{ij} t_j \leq T_i \quad (19)$$

$$x_{11} + x_{12} + x_{13} + x_{14} + x_{15} + x_{27} + x_{2,12} + x_{2,13} + x_{2,14} + x_{41} + \\ + x_{42} + x_{54} + x_{55} + x_{62} + x_{63} + x_{6,12} + x_{71} + x_{86} + x_{9,11} + x_{10,1} + x_{10,5} = 0 \quad (20)$$

$$x_{ij} \in \{0, 1\} \quad (21)$$

The formulated linear programming task was solved using the Solver module included in MS Excel, and the results are presented in Table 6.

Table 6.*Optimal allocation of employees to orders based on the criterion of minimum personnel costs*

	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14	Total cost
W1	0	0	0	0	0	1	1	0	1	0	1	1	1	1	3087
W2	0	0	0	1	0	1	0	1	0	0	1	0	0	0	2090
W3	1	0	1	0	1	0	1	0	1	0	0	0	0	1	2650
W4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W5	0	0	0	0	0	0	0	1	0	0	0	0	1	0	833
W6	1	0	0	0	1	0	0	0	0	0	0	0	0	0	954
W7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
W8	0	1	0	0	0	0	0	0	0	1	0	1	0	0	1705
W9	0	1	0	1	0	0	0	0	0	1	0	0	0	0	1683
W10	0	0	1	0	0	0	0	0	0	0	0	0	0	0	280
Total cost	824	1272	530	1060	1030	832	891	1040	1188	1166	1040	832	686	891	13282

Source: own elaboration.

According to the results obtained, the optimal plan for assigning employees to orders is as follows:

- employee W1 has been assigned to orders O6, O7, O9, O11, O12, O13, O14,
- employee W2 has been assigned to orders O4, O6, O8, O11,
- employee W3 has been assigned to orders O1, O2, O5, O7, O9, O14,
- employee W5 has been assigned to orders O8, O13,
- employee W6 has been assigned to orders O1, O5,
- employee W8 has been assigned to orders O2, O10, O12,
- employee W9 has been assigned to orders O2, O4, O10,
- employee W10 has been assigned to order O3.

All optimization constraints have been met, and the total labor costs amount to PLN 13,282 (Table 6). Table 6 also shows the salary costs for individual employees and for orders. The data in Table 6 shows that exactly two employees were involved in each order. In addition, two employees (W4 and W7) remain unassigned to orders. ($\sum_j^m x_{4j} = 0$; $\sum_{j=1}^m x_{7j} = 0$).

It is worth noting that the task allows for further modifications, e.g. in terms of the number of employees assigned to tasks, so that, for example, each employee is involved in at least one assignment. In the example discussed, this was not a necessary condition, as the employer selects contractors from a specific pool of employees, hiring them on a contract basis. It should also be remembered that additional limits will generate higher employment costs. The choice of approach and limits depends here on the individual preferences of the decision-maker.

4. Conclusions

To sum up the considerations presented in this article, it should be acknowledged that through the proper allocation of resources within a company, it is possible to achieve the lowest employment costs without having to search through a matrix of all possible assignment

combinations. In most companies, the process of assigning employees to tasks is done intuitively (manually), which does not guarantee the greatest possible financial benefits. With the support of appropriate IT tools, the process of obtaining the right assignment is significantly shortened. The linear programming model constructed and solved in the article can have a wide range of applications. Although the article describes its operation on the example of a service activity (gardening), it can be successfully applied in many other types of activities. All that is required is for the decision-making task to be formulated as a search for such an allocation of objects to tasks that generates the lowest cost and has the following constraints:

- maximum workload of objects (employees) and required for tasks (projects),
- specialization (competence) possessed by objects and required for tasks,
- task completion deadlines and object availability.

Additionally, it is worth emphasizing that the presented model is characterized by a high degree of flexibility and can be adapted to the conditions of the decision-making task. It can serve as a starting point for various forms of activity in which the individual characteristics of objects and their preferences for the tasks to be performed are known. Examples of applications of the presented model include problems of staffing customs posts with customs officers, taking into account the hierarchy of work (rank), the assignment of medical personnel to procedures in accordance with their qualifications, and the assignment of judges to adjudicate cases in accordance with their preferences or experience.

In line with the above, the article proposes the use of linear programming aimed at finding the lowest employment costs. The proposed algorithm focuses on the use of key employee competencies. The use of these unique abilities is an important link in the management of company resources, especially human resources. Identifying and purposefully placing employees with outstanding competencies in strategic areas (e.g., key development projects, innovation teams) allows for maximum efficiency. These employees are often the driving force behind innovation, contributing to shorter completion times for complex tasks and improving the quality of products or services offered. These competencies may include highly developed skills, knowledge, or attitudes that distinguish them from accepted market or internal company standards. These include, for example, in-depth technical knowledge, soft skills, or specific cognitive or adaptive abilities. Depending on the type of decision-making problem, the algorithm may apply to all of the above-mentioned skills. It can support the search for effective ways to use the company's resources, which can lead to competitive advantage and faster response to market opportunities. It can therefore be an important link in building organizational flexibility.

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OPPORTUNITIES AND THREATS RELATED TO QUALITY AUDITING IN ORGANIZATIONS – THE PERSPECTIVE OF ISO 9001:2026

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Purpose: The purpose of this study is to summarize the opportunities and threats related to auditing quality management systems in the context of the extended requirements of the new ISO 9001:2026 standard.

Design/methodology/approach: The study was based on the results of our own research on organizations with quality management systems compliant with the requirements of ISO 9001. The information concerns organizations operating in Poland. An analysis of subsequent editions of the ISO 9001 standard was also carried out in the context of changes in requirements, and a forecast of its further development was proposed.

Findings: The fifth update of the ISO 9001 standard, planned for 2026, will extend the requirements that should be taken into account during quality audits. This will force organizations to analyze their existing management systems and make the necessary additions. The study lists eight potential opportunities for obtaining information that the audit process can provide. The benefits of using these opportunities are shown. Eleven potential threats to the acquisition and use of information that may be generated by an improperly conducted audit process are identified. The consequences of each threat are highlighted. The relationships in the use of audit information are shown, and the responsibility of individual management groups for these activities is highlighted.

Practical implications: The results obtained have practical applications. The paper indicates the directions of change in the new ISO 9001:2026 standard. Information is provided on the potential opportunities and threats associated with auditing, which organizations can use to improve the audit process.

Social implications: The results obtained have social implications. They draw attention to the awareness and involvement of individual management groups in the context of obtaining and using audit information.

Originality/value: The study shows for the first time the directions of change in the ISO 9001:2026 standard that will affect auditing requirements. All potential opportunities and threats related to quality system auditing have been identified. The benefits that an organization can achieve by taking advantage of the opportunities offered by auditing are shown. Attention is drawn to the threats to auditing and their impact on the acquisition and use of information. The role of individual management groups in information management is shown. The study is particularly recommended for the top management of organizations that have quality management systems.

Keywords: quality audit, ISO 9001:2026, audit process, improvement.

Category of the paper: Viewpoint.

1. Introduction

Quality management systems have been in place in Poland since 1990 (Ligarski, 2002). They are based on the requirements of the ISO 9000 series of standards. The basic standard containing the requirements for the system, ISO 9001, has been updated four times so far, in 1994, 2000, 2008, and 2015. This standard contains requirements that must be met by organizations that intend to certify their quality management system. System certification requires two types of quality audits: internal audits, known as first-party audits, and certification audits, known as third-party audits. According to the definition in ISO 19011:2018, an audit is “a systematic, independent, and documented process for obtaining objective evidence and evaluating it objectively to determine the extent to which audit criteria are fulfilled” (PN-EN ISO 19011:2018). During an audit, the degree of compliance with a set of requirements applicable to a given organization is determined. The basic requirements are contained in ISO 9001, so any update to this standard directly affects the criteria relating to the audit. An audit should be a process focused on examining compliance, which has specific tasks to fulfill and precisely defined objectives to achieve (Ligarski, 2018a). A quality audit is intended to collect and process data in order to obtain the necessary information. It is intended to evaluate solutions and provide the information needed to make decisions. Many publications, both foreign and domestic, have been written on the subject of auditing. There is literature available on auditing and its role in organizations (Pivka, 2004; Russell, 2007; Sampaio et al., 2009; Hernandez, 2010; Francis, 2011; Claver, Tari, 2013; Okwiri, 2013; Abuazza et al., 2019; AL-Qatamin, Salleh, 2020; Lenning et al., 2022). Comprehensive studies on quality management and auditing systems have been published in Polish (Kreier, Łuczak, 1998-2002; Pacana, Stadnicka, 2006; Jedynak, 2007; Łuczak, Kuklińska, 2007; Matuszak-Flejszman, 2010; Wolniak, 2011; Ejdys, 2011; Lisiecka et al., 2017; Pacana, Stadnicka, 2017; Grzesiak, 2021).

Despite the existence of a relatively large number of publications on auditing and practical experience gathered over 35 years of auditing quality management systems in Poland, many organizations face various problems and limitations in the field of auditing. The author's research on a large sample indicates difficulties in properly understanding the audit process, its organization, supervision, and the use of information obtained from it (Ligarski, 2007, 2010, 2012, 2014, 2018b, 2024; Książek, Ligarski, 2020). This gives rise to various difficulties that arise in the auditing process and significantly affect the audit results obtained. Paradoxically, the passage of time exacerbates these adverse phenomena. Organizations conduct quality management system audits, but some of them obtain less and less useful information that they can use. The introduction of an updated version of the standard will force organizations to analyze their existing management system and make the necessary additions. Perhaps this is

a good time to reflect on the process of both internal and external audits. Identify the opportunities offered by auditing, analyze the risks associated with this process in order to better organize these processes within the organization and introduce the necessary changes so that the audit provides the information that is actually needed and can be used for development and improvement.

Based on over 25 years of experience in quality auditing and the results of his research, the author attempts to redefine the opportunities and threats presented by quality auditing and draws attention to the expanded requirements for quality management systems that will be included in the new, updated ISO 9001:2026 standard. The aim of the work is to summarize the opportunities and threats related to auditing quality management systems in the context of the extended requirements of the new ISO 9001:2026 standard.

2. Methods

The subject of the study are organizations with certified quality management systems compliant with the requirements of ISO 9001, operating in Poland. The study was based on literature research – an analysis of changes and modifications to the requirements of the ISO 9001 standard was carried out based on the base edition and four updates of the standard, and the author's expert knowledge in the field of auditing was used. The results of the author's previous research on a sample of selected organizations with quality management systems, which were published in scientific publications, were used to determine the changes in the auditing process. Detailed information on the methodology of qualitative research carried out using case studies is presented in scientific monographs (Ligarski, 2010; Książek, Ligarski, 2020). Detailed information on the methodology of quantitative research conducted using surveys is presented in scientific publications (Ligarski, 2007, 2010, 2014; Książek, Ligarski, 2020).

3. Results

3.1. Development of ISO 9001 and its new edition planned for 2026

ISO 9001 was first published as an international standard in 1987 by the International Organization for Standardization (ISO). This standard was based on the requirements of the British standard BS 5750, which was developed in the 1970s. In fact, the first standard for quality assurance systems consisted of three independent models – ISO 9001, ISO 9002, and ISO 9003 – adapted to different types of organizations and their activities (Table 1). The authors of the standards assumed that they would be modified and adapted to advances in

quality management. The first update took place in 1994. The three independent models remained, but a number of changes were introduced to improve the implementation of the systems and emphasize the prevention of non-compliance. The Polish versions of the standards issued by the Polish Committee for Standardization (PKN) initially appeared with a considerable delay. The next update of the standards took place in 2000. It was a groundbreaking and revolutionary update that introduced significant changes in the approach to quality management. A single universal ISO 9001 model based on a process approach was introduced, and greater emphasis was placed on continuous improvement and customer satisfaction. The next update in 2008 introduced minor changes and updates. The focus was mainly on clarifying the language and adapting the requirements to different types of organizations. The fourth update was carried out in 2015. A relatively large number of changes were introduced at that time – a risk-based approach was applied, attention was paid to the context of the organization, greater emphasis was placed on the responsibility of top management, and other changes were introduced. The structure of ISO 9001:2015 was adapted to the new High Level Structure (HLS), which facilitates integration with other management systems: environmental (ISO 14001), occupational health and safety (ISO 45001), and others.

Table 1.

List of international and Polish standards containing requirements for quality systems

No.	Type of standard	International standard	Polish standard
1	Base	ISO 9001:1987 Quality systems - Model for quality assurance in design / development, production, installation and servicing ISO 9002:1987 Quality systems – Model for quality assurance in production and installation ISO 9003:1987 Quality systems – Model for quality assurance in final inspection and test	PN-EN 29001:1993 Systemy jakości – Model zapewnienia jakości w projektowaniu / konstruowaniu, produkcji, instalowaniu i serwisie PN-EN 29002:1993 Systemy jakości – Model zapewnienia jakości w produkcji i instalowaniu PN-EN 29003:1993 Systemy jakości – Model zapewnienia jakości w kontroli i badaniach końcowych
2	First update	ISO 9001:1994 Quality systems – Model for quality assurance in design, development, production, installation and servicing ISO 9002:1994 Quality systems – Model for quality assurance in production, installation and servicing ISO 9003:1994 Quality systems – Model for quality assurance in final inspection and test	PN-ISO 9001:1996 Systemy jakości – Model zapewnienia jakości w projektowaniu, pracach rozwojowych, produkcji, instalowaniu i serwisie, PN-ISO 9002:1996 Systemy jakości – Model zapewnienia jakości w produkcji, instalowaniu i serwisie, PN-ISO 9003:1996 Systemy jakości – Model zapewnienia jakości w kontroli i badaniach końcowych
3	Second update	ISO 9001:2000 Quality management systems - Requirements	PN-EN ISO 9001:2001 Systemy zarządzania jakością Wymagania
4	Third update	ISO 9001:2008 Quality management systems - Requirements	PN-EN ISO 9001:2009 Systemy zarządzania jakością Wymagania
5	Fourth update	ISO 9001:2015 Quality management systems - Requirements	PN-EN ISO 9001:2015 Systemy zarządzania jakością Wymagania

Source: own work based on standards.

Work on the next update of the standard began in October 2023 during the annual meeting of the ISO/TC 176 committee in Rwanda¹. A preliminary schedule for the introduction of changes to the ISO 9001 standard was presented there. Initially, it was assumed that the updated version of the standard would be published in December 2025. However, new technological (digitalization, artificial intelligence, robotization, automation) and social (new role of employees, need for human involvement) challenges have created a need for further work to adapt to the changing realities in which organizations operate. Currently (September 2025), the draft ISO/DIS 9001:2025 is available and is in the consultation phase with ISO members. The updated ISO 9001:2026 standard is planned to be released in the second half of 2026. Based on the DIS draft of ISO 9001 and reports from the ISO/TC 176 Technical Committee, it is possible to predict with some degree of certainty the key directions of change that will be introduced into the standard being prepared. The proposed directions of change are the author's own forecast, prepared by the author of this study, and result from many years of observation of quality management systems and their adaptation to advances in organizational management. The first, which seems indisputable, is a separate approach to risks and opportunities. The new standard will clearly distinguish between risk and opportunity analysis. Organizations will have to assess both issues independently, which should lead to better planning. The identification and analysis of opportunities is intended to encourage organizations to actively exploit emerging opportunities and possibilities. The second direction of change is an emphasis on sustainable development, including environmental protection, social responsibility, and ethics, understood as integral elements of the quality management system. Organizations will have to analyze the impact of climate change within the context of the organization. The third direction is quality culture and knowledge management. Quality culture – values, ethics, understood as the foundation of the quality management system. Knowledge management interpreted as a tool for building stability and improving processes. The fourth direction, partly related to the third, is the new role of employees. New technologies (artificial intelligence, automation, robotization) will change the role of employees in the organization, increase the requirements for their competencies, but their commitment will still be needed. The fifth direction is supply chain resilience. Increased focus on analysis and management of disruptions. Creating dynamic strategies to respond to disruptions, which is intended to increase business resilience to crises. All of this will have an impact on greater supplier integration.

Looking at the possible directions of change in the new update of the ISO 9001:2026 standard, it should be noted that this will not be a revolutionary change, but there will be many significant changes - additions that should enable organizations to better adapt to current business and technology challenges and threats. Organizations will therefore be forced to rebuild their existing quality management systems and supplement them with the new requirements of the standard.

¹ The information presented in this paragraph is based on media reports and brief information posted on the Internet, where it is difficult to identify the sources of the reports.

3.2. Opportunities and threats posed by auditing quality management systems

The fifth update of the ISO 9001 standard, planned for 2026, will introduce new requirements that should be taken into account during first- and third-party audits. This is a good time to consider the opportunities and threats posed by quality management system audits, as well as who influences their course and is responsible for obtaining results. Quality auditing is a complex process that requires proper preparation and execution to achieve the expected results. A well-planned and executed process can provide an organization with valuable information that can be used in many areas of its operations. The opportunities created by the audit process can be applied both to internal audits, usually conducted by appropriately trained employees of the organization, and to third-party audits conducted by auditors from certification bodies. The potential opportunities offered by a well-executed audit process are summarized in Table 2.

Table 2.

Potential opportunities that a well-conducted audit process can offer

No.	Potential opportunities
1	Gathering information on the current state of the organization
a	Confirming compliance with requirements
b	Determining the effectiveness of the system
c	Identifying opportunities for development and improvement
d	Confirming risk and opportunity analyses
e	Identifying weaknesses
f	Detecting non-compliance, if any
g	Confirming compliance with the requirements of applicable legal regulations
2	Assessing the achievement of the organization's objectives at various levels
a	Assessment of the implementation of the mission, vision, and strategic objectives
b	Assessment of the implementation of the quality policy
c	Assessment of the implementation of quality objectives
d	Assessment of the implementation of objectives at the tactical and operational levels
3	Assessment of the functioning of processes in the organization
a	Assessment of links and interactions between processes
b	Assessment of the functioning of individual processes
4	Assessment of the awareness and commitment of the system manager
5	Assessment of the awareness and commitment of top management
6	Assessment of the awareness and commitment of middle management (process leaders)
7	Assessment of the awareness and commitment of selected employees
8	Promotion of a culture of quality

Source: own work.

A properly conducted quality audit process should provide a variety of information about the functioning of the organization. Auditors confirm the system's compliance with requirements. The organization thus obtains information on whether its system complies with the requirements of the standard. The effectiveness of the system is determined, whether the system functions properly and achieves its objectives. Areas for development and improvement of the system are identified. This is very important information that indicates in which areas the existing system can be developed or improved. The organization obtains confirmation that risks and opportunities have been properly analyzed. As a result of the audit,

weaknesses in the organization are identified where disruptions could potentially develop. Knowledge of such areas will enable preventive measures to be taken to prevent serious disruptions from occurring. As a result of the audit, existing non-conformities, i.e., areas where requirements have not been met, are identified. Effective corrective action should eliminate these problems. After the audit, the organization also receives information on whether the basic requirements resulting from legal regulations have been met. It can therefore be concluded that a properly conducted audit provides comprehensive information about the state of the organization. The organization obtains a variety of data which, after analysis, can be used for decision-making and action.

The second opportunity offered by a well-conducted audit process is the assessment of the achievement of objectives at various levels. When examining the system, auditors refer to the strategic objectives of the organization. They carefully assess the implementation of the quality policy and quality objectives. When confirming compliance, they assess the achievement of objectives at the tactical and operational levels. The organization thus obtains a comprehensive picture of the objectives being achieved, indicating which objectives are not being achieved or are only being partially achieved. This is very important information that is difficult to obtain from other sources.

A properly conducted audit assesses the functioning of processes in the organization from two perspectives. The first perspective is the assessment of the links and interactions between processes in the functioning system. The second perspective is the assessment of a specific process in the context of its functioning and effectiveness. The organization obtains unique information about the functioning of the entire set of processes and the operation of individual processes within that system. Such information can be used to improve the entire system and to improve individual processes.

A well-conducted audit process helps to assess the awareness and commitment of various groups and individuals. The awareness and commitment of the quality management system manager is crucial to the functioning of the system. The top management of the organization plays a very important role. By conducting audit investigations, the auditor is able to assess the awareness of these groups and their commitment to the functioning of the system. They also assess the awareness and commitment of middle management, including process leaders. They are also able to comment on the awareness and commitment of selected rank-and-file employees who have been audited. This provides very valuable information about awareness and commitment at different levels of the organization.

A well-prepared and committed auditor promotes a culture of quality. They should set an example of the desired behavior and thus encourage others to adopt similar attitudes. Their values, skills, and personal culture should serve as an example to everyone they meet.

All the potential opportunities that a well-conducted audit can offer have been listed here. However, for this to happen, it is necessary to properly plan, conduct, and supervise the audit process and skillfully use the information generated by the audit. Many groups and individuals

influence the audit process. Their awareness, skills, and commitment will determine whether the audit will be able to deliver all possible benefits.

If disruptions and negligence occur during the planning, implementation, and supervision of an audit, risks arise that can significantly affect the results of the audit. Equally dangerous are threats that arise at the stage of analyzing and using the information generated by the audit. Potential threats to the acquisition and use of information that may arise from an improperly planned and implemented audit process are listed in Table 3.

Table 3.

Potential threats to the acquisition and use of information that may arise from an improperly conducted audit process

No.	Potential threats
1	Insufficient information gathered on the current state of the organization
a	Insufficient confirmation of compliance with requirements
b	No or fragmentary determination of the effectiveness of the system
c	No or fragmentary indication of opportunities for development and improvement
d	No or fragmentary confirmation of risk and opportunity analyses
e	Failure to identify or fragmentary identification of weaknesses
f	Failure to detect or partial detection of non-compliance, if any
g	Lack of or partial confirmation of compliance with the requirements of applicable legal regulations
2	Lack of or partial assessment of the achievement of the organization's objectives at various levels
a	No or partial assessment of the implementation of the mission, vision, and strategic objectives
b	No or partial assessment of the implementation of the quality policy
c	No or partial assessment of the implementation of quality objectives
d	No or partial assessment of the achievement of objectives at the tactical and operational levels
3	No or partial assessment of the functioning of processes in the organization
a	No or partial assessment of the links and interactions between processes
b	No or partial assessment of the functioning of individual processes
4	No or partial assessment of the awareness and involvement of the system manager
5	No or partial assessment of the awareness and involvement of top management
6	No or partial assessment of the awareness and involvement of middle management (process leaders)
7	No or partial assessment of the awareness and involvement of selected employees
8	No or insufficient promotion of a culture of quality
9	No or insufficient ability to interpret (understand) information obtained from the audit
a	At the system management level
b	At the top management level
c	At the middle management level (process leaders)
10	Lack of or insufficient ability to use information obtained from the audit
a	At the system management level
b	At the top management level
c	At the middle management level (process leaders)
11	Lack of or insufficient assessment of changes introduced by post-audit actions
a	At the system management level
b	At the top management level
c	At the middle management level (process leaders)

Source: own work.

The main threat posed by an improperly planned and conducted audit process is that insufficient information about the current state of the organization will be obtained. Depending on the scale of the negligence and mistakes made, there may be a complete or partial lack of necessary information. Confirmation of compliance with requirements will be fragmentary and

will only apply to selected areas of the system. The effectiveness of the system will not be determined, or will only be done so in a fragmentary manner. The possibility of development and improvement will not be indicated, or will only be done so partially. The organization will not obtain confirmation of the risk and opportunity analyses carried out, or it will only be fragmentary. Weaknesses in the system will not be identified, or will only be done so in isolated cases. Not all non-conformities that exist in the system will be detected. There will be no confirmation of compliance with the requirements of binding legal regulations, or it will only be done partially. The lack or insufficient amount of information about the current state of the organization will result in a deficit of necessary data. Despite conducting an audit, the organization will not have a sufficient amount of data, which will subsequently prevent its proper analysis and use for decision-making and action.

The organization will not have an assessment of the achievement of objectives at various levels, or it will only be done partially. Therefore, it will not have comprehensive knowledge of how the objectives are being achieved. There will be gaps in the assessment of process performance. The organization will therefore not gain knowledge of how the entire process system works and how individual processes work.

The organization will not receive or will only receive fragmentary information about the awareness and commitment of individual groups and individuals. As a result, the awareness and commitment of the system manager, top management, and other employee groups will not be known. Auditors will not promote a culture of quality or will do so only at a minimal level.

The threats presented show the information deficit that can occur after an improperly conducted audit process. The second issue is the ability to interpret and use information from the audit and to assess the changes that have occurred as a result of post-audit activities. An organization can obtain a lot of information from an audit, but the question is how individual stakeholder groups will be able to interpret and use this information. In principle, there are three stakeholder groups. The first group is the system manager. In larger organizations, some of the system manager's responsibilities are transferred to the audit process manager. The second group is senior management, and the third group is middle management. In smaller organizations, one person manages the system and directs audits. In this case, that person is responsible for the whole process, i.e., planning and conducting audits and using the information obtained. In larger organizations, where tasks are divided, the audit process manager is responsible for planning, conducting, and supervising audits, while the system manager is responsible for the ongoing supervision of the system's operation and for the use of all available information. In this case, the audit process manager passes the information on to the system manager, who then makes decisions and coordinates activities at the level of the entire organization. Senior management is informed by the system manager about the results of the audit and makes key decisions regarding changes in the organization. Middle management, on the other hand, is responsible for implementing specific actions and introducing changes to processes. Each of the identified stakeholder groups should properly

understand the information obtained from the audit. Each group should be able to use this information skillfully and assess the changes it brings. This gives rise to three further risks. The first is the lack of or insufficient interpretation and understanding of the information obtained from the audit. The second is the lack of or insufficient ability to use the information. The third risk is the lack of or insufficient assessment of the changes brought about by post-audit activities.

By being aware of all the potential risks associated with the audit and the use of information obtained from it, it is possible to better understand the process and take measures aimed at eliminating or at least significantly reducing negative phenomena.

4. Discussion

The author presented the evolution of the ISO 9001 standard and the changing requirements for quality management systems. He presented a forecast of the most important changes that will be introduced by the ISO 9001:2026 standard. Based on this information, he redefined all the potential opportunities and threats that a quality management system audit can generate. The identified opportunities and threats can be related to both first-party and third-party audits. This approach is in line with the current search for a set of requirements that will enable effective auditing of quality systems (Chiromo, Msibi, 2023; Sepeng et al., 2025; Schroeder et al., 2025). It is particularly important to identify potential opportunities for first-party audits. Internal audits are usually conducted by appropriately trained employees of the organization. Therefore, the list of potential opportunities can be treated as a checklist of what information internal auditors should provide from the audit. A well-conducted internal audit should provide all the information listed here. Checking the information provided by a given audit answers the question of how many of these opportunities the auditors have realized. The organization gains the ability to evaluate the performance of its internal auditors. The number of shortcomings and unfulfilled opportunities will determine what actions should be taken in relation to auditors to improve their skills and increase their involvement during the audit. The need for such actions at the internal audit planning stage was emphasized in a publication on the automotive industry (Chiromo, Msibi, 2023). In the case of a third-party audit, the organization has no direct influence on improving the competence of auditors because they are auditors of the certification body. However, it can evaluate the work of these auditors based on a list of opportunities and request that the next audit be conducted by people who will be able to exploit all potential opportunities. The certification bodies themselves are trying to develop interpretations of the auditing requirements in the context of ISO 19011 and to create guidelines in this area (Sepeng et al., 2025; Schroeder et al., 2025).

The potential audit threats identified in the study refer not only to the possibility of obtaining information, but also to the possibility of processing and using it. Potential threats show what gaps and partial information can be obtained during an improperly conducted audit process. The second part of the threats draws attention to issues related to the interpretation, use, and evaluation of information obtained from the audit, both first and third party. The organization's management is responsible for the use of audit information. Three levels are indicated here: system manager, top management, and middle management - process leaders. The results of the audit go directly to the quality management system manager. They should interpret the information obtained appropriately and initiate and supervise the use of this information. They send key information to top management and appoint individuals and teams to carry out actions. Responsibility for the implementation of the assigned tasks usually lies with middle management – the leaders of the given processes. The system manager is directly responsible for supervising all post-audit activities and evaluating the changes they have brought about. In order for the information obtained from the audit to be used properly, appropriate preparation and skills are needed at each of the three levels indicated. When interpreting the risks related to understanding and using audit information, the organization should ask itself questions about the awareness and skills at the system management level, top management, and middle management. The results obtained are consistent with the results of other studies, which clearly articulate the need for greater involvement of the organization's management (Palmes, 2024; Sepeng et al., 2025).

5. Summary

The next update of the ISO 9001 standard, planned for 2026, will introduce new requirements for quality management systems and additions to existing requirements. This will necessitate the restructuring and supplementation of existing quality systems in organizations. It will also directly affect auditing requirements. In preparing for these changes, organizations should reconsider the opportunities and threats posed by auditing in order to better utilize this process for the needs of the organization.

The paper presents all the potential opportunities and threats associated with quality auditing. They are referred to first and third party audits. Attention is drawn to the opportunities for organizations to exploit potential opportunities. Individual threats and their consequences for the organization are analyzed. The focus is not only on obtaining information, but also on its processing and use. Groups of people responsible for proper information management are identified. The discussion referred to the results of research by other authors. The results of the research show, using the example of organizations with a quality management system operating in Poland, what changes will be needed in the auditing process in the context of the

update of the ISO 9001:2026 standard. What opportunities and threats does this process create for organizations? Such information may be useful for organizations that are preparing for changes in connection with the planned release of a new edition of the standard in 2026. They are also a voice in the international discussion on changes in the auditing process. In the long term, this debate inspires changes to auditing guidelines, which will also be reflected in the amendment to ISO 19011.

In conclusion, it is worth noting the limitations of the research. The research was conducted on selected organizations with quality management systems operating in Poland. At present (October 2025), the requirements in the new edition of ISO 9001 have not been specified, and the paper contains forecasts and predictions of the directions of change. In many countries, there is an ongoing discussion about changes in auditing, and further research is needed in this area.

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ECONOMICALLY AND PSYCHOLOGICALLY SAFE TEAMS – AN IDEA DERIVED FROM THE DIAGNOSIS OF DIFFERENCES IN THE PERCEPTION OF EMPLOYEE EXPERIENCE ANTECEDENTS

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Purpose: Employee experiences under the conditions of the experience economy are, due to effects they imply (such as greater employee engagement) a factor of competitiveness – and, at the same time, of providing security for teams and organizations, which can be shaped by influencing the antecedents of experiences. The purpose of this article is to diagnose the research gap in the exploration of the antecedents of employee experience.

Design: In addition to inference on the basis of critical analysis and evaluation of the literature on the subject, a questionnaire survey of the perceptions of the antecedents of experiences at work by individual members of a small, creative, effective team was used as a research method in order to find out which antecedents are affected by the largest perceptual spreads and at the same time – the lowest average assessment of them.

Findings: These antecedents were identified as sources of the team's safety reserves. It turned out that the reserves concern the antecedents – knowledge sharing.

Practical implications: Conscious influence – within the framework of employee experience management – on this antecedent will therefore improve the economic and psychological security of the team.

Social implications: Identifying the coherence between the antecedents of employee experience with team effectiveness criteria enabled the construction of the concept of conjunctively integrating economic and psychological safety.

Originality/value: The article indicates the necessity of personalizing the formation of employee experience antecedents, even within a small team.

Keywords: secure teams, antecedents of employee experience, creative team, employee experience management, personalization.

Category of the paper: Research paper.

1. Introduction

Employee Experience Management (EEM) constitutes – as evidenced by the literature (Reina, Daaz-Muaz, Rodriguez-Fernandez, 2024) – a relatively new and expanding research area encompassing topics that can be classified within economics (well-being) and management (organizational culture, engagement, human resource management, workplace health and safety). Management in this field is focused on shaping the antecedents of employee experiences to align their interests with those of the organization (Lipka, Waszczak, Winnicka-Wejs, 2014), which corresponds to – closely related to intrinsic motivation (the positive pole of the self-determination continuum) (Gagné, Deci, 2005, p. 336; Ryan, Deci, 2000, p. 61) – integration.

The theoretical objective of this article is to identify the list of antecedents of employee experiences that appear in existing Employee Experience Management (EEM) frameworks or models, and to compare this list with the specification of antecedents that have been empirically examined so far. Comparing both specifications should allow for verification of the hypothesis regarding the existence of a research gap, which has cognitive value. The theoretical-methodological and, at the same time, utilitarian objective is to align the antecedents of employee experience, as presented in EEM frameworks or models, with the team effectiveness criteria discussed in the literature on the subject. The purpose is to substantiate the hypothesis that most antecedents are congruent with the concept of psychological safety, and that each antecedent is reflected in the aforementioned team effectiveness criteria. Knowledge in this area holds practical importance, as it generates an imperative for practitioners to prioritise the development of those antecedents that may bring the greatest mutual benefits to both the organisation and its employees. Existing literature indicates that EEM influences both work performance and profitability (Silvestro, 2002) as well as employee loyalty (Veloso et al., 2021). The theoretical-utilitarian objective is also to demonstrate that within a small creative team, differing assessments exist regarding the importance attributed to individual antecedents. The hypothesis verified in the study assumes that even within such a team, there may be substantial differences in the perception of particular experience antecedents, which should be reflected in the personalisation of their development.

2. Methods

Verification of the first hypothesis (concerning the research gap) was based on a critical analysis and an evaluation of the literature on the subject, focused primarily on comparative assessment. The antecedents of employee experience can be determined based on

EEM models/approaches (IBM, Globforce Framework, 2016; Bersin et al., 2017; Morgan, 2017; Maylett, Wride, 2017; Yildiz et al., 2020; Nuernberg, 2023) or empirical research results in this area. In verifying the second hypothesis, the literature review was extended to include works addressing team effectiveness, with particular emphasis on the widely discussed findings of Google's Project Aristotle (Duhigg, 2016). Achieving the outcome in the form of assigning antecedents to effectiveness criteria required the application of content analysis – a qualitative method described in the literature on the subject (Neuendorf, 2002). Verification of the final hypothesis was conducted in two subsequent steps.

In the first stage of the research process, a team is selected for which the expected effectiveness (e.g., in the case of a newly formed team) or effectiveness reserves (existing even in highly effective teams) are to be determined. Reference should be made to:

- the content of tasks performed by the team and their variability,
- the period of the team's operation, together with the coexisting internal (organizational) and external (organizational environment) context of its operation,
- decision-making methods within the team,
- communication methods,
- team diversity characteristics (gender, age/generational affiliation, seniority (total, in the organization, in the team)).

In the second stage, members of the diagnosed team assess individual antecedents on a scale of 1 (lowest rating) to 7 (which allows for adequate but not excessive detail), and in the third stage, the diagnostician compiles the antecedents according to the average and range of ratings.

3. Results

When it comes to antecedents of experiences, an analysis of the above six EEM approaches/models allowed us to identify 30 different types (Table 1), while from the publication by Rohayati et al. (2025, p. 20), it appears that the empirically studied (Pangallo et al., 2022; Linde et al., 2008; Mrthot et al., 2018; Giesser, 2011; Yanqing et al., 2015; Hassard et al., 2016; Michailidis, Cnopley, 2018; Baranik et al., 2019; Lungu et al., 2019; Kirchner et al., 2021; Vanharanta et al., 2022; Rui et al., 2012; Ziebertz et al., 2015; Camps et al., 2016; Chanki, Moraus, 2022; Synove, Halkjelsvik, 2020; Chen et al., 2022; Niebuhr et al., 2022) and simultaneously occurring in EEM models/approaches include:

- employee relations (identified in the IBM model, as well as in the Bersina et al. and Morgan et al. models),
- job characteristics (also present in the IBM model, the Globforce Framework, as well as in the approaches of V. Nuernberg and Bersina et al. and in the Morgan model),

- organizational justice (referred to in the antecedents in the Maylett and Wride model, as well as in the Bersina et al. model, the Morgan model, and the Yildiz et al. model),
- leave (appearing in the form of work-life balance and/or choice options in the IBM model, Globforce Framework, Yildiz et al. model, as well as in the Bersina et al. model and the Morgan model).

A comparison of antecedents defined theoretically (in EEM models/approaches) and empirically tested antecedents shows that empirical gaps concern:

- a shared vision, mission, clear expected goals and a sense of purpose,
- a sense of belonging,
- a culture of recognition/appreciation/reward, bonuses,
- feedback,
- knowledge sharing,
- adequate EEM,
- positive and inclusive, humanistic working conditions,
- a sense of well-being,
- psychological contract,
- investment in development/careers, including through investments in coaching, experimentation, inspiration, training, allowing independent learning, facilitating mobility, organizational support,
- empowerment, participatory management, allowing employees to have a say,
- reflecting organizational values, and
- a transformational management style.

When it comes to antecedents of employee experiences and team effectiveness criteria, research initiated by J.R. Hackman in the 1970s and continued by him later (2002) shows that five conditions (Table 1) are more important for effective teamwork than individual personality traits, attitudes or behaviors. In turn, an analysis of 64 analytical teams in the US conducted by J.R. Hackmann and M. O'Connor in 2004 shows that “74% of deviations based on reliable performance criteria were controlled by these conditions”. The content of the 5-element set of conditions/performance criteria was also confirmed in Google’s Project Aristotle (Duhigg, 2016).

As the subject of further analysis was 30 antecedents of employee experience resulting from EEM approaches/models (see above), Table 1 contains an attempt to assign them to five conditions for effective teamwork.

Table 1.*Team effectiveness criteria and the antecedents of employee experience*

According to Google's Project Aristotle, the key criteria for team effectiveness are	Antecedents of employee experience resulting from EEM approaches/models
1. Psychological safety	– Fair treatment and trust within the organization. – Sense of belonging. – Team-based work environment. Small, empowered teams. – Relationships between coworkers. – (Perceived) employee support. – Knowledge sharing. – Openness to experimentation. – Psychological contract. – Care for well-being. – Humanistic workplaces. – Opportunities to invite other people.
2. Reliability	– Diversity, positivity, fairness, and inclusivity in the workplace. – Training options. – Appreciation and rewards.
3. Structure and transparency	– Regular, constructive feedback. – Employee input. – Empowerment. – Transparent and clear communication. Fair treatment of employees. – Involvement in decision-making processes. Participatory management. – Shared vision and commitment. Clear, transparent goals and a sense of purpose. Expectations. – Transformational leadership style. – Agile performance management. – Reflecting organizational values. – Flexibility. Ability to choose suitable options.
4. Meaningfulness of work	– Autonomy at work. Meaningful work; – Variability of the work environment.
5. Importance of work	– Continuous learning. Development. – Independent determination of learning dynamics. – Investment in employees. – Inspiration. – Opportunities for development and career advancement.

Source: own classification based on the above sources.

It should be emphasized that although the publications cited on team effectiveness criteria are significant, they do not exhaust the literature on the subject, which is very rich in this area. Much attention is devoted to team communication and feedback (see Table 1). For example, the negative impact of open workspaces on cooperation results is raised (Bernsten, Turban, 2018), as well as the positive impact of spatial proximity, but not in the form of such spaces. In turn, K.W. Rockmann and G.B. Northcraft (2006) prove the superior effectiveness of face-to-face communication, pointing to the need to balance it with email communication. However, according to S. Hofert (2021a), members of a highly effective team only spend half of their time working together, and only 35% of the variability in team performance can be explained

by the number of personal contacts between team members. M. London et al. (1999) identify (based on factor analysis) four dimensions of feedback:

- positive reinforcement,
- evaluative feedback,
- variety in work,
- focus on development,

emphasizing that feedback must be used by the team, i.e., it must “reach fertile ground”, i.e., be expected.

Attention is drawn to the fact that employees sometimes prefer feedback that allows them to adapt their behavior to the requirements of managers (Zengler, Folkman, 2014), citing its impact on work progress as an argument (Fishbach, Eyal, Finkelstein, 2010). At the same time, in the case of effective teams (Parker, Collins, 2010), the optimal feedback rate is between one (negative feedback) and five (positive feedback), while in the case of teams with poorer results, there are three negative feedbacks for every positive feedback (Zengler, Folkman, 2013).

According to L. Dahlander and D.A. McFarland (2013), teams that have been working together for a long time, have gone through “difficult times” (negative, shared experiences), and agile teams are more effective (So, Scholl, 2009; Hofert, 2021b). Cognitive errors in team decision-making also influence decisions (Loie et al., 2000) and thus the effectiveness of teams. A meta-analysis presented in the literature (Wallrich et al., 2024) shows that team performance is positively correlated with diversity, while hierarchy is associated with both positive and negative effects on team effectiveness (Pearce, Sims, 2002; Piecha et al., 2012; Greer et al., 2018). The composition of teams also has an important impact on effectiveness. For example, it is believed (Miron-Spector et al., 2012) that within effective research teams, 20% should be divergent thinkers, 20% convergent thinkers, 10% detail-oriented, and the remaining 50% mixed types.

The study covered a small (5-person) creative team (generating non-monothematic knowledge – economics, management, psychology), functioning (in its core, unchanged in terms of personnel) for 18 years, whose members have experienced both “good and bad times” together (the latter caused, among other things, by reorganizations, the need to compete for resources, insufficient support, and the need to function under COVID-19 conditions). Initially, these individuals worked in close physical proximity, but now they meet primarily remotely and also communicate frequently by phone and/or email. Despite the formal hierarchy, basic decisions (e.g., on the selection of research topics) are made jointly, which makes it possible to eliminate serious cognitive errors and make fuller use of the qualifications and personality of each team member, creating opportunities for their autotelic experiences (in the sense of Csikszentmihalyi, 1975) at work. Particularly intensive communication takes place between the manager and individual employees, with all employees receiving more positive than negative feedback. The team is diverse in terms of gender, age/generational affiliation, and length of service (overall, in the organization, and in the team). The team can be considered

to function effectively, as all its members fulfill (some with “significant excess”) their short- and long-term (those working longer – over a long period of time) tasks and all are positively (some very positively) evaluated by customers and people from other teams. Therefore, the aim of the diagnosis in this case was not to determine *ex ante* effectiveness, but the scale and type of its reserves. The study was conducted in December 2024. It shows that:

- the greatest discrepancy in the responses of team members concerns antecedents – sharing knowledge (difference: 4), followed by: adherence to the psychological contract, sense of belonging, and experiencing adequate variability in the work environment (difference: 3 in each case), while
- the smallest difference relates to antecedents: attention to work ergonomics, attention to updating knowledge/skills, and feeling appreciated.

The lowest-rated antecedents are: supporting employees' sports and recreational activities (average rating: 3.4), empowerment (3.8), investing in employees (4.0), and knowledge sharing (4.0). The last of these antecedents, due to its presence in the set of antecedents with the greatest divergence of responses, must also be considered key to increasing the operational security of the team under study.

4. Discussion

The theoretical analysis (concerning the first hypothesis) shows that there are still serious gaps in research on the antecedents of employee experience. The subject of further research may therefore include the impact of antecedents that have so far been insufficiently examined on work performance, profitability, or employee retention time within organisations.

As demonstrated (the second hypothesis), each antecedent of employee experience can be assigned to one of the five key criteria of team effectiveness identified in Google's Project Aristotle. Notably, the most important antecedent of employee experience, regardless of their place of residence, i.e., the meaningfulness of work, is defined in the same way as the criterion of effectiveness (which is not surprising given the relationship between meaningfulness of work and commitment to work) (Shahid, 2019).

As many as one third of antecedents (Table 1) are related to psychological safety. It has been shown that the experience of members of the effective team studied can be enriched primarily by knowledge sharing practices, which should further increase its effectiveness. The study was conducted on a single team, so the presented methodology should be verified on a larger number of teams, which will allow – for their individual characteristics (e.g., in terms of size or type of work tasks) – to determine standards and verify the universality of the methodology (the spectrum of teams that can be diagnosed, as well as the objectives of the diagnosis (confirmation of (in)effectiveness, its scale, efficiency reserves), and the types of

organizations in which these teams operate. Shaping – through antecedents – the experiences of employees simultaneously “activates” efficiency reserves, creating space for the economic and psychological growth of the teams in which they operate.

The study has thus confirmed the hypothesis that even within a team of this nature, there may exist profound differences in the perception of individual antecedents of experience. Consequently, there is potential for leveraging efficiency reserves – both economic and psychological.

5. Summary

The authors are aware of the weaknesses and limitations of the conducted study. Firstly, the analysis was limited to only one of the sets of effectiveness criteria presented in the literature on the subject; consequently, other possible sets of such criteria (see literature in Section 4) were not taken into account. Secondly, in verifying the hypothesis concerning the perception of individual antecedents, only members of a single team were examined. Thirdly, contextual factors – including cultural conditions – were not considered. Therefore, this study does not in any way justify generalisation of its conclusions. Nevertheless, it confirms the perceptual diversity regarding antecedents of employee experience, noticeable even in the case of a team with a long history of collaboration and, consequently, ongoing exchange of thoughts and expectations among its members. This finding emphasizes the necessity of personalising the development of employee experience antecedents. This constitutes an important conclusion of the study, alongside the recognition that such personalisation – in view of the differences between employees and due to the reflection of antecedents in team effectiveness criteria – simultaneously entails shaping teams that are both economically and psychologically safe. The conducted analysis thus enabled the formulation of this insight. Until now, economic and psychological safety in team functioning have rarely been addressed in a conjunctive manner; instead, they have typically been treated as separate constructs. The present study, however, demonstrated the inherent unity of these two dimensions of safety.

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INSTITUTIONAL CONDITIONS FOR THE ORGANISATIONAL ACTIVITIES OF CHAMBERS OF TOURISM IN POLAND

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Purpose: The article aims to identify the institutional conditions for the organisation of the activities of chambers of tourism in Poland.

Methodology: The author used a critical analysis and desk research method. The choice of this second approach was justified by the attempt to fill a research gap, including referencing secondary research sources. The fundamental desk research method was also applied. To identify the collective of chambers of tourism, resources from the National Court Register were utilised. Current normative-legal acts were also analysed in order to clarify issues related to the activities of the studied business associations and reports from economic practice.

Findings: The community of chambers of tourism is geographically diverse, with a profile of activities that reflects this diversity. These chambers operate as representatives at the local, regional, and national levels. Such entities have the predisposition to be leaders in the industry environment and key stakeholders in initiatives dedicated to the development of tourism at the national scale.

Research limitations: The presented considerations are preliminary, exposing only some aspects related to the activities of chambers of tourism. However, they will contribute to deepening the analysed issues within the framework of planned quantitative and qualitative research.

Practical implications: The results of the conducted research refer to the extensive discussion carried out in the literature on the subject and in economic practice dedicated to the role of business chambers.

Social implications: The current issues were presented, which may also interest representatives of the business practice. A group of Polish tourism chambers was identified, highlighting selected issues illustrating their activities.

Originality: The article concerns current scientific problems and economic practice.

Keywords: institutional conditions, business self-government, tourism, chambers of tourism.

Category of the paper: research paper.

1. Introduction

Contemporary institutions are an integral part of the economy. In a broader sense, they are defined as „socially shaped patterns, such as family, production associations, interconnected by a network of mutual dependencies” (Włudyka, 2018, p. 72). In the context of social sciences, institutions are also understood as formal laws and informal norms. These norms shape and restrict economic decisions (Sagan, 2021, p. 29). One of the market institutions is business self-government. The establishment of this type of self-government is associated with the implementation of fundamental tasks aimed at ensuring social and economic order (Lüke et al., 2021). Business self-government has the characteristics of a formal institution, which can respond to new economic challenges and serve as a partner in dialogue with public administration entities (Zdebski, 2023). Its influence on the economy is realised through organisations represented by entrepreneurs. According to Antkowiak and Kmiecik (2015, p. 292), „thanks to the business self-government, the community of entrepreneurs from individual, dispersed units becomes an organised public-law community, that is, a self-governing community equipped with administrative powers”. The presented view highlights the crucial role that organisations created by entrepreneurs play in participating in fundamental economic matters.

The organisational form of the business self-government is the chambers of commerce (Manczak, 2025). In economic practice, professional organisations, including those for entrepreneurs' self-government, employers' organisations, and craft self-government organisations, also operate (Cendrowicz, 2021, p. 22; Bandarzewski, 2023, p. 5). One of the criteria for establishing chambers is that of a sectoral nature. In this way, national organisations of tourism business self-government were also established. Tourism chambers are an example of organisations whose members are entrepreneurs engaged in tourism activities. It is worth noting that basic tourism services include accommodation, catering (gastronomic), transport services, and those related to forms and types of tourism (e.g., spa, conference, and congress services) (Panasiuk, 2019, p. 18). Thus, these chambers are an example of the representation of entrepreneurs providing broadly understood tourism services or one of the mentioned categories of services. The institutional conditions within their activities determine legal solutions, including practices rooted in the socio-economic landscape. In a broader context, the article's topic explores the role of chambers of commerce in a market economy, including proposed changes to enhance their position in dialogue with public administration and the tasks they undertake. The comments submitted also correspond to the issues faced by tourism chambers, which represent the interests of entrepreneurs and focus their activities on economic matters.

2. Purpose and procedure used

The article aims to identify the institutional conditions for the organisation of the activities of tourism chambers in Poland. The adopted subject scope includes issues from the areas of law, management, and entrepreneurship. A critical analysis (Fairclough, 2001) and the desk research method were used. The choice of the second approach was justified by an attempt to fill the research gap, including references to key sources of secondary research. The desk research method was primarily applied (Bednarowska, 2015). For the research carried out, the authors formulated the following research questions:

- What are the institutional conditions of domestic tourism business organisations?
- Which national chambers function as representatives of entrepreneurs providing tourism services?

The answers to the questions posed above were developed based on the results of the conducted discussion, referencing theoretical issues as well as reports from economic practice. An examination of tourism chambers reveals interesting theoretical and practical aspects. The article aims to identify active tourism chambers and unite tourism entrepreneurs. For these organisations, the current register is the National Court Register (NCR). To this end, an exploration of the content of this public register was conducted. First, chambers listed in the NCR were separated, and subsequently, a regional criterion, i.e., province, was applied. The list was analysed according to the location of the chambers' registration in all provinces. Ultimately, only those organisations were selected whose name directly indicates a tourism profile as the key area of their activities or activities closely related to tourism. The article adopted the list of chambers as of July 3, 2025.

3. Chambers of tourism – legal framework and implemented tasks

The business self-government „has the character of non-territorial, public-law compulsory associations, appearing as economic unions. Their competencies pertain to a strictly defined sphere of economic activity, a certain category of individuals who, in an organised and authoritative manner, perform, alongside the bodies of local government, a decentralised part of state administration” (Ruch Społeczny PSG, 2021). The cited perspective outlines not only the essence of the analysed category but also signals issues that connect theoretical considerations with those of a practical nature. The primary criterion for distinguishing business self-government is subjective. Its members are only (exclusively) entities conducting business activities (entrepreneurs) (Bandarzewski, 2014, p. 13).

The Act on Business Chambers [AonBC] outlines the principles of associating economic entities, both natural and legal persons, within this type of representation. Article 1 of this act recognises that entrepreneurs may associate in business chambers. Meanwhile, Article 3 of the Entrepreneurs' Law states that economic activity is organised earning activity conducted in one's name and in a continuous manner. This legal provision allows for the specification of the subjective criterion applicable to the distinction of business self-government organisations. A business chamber is an example of a business self-government organisation that represents the economic interests of its members, especially with public authorities (Article 2 of the AonBC). These organisations are not only representatives of entrepreneurs' interests but also representatives of a given community. Chambers are perceived as organisations of business self-government, uniting entrepreneurs and established to defend the interests of their members (Bandarzewski, 2021). They most commonly operate as voluntary organisations gathering entrepreneurs at the industry, national, regional, local, and bilateral levels (as Polish-foreign chambers) (Dąbrowski et al., 2023). Membership in a chamber is based on an optional membership. In Poland, its operational model is similar to solutions applicable in the United Kingdom (Cendrowicz, 2021, p. 26). This model is referred to as the Anglo-Saxon model.

A chamber may be established if at least 50 entrepreneurs, hereinafter referred to as "founders", undertake such an initiative in the area of operation of the chamber being created, covering the area of the voivodeship. Conversely, if the territorial scope of the chamber's operations exceeds that of the voivodeship, in this case, the number of founders should be at least 100 (Article 7 of the AonBC). The minimum number of founders of a chamber is a key condition that must be met in order to establish it. The business chamber independently defines its tasks in its statutes. The method of its preparation is determined by its founders (Bandarzewski, 2014, p. 125). The highest authority of the Chamber of Tourism is the General Assembly of its members. Consequently, this assembly makes key decisions regarding the functioning and development of this organisation, as well as elects and supervises its authorities. A chamber of tourism must also be registered in the NCR. This results from Article 49 of the Act on the National Court Register [AonNCR], which allows for registration in the register of associations. Importantly, in 2023, the Supreme Court stated that economic chambers are social organisations. This legal qualification confirms their registration in the NCR in the register of associations, other social and professional organisations, foundations, and independent public healthcare facilities (Supreme Court, 2023). As a result, business chambers and their organisational units are subject to the obligation to be registered in the NCR, and they acquire legal personality upon registration (Article 8 of AonBC). Based on this, the activities of chambers of tourism are consistent with those conducted by social organisations, which may have implications for management-related actions. In a situation where the chamber plans to conduct business activities, it is required to apply for entry in the business register (Article 50 of the AonNCR). This register is referred to as the Central Registration and Information on Business Activity.

According to the applicable regulations, the chamber of commerce may (Article 5 of the AonBC):

- contribute to creating conditions for the development of economic life and support economic initiatives of members,
- support, in collaboration with relevant educational authorities, the development of vocational education, support apprenticeship in workplaces, and professional development of employees,
- delegate its representatives, at the invitation of state authorities, to participate in the work of advisory and opinion-making institutions regarding manufacturing, trade, construction, and service activities,
- organise and create conditions for resolving disputes through amicable and conciliatory proceedings and participate under separately defined rules in judicial proceedings related to the economic activities of its members,
- issue opinions on existing customs related to economic activities,
- inform about the functioning of entrepreneurs and express opinions on the state of economic development in the area of the chamber's operation.

The tasks presented above, mandated by law, are also carried out by chambers of tourism through initiatives such as (Dębski, 2013):

- diagnosing the needs and factors that affect the activities of entities in the tourism industry,
- supporting initiatives dedicated to resolving conflict situations through the use of alternative dispute resolution methods,
- integrating community members around important issues related to conducting business activities,
- providing training for its members,
- organising cultural events to strengthen social relations,
- playing a leadership role in the industry to voice economic issues affecting the activities of tourism entrepreneurs.

Chambers of commerce can and should also take action to assess the implementation and functioning of legal regulations concerning business operations (Migdał, 2023a, p. 196). However, the literature notes that the tasks assigned to these organisations are mainly advisory, consultative, and without authoritative power. Furthermore, their initiatives for regional and local development are mostly limited to holding meetings, conferences, signing cooperation agreements, and creating additional organisations that identify socio-economic needs, but do not have an impact on decisions made (Walkowiak, 2014, p. 101). The current situation can be linked to the voluntary membership in such associations. Consequently, it means a significantly reduced influence on the execution of public tasks by chambers of commerce (Bandarzewski, 2014, p. 287).

A key issue for any organisation is having adequate financial resources that correspond to the scope of its planned undertakings. The members of the chambers establish in the statute the method of determining the amount of contributions and their payment, as well as obtaining other financial resources to cover the costs of their operations (Jurewicz, 2013, p. 36). Voluntary membership in the discussed organisations, combined with entrepreneurs' moderate interest in membership, translates into their bargaining power. The noted point concerns the position of national chambers of commerce in a broader context.

4. Chambers of tourism – an attempt at identification

The article aims to define the community of national tourism chambers, specifying their profile, the scope of their activities, and their affiliation with selected business bodies. It can be assumed that this set was closed during the research. Considering the adopted research assumptions, it was decided to search the resources of the NRC. In this register, there are 632 entities registered as chambers (Ministry of Justice, 2025). Among the distinguished organisations, 20 tourism chambers had active status in the NRC (Table 1). It should be noted that the analysed chambers represent 3.3% of the total collection of chambers registered in the associations register. Most tourist chambers are registered in the Mazowieckie and Małopolskie Voivodeships. However, the registration location does not determine the actions taken or the representation of the interests of entrepreneurs conducting business in a given voivodeship. In the case of entities from the Mazowieckie Voivodeship, it can be considered that, in the vast majority, they have a nationwide profile and operate for the benefit of the tourism industry. The status of the discussed organisations in the Business Register was also examined. Half of them appear in this public register. Chambers of tourism can conduct business activities on general principles (Article 14 of AonBC). Importantly, the income generated from this business activity can only be used to achieve statutory goals.

The subject scope of the analysed chambers is focused on tourism activities, which are broadly understood. In the studied population, there is one bilateral chamber (Polish-Ukrainian Tourist Chamber). Selected chambers focus on hoteliers (Małopolska Chamber of Hotel Industry, Polish Hotel Industry Chamber), restaurateurs (Chamber of Polish Gastronomy, Wielkopolska Chamber of Gastronomy), or combine the interests of these mentioned groups of entrepreneurs (Polish Chamber of Restaurant Keepers and Hoteliers). Several organisations operate at the regional level (Dolnośląska Chamber of Tourism, Pomorska Chamber of Tourism and Hotel Industry, Śląska Chamber of Tourism, Wielkopolska Chamber of Tourism, Środkowopomorska Chamber of Tourism) or the local level (Nowy Sacz Chamber of Tourism, Kraków Chamber of Tourism, Warszawska Chamber of Tourism).

Table 1.*National chambers of tourism*

No.	Chamber	Year of establishment*	Voivodeship	Entry in the Register of Entrepreneurs**
1.	Nowy Sącz Chamber of Tourism	2000	Małopolskie	-
2.	Krakow Chamber of Tourism	1992	Małopolskie	+
3.	Małopolska Chamber of Hotel Industry Gremium	2004	Małopolskie	-
4.	Dolnośląska Chamber of Tourism	1992	Dolnośląskie	-
5.	Chamber of Tourism of the Republic of Poland	2009	Dolnośląskie	-
6.	Chamber of Polish Gastronomy	2020	Mazowieckie	+
7.	Polish Hotel Industry Chamber	2003	Mazowieckie	+
8.	Polish Chamber of Tourism	1990	Mazowieckie	+
9.	Warszawska Chamber of Tourism	1994	Mazowieckie	+
10.	Polish Chamber of Youth Tourism	2002	Mazowieckie	-
11.	Chamber of Polish Health Resorts	1991	Podkarpackie	+
12.	Polish Chamber of Agritourism	2004	Podkarpackie	+
13.	Polish Chamber of Restaurant Keeper and Hotelier	2007	Pomorskie	-
14.	Pomorska Chamber of Tourism and Hotel Industry	2021	Pomorskie	+
15.	Śląska Chamber of Tourism	2005	Śląskie	+
16.	Chamber of Tourism „Circle of Health Tourism”	2014	Świętokrzyskie	+
17.	Wielkopolska Chamber of Tourism	2004	Wielkopolskie	-
18.	Wielkopolska Chamber of Gastronomy	2002	Wielkopolskie	-
19.	Środkowopomorska Chamber of Tourism	2001	Zachodniopomorskie	-
20.	Polish-Ukrainian Tourism Chamber	2013	Podlaskie	-

* The date that appears on the website of the respective chamber has been accepted.

** The author decided to omit the entry date in this register. Only the fact of having an entry in this list by the selected chamber was recorded.

Source: own research.

Featured associations of entrepreneurs operate within spatial frameworks in which tourism is regarded as one of the essential factors of regional development and contributes to job creation. Importantly, there are also two chambers whose aim is to represent entities operating in the area of health resort tourism (Chamber of Polish Health Resorts, Chamber of Tourism „Circle of Health Tourism”). The Chamber „Circle Health Tourism” was established as an industry cluster, functioning within a grassroots regional initiative dedicated to creating innovations in health tourism services (Knefel, Molenda-Grysa, 2018).

In the studied population, the Polish Chamber of Tourism (PCT), which has been operating since 1990, deserves special attention (Napierała et al., 2017). PCT has regional branches (Kujawsko-Pomorskie, Łódzkie, Małopolskie, Mazowieckie, Podlaskie, Pomorskie, Śląskie, Warmińsko-Mazurskie, Wielkopolskie). The members of the chamber are representatives from diverse tourism-related backgrounds, including those offering a variety of tourism services. It was determined that this group includes travel agencies, accommodation facilities, academic institutions, event companies, tourism organizations, amusement parks, research institutions, insurance companies, ski resorts, branches of the national airline, companies offering reservation systems, entities in the trade market, entities involved in organizing the tourism

information system, industry organizations, passenger transport operators, and cultural heritage sites (PCT, 2025).

At the national level, the Polish Chamber of Commerce (PCC) is distinguished, as mentioned in the act on chambers. Chambers can voluntarily affiliate with the PCC. Business and social organisations that aim to support economic development can also join this chamber (Article 11 of the AonBC). Its membership includes 160 regional, sectoral, and bilateral chambers, as well as other economic entities (PCC, 2025). It has been established that there are only two tourism chambers among its members (Polish Chamber of Tourism, Polish-Ukrainian Tourism Chamber). The community of tourist entrepreneurs is represented to a small extent in the forum of the leading national business self-government organisation.

5. Discussion of the results obtained

Based on the obtained results, the author decided to formulate answers to previously accepted research questions. The first of these concerned the institutional conditions of the tourism self-government organisation. To this end, reference was made to the binding normative and legal acts concerning economic chambers. The statutory provisions regulate the fundamental issues related to the establishment and operation of the analysed organisations of entrepreneurs in the tourism industry. It is worth noting the role of tourism chambers in representing the environment. The representativeness of economic organisations is defined multidimensionally and appropriately to the context and identified needs. The following entities can be considered representative (Brzeziński et al., 2023, p. 95):

- associations whose membership base reflects the structure of enterprises (on an industry, regional, or national scale), enabling, among other things, the conduct of statistical research,
- business associations that have the power to ensure effective communication channels with as wide a group of enterprises as possible and current market knowledge (for consultative processes, but also investment, trade, etc.),
- organisations capable of implementing specific solutions developed with the public sector in the economic space,
- entities explicitly defined in the statute or designated by an authorized public entity.

The indicated features of organisational representativeness distinguish entities that can be identified based on their members by adopting selected spatial scopes. Another feature involves creating effective communication channels to understand entrepreneurs' opinions on current market issues (Globočnik Žunac et al., 2021). One feature can also be linked to the agency of chambers in implementing solutions in business practice, including those related to developed

economic projects (Czop, 2016). The last feature concerns solutions that arise from the applicable legal order and exemplify an institutional approach. By comparing the characteristics that determine the representativeness of tourism chambers, it can be concluded that the examined chambers are diverse in terms of geography. This collective includes organisations that operate at the national, regional, and local levels. Some chambers focus on issues related to the hotel industry, gastronomy, health tourism, youth tourism, or agritourism. In the vast majority of cases, the names of the chambers indicate their broad interest in tourism activities. Considering the number of chambers from the perspective of geographical criteria (national, regional, local) or thematic criteria (hotel industry, gastronomy), their degree of representativeness is moderate, also referencing the Anglo-Saxon model. For instance, in the continental model (France, Germany, Austria), membership for entrepreneurs in the chamber is mandatory. It leads to the following implications (Bandarzewski, 2014, p. 283):

- guaranteeing representation of all sectors of the economy, including entrepreneurs,
- presenting a unified position of entrepreneurs,
- contribution by all members,
- ensuring stable funding for the operations of the chamber.

The characteristics of the continental model explain the position of chambers, their representativeness, and the scope of their activities. In Poland, granting such powers to chambers would require initiating legislative changes that focus on the role of business organisations in the economy and developing sector-specific solutions (Dąbrowski et al., 2023). Consequently, this would require designing a truly representative institution, with strong competencies and its tasks, which would redefine the way dialogue between administration and the market occurs (Guziejewska, Michalak, 2021). Strengthening the position of business chambers aligns with solutions that promote the creation of an institutional space for cooperation relations with various stakeholder groups.

Chambers of tourism have the predisposition to play the role of a leader in the tourism industry and to be an expert in activities dedicated to the development of socio-economic projects. The role refers to the discussion on the issues of organisational leadership (Ntakalos et al., 2023). It is worth recalling that leadership is the obligation to indicate areas for analysis and evaluation, to protect the organisation from waste of resources, and to ensure real results (Drucker, 1999). In the case of chambers, it is important to specify the issues that will contribute to building their position and bargaining power in efforts on behalf of their members and other significant areas of the economy. Their tasks encompass initiatives such as integrating different industries and fostering partnership among entrepreneurs, lobbying industry interests to public entities implementing tourism policy, undertaking pro-quality actions including entity certification within the industry, and promoting innovation (Panasiuk, 2016, p. 10).

The second research question concerned national tourist chambers. Among national tourist chambers, PCT holds a prominent position. However, there is also the Chamber of Tourism of the Republic of Poland operating on a national scale, which focuses on representing the interests of the tourism industry. Members of this chamber include regional chambers (Dolnośląska Chamber of Tourism, Śląska Chamber of Tourism) as well as local ones (Nowy Sącz Chamber of Tourism, Warszawska Chamber of Tourism). Most chambers are registered in the Mazowieckie and Małopolskie Voivodeships. The general trend indicates that such organisations operate at a national level. Identifying chambers of tourism is a significant issue in the debate regarding entrepreneurs' interest in membership in economic associations. However, expanding on the presented view, one could argue that their activities should focus on aspects related to the development of tourism at every level (local, regional, national). Chambers of tourism should be considered leaders and leading advocates of the tourism industry. Their activities are dispersed throughout the country. However, it is not the number of organisations that determines their position in the general population of economic chambers, but the development of competencies that foster active involvement in public debates and the activation of their members' communities. Another aspect is the conditions for joining or resigning from a particular association of entrepreneurs. In the case of organisations operating in tourism, the indicated actions are relatively straightforward. The presented view pertains to service activities, including organisations that associate with entities providing various services.

In Poland, there are several entities and organisations focused on tourism issues, including entrepreneurs (Migdał, 2023b). Therefore, it is not an easy task to acquire at least 50 entrepreneurs interested in establishing a tourism chamber at the regional level (for a given voivodeship). Among the leading entities working for tourism, significant roles are played by organisations such as the Polish Tourism Organisation (PTO), as well as regional and local tourist organisations. The Act on the Polish Tourist Organisation regulates the status of the mentioned organisations. Their activities align with basic concepts regarding „the creation of an efficiently functioning support system for the development of the tourism sector, similar to those operating in European Union countries, particularly through the activation of promotion, support for tourist information, support for development and modernisation plans of tourism infrastructure, and cooperation” (Migdał, 2023b, p. 206). Moreover, they are examples of destination management organisations within the national system for tourism development. These entities have a different legal status from chambers of tourism. The representation at the regional and local levels primarily includes enterprises from the tourism industry. However, they are not the only members of these representations, as is the case with chambers. Importantly, the legal-organisational form of regional and local tourist organisations is associations, and they have the attributes of public organisations (Fedyk, Morawski, 2014, p. 242). The PTO, as a type of destination management organisation, operates to strengthen the promotion of Poland in the field of tourism both domestically and abroad (Manczak, 2024). Meanwhile, regional and local tourist organisations are key partners

in cooperative actions initiated by the national tourism organisation. The indicated entities function as organisations for cooperation between local government (especially at the voivodeship level) and the tourism industry (broadly understood due to the heterogeneous nature of the tourism economy) in promoting the area where this organisation operates, as a tourist-attractive region both domestically and abroad (PTO, 2025). Regional and local organisations include not only entrepreneurs but also all entities interested in tourism issues. There must also be representation from local government among their members. On a national scale, there are 16 regional tourism organisations and 124 local tourism organisations operating as of March 31, 2025. These organisations do not carry out tasks solely for the benefit of their members, but conduct activities on a broader scale and for the entire environment. Their main task remains to support the development of the tourism sector in the area of their activity by creating a sense of community and strengthening local identity (Migdał, 2023b, p. 216).

In light of the remarks mentioned above, the heterogeneous nature of the tourism economy creates opportunities for developing various forms of representation for entities, which can be industry-specific or unite certain entities. The existing state of affairs influences the position or recognition of tourism chambers in the business environment. One can risk stating that strengthening the position of each chamber, including its perception as a key representative of the tourism industry, is linked to the ability to configure a set of relationships that allow for better coping in the market or with other entities focused on entrepreneurs (Stańczyk-Hugiet, 2012).

Considering the achievements of management theory, the institutional conditions of tourism chambers also involve aspects related to identifying their organisational effectiveness. For this purpose, Key Performance Indicators (KPIs) are used, which represent an example of a management tool and are implemented to increase management efficiency at both the operational and strategic levels (Ostapko, 2018; Czerwińska, Pacana, 2020). The use of KPIs enables not only a quick response in some fields of the organisation's activity but also contributes to long-term planning within future undertakings (Pacana et al., 2022). This approach highlights significant issues from the perspective of further research devoted to tourist chambers. This area will contribute to a deeper understanding of the analysed problem and its specification.

6. Conclusions

In summary, the legal framework for the activities of tourism chambers has been regulated in an institutional context. The Act on Chambers of Commerce outlines selected aspects that also define significant organisational issues and determine the activities of entrepreneurs' associations. An attempt was made to identify tourism organisations, highlighting their key

characteristics. The collective of national tourism chambers comprises organisations listed in the NCR. This collective is geographically diverse and takes into account their profile of activities. Tourism chambers operate as representatives at the local, regional, and national levels. The presence of the tourism business self-government organisation refers to institutional solutions aimed at establishing a separate representation for entrepreneurs in a given industry and building its position not only in public administration but also in local government. However, the establishment of tourism chambers also demonstrates the potential and commitment of industry representatives to develop positions and address significant economic issues. As a result, collectives of entrepreneurs are emerging that have the potential to be leaders in the industry environment and key stakeholders in initiatives dedicated to developing strategic programs for tourism development.

A limitation of the conducted research is the lack of access to up-to-date secondary data on the activities of tourist chambers of commerce. Based on the observations made, it was concluded that exploring the issues covered in the analysis requires taking specific actions dedicated to the entities that make up the analysed group. It is also important to invite representatives of chambers of commerce to joint scientific initiatives. The purpose of these actions could be to conduct research focused on identifying the organisational effectiveness of national chambers of commerce in the field of tourism. The presented considerations are preliminary, highlighting only some aspects related to the activities of tourist chambers. In addition, they will contribute to deepening the obtained results through research (quantitative, qualitative) planned among the members of the analysed associations of entrepreneurs. These studies will constitute one of the areas of future scientific endeavours.

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SYNERGY OF CHINESE CRAFTSMANSHIP AND ARTIFICIAL INTELLIGENCE

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Purpose: Contemporary crafts are changing and evolving, incorporating new technologies into crafts practices. This article explores the issues of innovative technologies and crafts within the context of Artificial Intelligence (AI). It aims to specify the phases of AI implementation in Chinese crafts, the accompanying frameworks, aspects, methodologies indicated in the literature, and to characterize future research directions and methods for encouraging craftsmen to implement AI. The above aims to fill the existing research gap in the craft space and examine potential good practices that can be transferred to the craft field in other countries.

Design/methodology/approach: The article draws upon a review of the relevant literature identified through the scientific databases Web of Science and Scopus.

Findings: Four main approaches to the topic of crafts and new technologies were identified: the use of AI in artistic crafts, the idea of the Chinese "craftsman spirit," AI & machines, and other aspects related to crafts. The generated terms outlined the popularity of specific terms in scholarly works devoted to the studied issues. Furthermore, two directions for future research were identified: i) artisan entrepreneurship dynamics, and ii) determining the phases of AI introduction in Chinese crafts. Moreover, the preliminary methods outlined in the analyzed texts to encourage craftsmen to adopt AI were specified.

Originality/value: The principal contribution lies in developing guidelines for craftsmen considering the integration of AI into their craft practices, serving both as a thematic guide and as a foundation for future research on applying emerging technologies in craftsmanship. The findings also enhance awareness of the economic significance of new technologies within the craft sector.

Keywords: chinese craft, new technologies, innovative technologies, Artificial Intelligence (AI), craft skills, cultural economics, sustainable development.

Category of the paper: Research paper.

1. Introduction

The resurgence of craftsmanship, its ruptured renaissance (Buechley, Perner-Wilson, 2012), is evident in the interest in craft skills and the culture of "Do It Yourself" (DIY) and unique craft products, the emergence of digital production and hybrid forms of making, the metamorphosis and redefinition of the position of craft skills, techniques, patterns and materials, as well as the promotion of sustainable practices (Woolley et al., 2015). Many features distinguish craft activity, including: i) understanding and engagement with materials, ii) use of tactile skills and hand-operated tools, iii) non-mass production, iv) influence of the creator on the concept, design and aesthetics of the finished product, v) cultural embeddedness of the finished product and vi) refinement of skills acquired over time (CEARTE, 2017). This article addresses the latter, which relates to the craft industry's adaptation to ongoing technological changes. These changes are driven by advances in the sector, which not only influence the characteristics of manufactured products and services but also stem from market forces, competitive observations, and stakeholder expectations. The use of new technologies in crafts is described not only as an inevitable process but also as a necessary approach to optimally utilizing potential, a prerequisite for effectively coping with constant change, maintaining competitiveness, increasing productivity, optimizing work processes, and improving customer communication (Kocak, Pawlowski, 2024).

Crafts are evolving and open to interdisciplinary work (Niedderer, Townsend, 2012), which is evident in design, economics, computer science, engineering, and robotics. As the digital generation increasingly engages in analog crafts, not only models focused on one space but also those that combine both are becoming popular, as used, for example, by the e-commerce platform Etsy (Westecott, 2011). This synergy is also associated with pedagogical innovations (Kermik, 2012). For example, in Finland, crafts are seen as an innovative school subject that engages creative thinking and modern practices related to digital materials (Kouhia, Kokko, 2022). This relationship is two-way. Research by LaMore et al. (2013) indicates, among other things, that craftsmanship is related to a country's ability to educate innovative scientists and engineers. These researchers noted that graduates of science, technology, engineering, and mathematics programs are significantly more likely to possess extensive skills in arts and crafts than the average person (in this case, the study involved professionals from the Honors College at Michigan State University, and their results were compared to those of average Americans). Furthermore, experiences in arts and crafts are significantly correlated with the creation of patentable inventions and the founding of new businesses. In particular, lifelong exposure to arts and crafts is most beneficial for innovators and entrepreneurs (LaMore et al., 2013). Table 1 presents examples of features linking elements of craftsmanship and other sciences, including those involving new technologies, to which contemporary scientific research is devoted.

Table 1.*Common features linking elements of craftsmanship and new technologies*

Elements of synergy	Common/ new features	Source
Crafts, design practices, digital technologies.	Practices passed down from generation to generation include access to technology (nowadays, analogue-digital methods, the use of computer tools, and exploring the digital world).	Duarte-Poblete et al. (2024)
Craftsmanship, manufacturing technologies, digital design.	Requires experimentation, creativity, and time to master.	Ohayō (2024)
Mathematics, technology, art.	Improvements in computer-aided design and 3D printing technologies are transforming complex designs into feasible designs.	Handmade Business (n.d.)
Computer generative systems, craft knowledge, digital production technologies.	A new way to design and create unique works.	Marshall, Univer, Atkinson (2007)
Craft, interaction design (giving form to computational materials).	Care in the process of creation and through the artifact.	Tsaknaki, Vallgård (2023)
- Electronics, crafts (related to sculpting, sewing, and painting). - Crafts, art, design. - Art, crafts, computing.	Hybrid craft categories, digital design as a craft form, and expanding technological cultures.	Buechley, Perner-Wilson (2012)
Digital work, craft practice.	The importance of personalization in production and consumption within a culture. Comparing hand and brain activity during computer use and activities requiring personal engagement and tacit knowledge.	Bunnell (2004)

Source: own study.

Some researchers point to the current shift from modern craftsmanship towards the era of post-craftsmanship – crafts that engage with digital technologies (Flanagan, Xue, 2024). However, attitudes toward crafts and technology are not uniform across the globe. Autio et al. (2019) noted, that these differences stem from differences in national curricula, pedagogical traditions, and cultural differences in technology.

In the People's Republic of China, Artificial Intelligence (AI) is described as an opportunity to accelerate productivity growth in an aging society. Barton et al. (2017) highlight the following opportunities offered by AI: improving productivity (supporting or replacing humans), streamlining industrial machinery, supporting supply chains and logistics, predicting failures, identifying bottlenecks, automating processes and decisions, and creating new products and services, new professions, and new companies. These researchers also emphasize that, internationally, China has the largest workforce engaged in activities that can be technically automated (Barton et al., 2017). *A development plan for the next generation of artificial intelligence* was established in China as early as 2017, establishing 2030 as an essential point on the timeline, indicating leadership plans in the field of AI, both in economic terms and within the framework of ethical standards and norms (Roberts et al., 2021).

China is currently considered a global leader in technology, including AI. The country aspires to become a global innovation hub and is reducing its dependence on non-Chinese technologies, increasing its self-sufficiency in next-generation information technologies (Lu, Morell, 2021). Ma, Zhang (2024) draw attention to the potential for international knowledge diffusion, as evidenced by tangible results such as the number of patents filed by

the Chinese Patent Office. In 2024, China ranked 11th (out of 133 economies) in the Global Innovation Index for its innovation potential (Global Innovation Index 2024, 2024). The state's central role mainly drives the development of AI in China, its strategic role in stimulating technological progress and industrial modernization (Zheng, 2024), and then through private-sector technology companies and academic research. AI has also been described as a key driver of international competition, primarily with the United States. AI is a strategic priority for China, particularly motivating it to implement AI faster than in other countries (Uber, 2020).

Considering the above, and the fact that China's implementation of technological policies is an essential source of knowledge for other countries (Abdikarov, 2023), this article focuses on presenting the environment of Chinese crafts and the issues of new technologies limited to AI. The article aims to answer the following questions: i) What are the distinct phases of AI application in Chinese crafts? ii) What frameworks, aspects, and methodologies have been applied in the existing literature to address these issues? iii) What are the future directions for research? iv) Which methods of encouraging craftsmen to adopt AI are significant enough to be used by skilled trades people and craft stakeholders in other countries?

2. Literature review – crafts and new technology

The report *Understanding the New Technological Context for Craftsmanship* (Ohayō, 2024) provides preliminary direction regarding the researched issue, including treating new technologies in crafts as a complement to traditional craft skills, used alongside analog tools, as tools with prospects. The most accessible new technologies include: Computer-Aided Design (CAD) software, 3D modeling, 3D printing, Computer Numerical Control (CNC) production systems, and AI. The potential of innovative technologies in the context of craftsmanship lies in their focus on improving profitability and working conditions (including efficiency and speed), differentiating from the competition, and their application in the areas of design, production, material handling, customer relations, management, sales, communication, and learning systems (Ohayō, 2024). Practical considerations of emerging technologies in their application to craftsmanship are presented in Table 2. Table 3 summarizes the concerns and potential threats of new technologies in the crafts space.

Table 2.*Practical aspects of new technologies from the point of view of their application in crafts*

Element of new technologies	Practical aspect	Source
Internet of Things	– Development of new digital business models. – Optimization of existing processes.	Pomp et al. (2022)
New technology (as a general category)	– Interest in crafts among the younger generation. – Adapting crafts and adapting them to contemporary demands. – Creating new professions.	District Employment Agency in Mława (n.d.)
Digital technology	– Understanding the potential of a given material (beyond its traditional uses) and expanding its "boundaries". – Simplifying the production process. – Increasing efficiency. – Increasing market competitiveness. – Cheaper prototyping. – Faster prototyping.	Ohayō (2024)
New technology (as a general category including, among others: CAD, 3D printing, CNC, Laser cutting, Thread Control Digital Loom TC2, scanning, acoustic applications, inkjet printing, digital design software, water jet cutting, puk welding, cutting plotter)	– Ability to develop and test new projects. – Ability to maintain digital documentation of products and ongoing work. – Improved management processes (including customer management and customer service). – Improved communication. – Improved accounting and billing. – Reduced prototyping time and costs. – Facilitated experimentation and testing. – Ability to incorporate other disciplines (previously unrelated to crafts) into craft production.	
Digital technology	– Enabling new creative opportunities that were not previously activated due to financial and time costs or the impossibility of implementing them.	Perry (2016)
New technology (as a general category)	– Blurring the perception of boundaries between traditional handicrafts and technologically advanced creativity. – Shorter turnaround times. – Creating products that are attractive to buyers. – Supporting career transitions in crafts.	Handmade Business (n.d.)
New technology (as a general category)	– Changing the way crafts are created, shared, and sold. – Supporting process improvement, reaching a wider audience, and preserving craftsmanship. – Changing the way crafts are appreciated.	Unleasher Innovation (n.d.)
CAD	– Enabling precise design.	
Graphic design software (e.g. Adobe Illustrator, CorelDraw)	– Assistance in creating digital projects, with the option of printing or transferring them to physical media.	
3D modeling software (e.g. Blender, Rhino)	– They enable the creation of prototypes or precise forms.	Unleasher Innovation (n.d.)
Laser cutting and engraving	– Capable of precise cutting in a variety of materials and precise machining. – Possibility of personalized engraving.	
3D printing	– Ability to create custom parts, molds and finished products.	
E-commerce and digital markets	– Unlimited sales to the local market. – Ability to build a personal brand. – Ability to analyze customers, their behavior, preferences, and purchasing patterns, which are the basis for creating marketing strategies and product customization.	
Social media platforms	– The opportunity to share work, present and promote ideas, and increase market visibility. – The opportunity to create a community around crafts and build partnerships. – Offering tutorials.	

Cont. table 2.

CAD	– Enabling precise design.	CEARTE (2017)
Graphic design software (e.g. Adobe Illustrator, CorelDraw)	– Assistance in creating digital projects, with the option of printing or transferring them to physical media.	
3D modeling software (e.g. Blender, Rhino)	– They enable the creation of prototypes or precise forms.	
Laser cutting and engraving	– Capable of precise cutting in a variety of materials and precise machining, – Possibility of personalized engraving.	
3D printing	– Ability to create custom parts, molds and finished products.	
E-commerce and digital markets	– Unlimited sales to the local market. – Ability to build a personal brand. – Ability to analyze customers, their behavior, preferences, and purchasing patterns, which are the basis for creating marketing strategies and product customization.	
Social media platforms	– The opportunity to share work, present and promote ideas, and increase market visibility. – The opportunity to create a community around crafts and build partnerships. – Offering tutorials.	
New technology (as a general category)	– Enabling digital skills learning and craft teaching online.	
New technology (as a general category)	– Mitigating environmental impact. – Contributing to the value of craftsmanship in terms of maintaining national identity and regional traditions, strengthening local communities. – International exhibition.	Sohoni, Kothari (2024)

Source: own study.

Pomp et al. (2022) point out that local crafts and small and medium-sized enterprises lack the knowledge to assess the potential of IoT solutions. Creating a platform dedicated to craftspeople, enabling them to independently implement new solutions, could be helpful. Its goal would be to support the identification of suitable IoT use cases and the resulting business models, including the review of components (e.g., sensors) without specialized knowledge in these areas (Pomp et al., 2022).

Table 3.*Concerns about introducing new technologies into craft practices*

Fears/ Threats	Source
– Lack of specialist knowledge to assess the potential of new technologies and their adaptation to one's own needs.	Pomp et al. (2022)
– High costs (of materials, machinery, access to licenses). – Difficulty of mastering. – Time-consuming to master. – Concern about the loss of meaning and ethos of craftsmanship, including the loss of traditional craftsmanship, craft skills, and the bond between craftspeople and craft consumers. – Concern about the depersonalization of products – stripping them of their individuality and uniqueness. – Fear of job loss or devaluation of traditional skills. – Loss of control over production. – Ethical and environmental concerns regarding, among other things, materials, energy requirements, and ethical implications of using AI. – Concern about compromising authenticity. – Concern about inconsistency with the cultural or artistic identity of the tradition. – Loss of well-being resulting from experience and direct contact with the material.	Ohayō (2024)
– Loss of importance of crafts. – Disappearance of some crafts.	District Employment Agency in Mława (n.d.)
– Associating advanced technologies not with a craft workshop, but with an industrial park. – The need to acquire new skills. – The need to invest in hardware or software. – Unfavorable comments from other creators regarding new working methods. – Stereotypes of creators as refugees from the modern world.	Handmade Business (n.d.)
– - Unequal access due to specialized skills, equipment and tools.	CEARTE (2017)
– The aspect of cultural authenticity. – The aspect of respect for tradition.	Olalere (2016)
– Possibility of deepening inequalities between groups of people with lower and higher qualifications (including due to the area of education, gender, and place of residence – cities/villages).	Barton et al. (2017)
– The need to introduce reforms.	Hu (2021)

Source: own study.

Dedicated programs are fostering the implementation of new technologies in crafts. The first example is a project implemented in collaboration with the Distributed Design Platform and World Crafts Council Europe. It focused on supporting craftspeople in adapting and utilizing information and communication technology tools to promote innovative forms of creativity that integrate cutting-edge digital production technologies. It included participation in an online master class program, which included workshops and work sessions focused on new and emerging digital markets for creative industries, collaborative practices and sustainability, and design for action, engagement, and resilience (FABLABBCN, n.d.). In addition to creating platforms, projects aimed at revitalizing, valorizing, and supporting traditional craft techniques combined with groundbreaking technologies involve the development of methodologies, curricula, entrepreneurial skills, and vocational training courses (Ministère Chargé De L'enseignement Supérieur Et De La Recherche, n.d.).

Another proposed solution is to engage universities in the topic in terms of sharing knowledge and inspiring (Perry, 2016).

3. Material and Methods

This article attempts to conduct a Structured Literature Review (SLR) of the texts indexed in two scientific databases – Web of Science (WoS) and Scopus. Texts were selected using keywords linked by AND/OR operators, presented in Table 4.

Table 4.
Quantitative data regarding the SLR

	WoS	Scopus
Keywords: Chinese OR China	2,821,278	2,231,452
Keywords: craftsman OR craftsmen OR artisan OR skilled trades people	10,217	13,202
Keywords: AI OR artificial intelligence	411,456	884,608
Keywords: Chinese OR China AND craftsman OR craftsmen OR artisan OR skilled tradespeople AND AI OR artificial intelligence	7	13
Duplicates removed	0	-4
Negative selection	-1	-1
Texts analyzed	6	8
The sum of the texts analyzed	14	

Source: own study.

Seven texts were obtained from the WoS database and 13 from Scopus. Four duplicates were found, *two texts that did not concern the researched issue were also rejected*¹, so 14 texts were included in the analysis. A Tab delimited file from the WoS database and a CSV file from Scopus were downloaded. The obtained bibliographic and text data were analyzed using VOSviewer version 1.6.20 separately for each database. Subsequently, the content of the selected texts was analyzed.

4. Results

4.1. Bibliographic data

The analyzed publications were published between 2013 and 2025. Particular research interest in the discussed topics was visible between 2020 and 2022, and in 2025 (Figure 1). The dominant subject areas were Social Sciences (WoS: 2, Scopus: 5), Computer Sciences (Scopus: 5), and Arts and Humanities (WoS: 2, Scopus: 4), illustrated in Figure 2. Most texts were scientific articles (WoS: 5, Scopus: 6) and proceedings papers (WoS: 2, Scopus: 5), published in English. All texts were affiliated or co-affiliated with both databases of Chinese academic institutions. The most significant number of texts were assigned to China (WoS: 5,

¹ One text referred to the work of the artist Ai Weiwei, whose surname is not an abbreviation for artificial intelligence. The second text was only an introduction to the conference devoted to the broad concepts of new technologies and did not include text data that could be analyzed.

Scopus: 7). In terms of citations, China (WoS: 63) and the United States (Scopus: 176) lead the way.

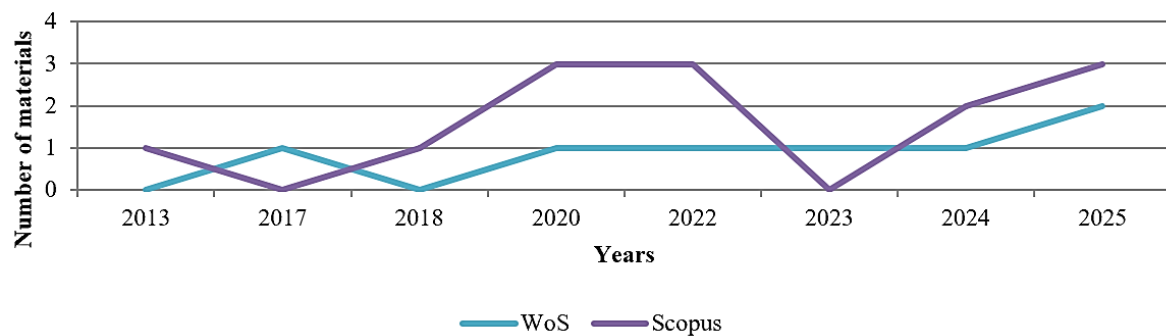


Figure 1. Number of publications in the period 2013-2025.

Source: own study.

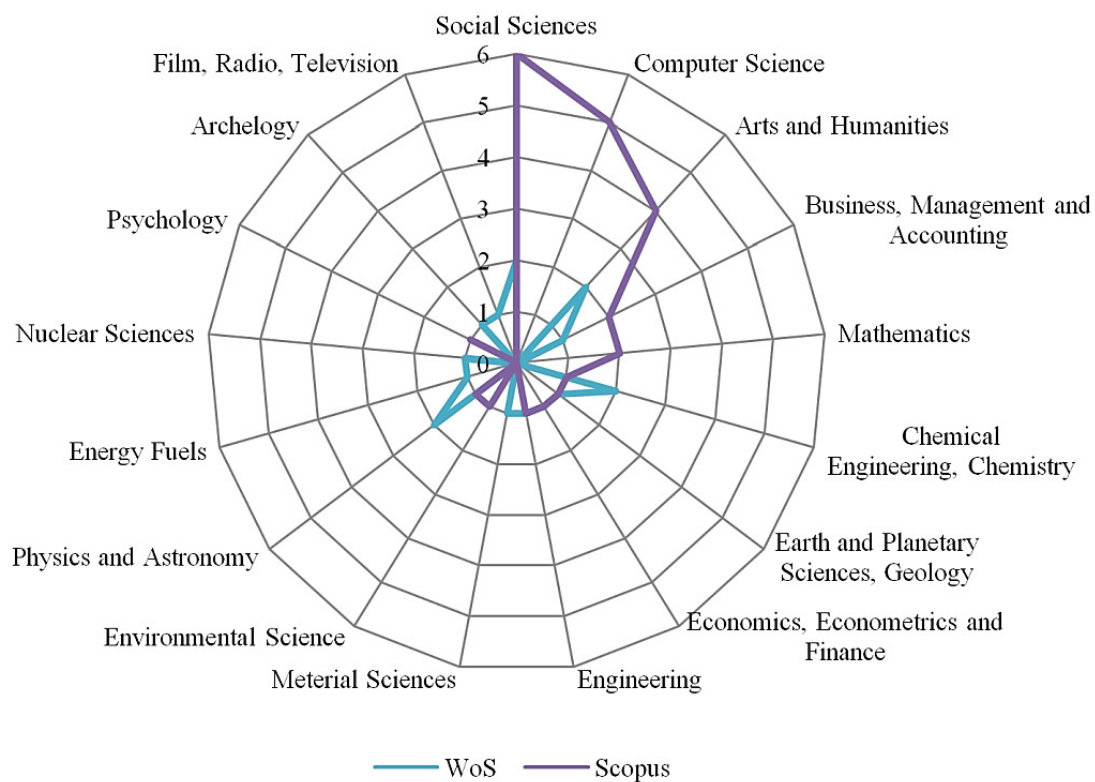


Figure 2. Number of publication divided into subject areas.

Source: own study.

The primary bibliographic data broken down by both databases are presented in Table 5.

Table 5.*Main bibliographic data of the analyzed texts (in number)*

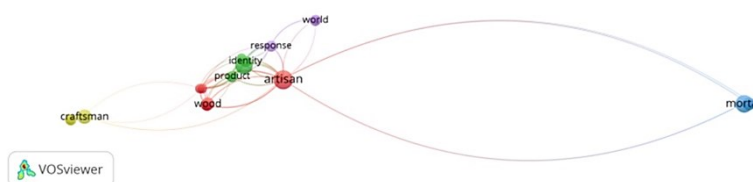
	Category	WoS	Scopus
Type	– Article.	5	7
	– Proceeding papers.	2	5
	– Book.	-	1
Language	– English.	7	12
	– Chinese.	-	1
Affiliation	– Chinese.	7	13
	– Non-Chinese.	-	11
Country/ territory	– China.	5	7
	– United States.	-	2
	– Australia.	-	1
	– Colombia.	-	1
	– Finland.	1	1
	– Italy.	1	-
	– Peru.	1	1
	– Portugal.	1	1
	– Switzerland.	1	1
	– United Arab Emirates.	1	-
Citation-country	– China.	63	-
	– Portugal.	5	3
	– Colombia.	-	4
	– Switzerland.	3	4
	– United Arab Emirates.	3	-
	– United States.	-	176

Source: own study.

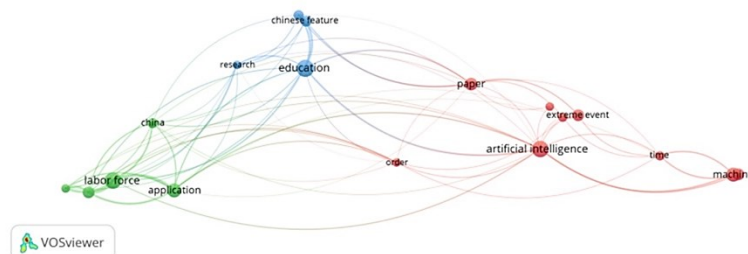
4.2. Text data

Text data from the titles and abstracts of the analyzed texts indicate that the texts indexed in both databases are not thematically homogeneous. They can be divided into cluster terms, as shown in Figure 3a-b. The WoS database contains five clusters: i) craftsmen and readout technique, ii) mortar, iii) word, iv) artisan and AI, and v) product and identity. The Scopus database contains three clusters: i) labor force and service industry, ii) research and education, and iii) AI and machine. Figure 3c-d indicates the timeline of the analyzed terms. The oldest terms in WoS include: 'word', 'craftsmen', and 'Chinese feature'. The youngest terms include: 'wood', 'product', and 'extreme event'. The last visualization (Figure 3e-f) indicates the level of intensification of exploring given terms (the brighter the field, the more advanced the exploration).

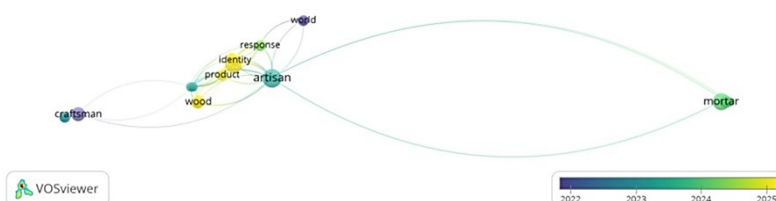
a) WoS*



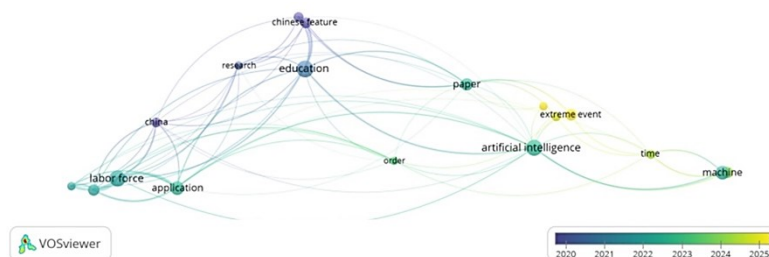
b) Scopus**



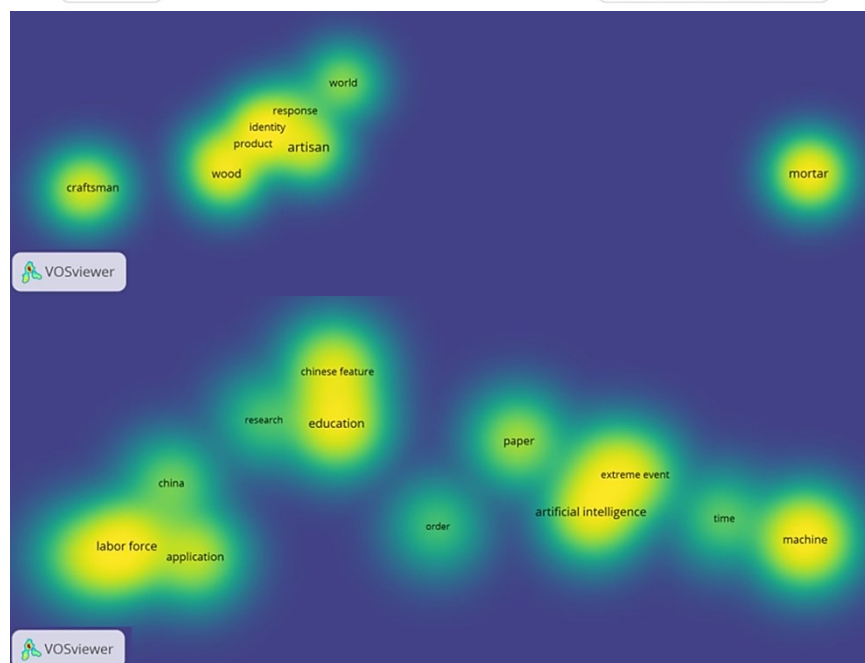
c) WoS*



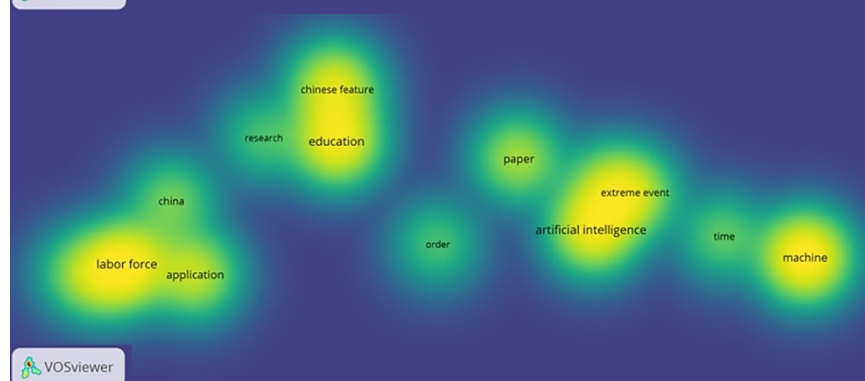
d) Scopus**



e) WoS



f) Scopus**



* Detailed data for WoS: title and abstract field, full counting method, minimum number of occurrence of a term: 3; of the 286 terms, 19 meet the threshold.

** Detailed data for Scopus: title and abstract field, full counting method, number of occurrence of a term: 5; of the 715 terms, 18 meet the threshold.

Figure 3a-f. Visualizations of the terms: a-b) network visualization, c-d) overlay visualization, e-f) density visualization

Source: own study.

The selected articles focus on four main themes: i) the use of AI in the work of artisans, ii) the idea of the "spirit of craftsmanship" with Chinese characteristics, iii) AI in working with machines, and iv) other aspects related to craftsmanship.

Artistic crafts are addressed in the context of producing carved wood window grilles characteristic of traditional Chinese architecture. X.H. Kang and J. Wang (2025) explore the potential of using new technologies, including image-generating AI (Stable Diffusion Model/SDM), to optimize design by combining traditional elements with innovative styles. The article focuses on presenting a translational transformation of crafts aimed at shortening the product research and development cycle, accelerating the process of converting ideas into products, and improving production efficiency (Kang, Wang, 2025). Another example of traditional crafts is the craft of kite-making, which is struggling with generational replacement and declining public interest. Zhang et al. (2025) present a solution to these challenges by integrating generative AI and launching a connected interactive platform through which individuals can create kite designs themselves.

Another topic discussed here is the idea of "craft spirit," which now extends beyond craft workshops. In this context, AI is discussed in conjunction with the education of preschool children and their teachers to increase innovation awareness and technological knowledge in the youngest (Meng, Xin, Fan, 2022). Intelligent strategies for developing craftspeople within the apprenticeship system and creating a modern craft improvement system are the central theme of the text by H.-J. Ni (2020). The article addresses the importance of educating Chinese craftspeople and developing the craft spirit, explaining that it refers to the pursuit of excellence, professionalism, and professional ethics. Nowadays, the craft spirit encompasses five dimensions: psychological characteristics, technical skills, responsibility, energy immersion, and innovation (Ni, 2020).

The issue of AI and machine work is presented in two ways through the mythology of the era of artificial intelligence – presenting myths related to the creation of self-moving devices (Mayor, 2018) and references to quite general observations that we operate in an era of co-creation of machines and scientists, engineers and skilled craftsmen, enabling the performance of "more creative" work (Li et al., 2024). In the article written by M. Mousa, A. Arslan, and T. Lange (2025), the researchers determined the impact of extreme events (including the COVID-19 pandemic, political changes, and the war in Ukraine) on reorienting the entrepreneurial identity of Egyptian artisan entrepreneurs selling handmade dresses, carpets, and papyrus. AI was mentioned here as one of the specific factors (besides stable demand, long-standing social networks, stable consumer tastes, the number of tourists, and government support) influencing the stability or change of this entrepreneurial identity due to extreme events. The second aspect is accepting AI's contribution and treating it as a "co-creator" or "team member", adapting to changes (Mousa, Arslan, Lange, 2025).

Craftsmanship is also used as an indirect reference in the articles studied. For example, He et al. (2023), focusing on nuclear data detection and reading techniques, use the quote "A craftsman must sharpen his tools to do his job" by Confucius. However, its significance refers to the vital preparation process, not to tools or craftsmanship. The preparation and material selection aspect is also emphasized in Zai et al. (2024) study of organic additives used in mortars in the Gugong Palace Museum (Forbidden City). This text highlights the adherence of Chinese craftsmen to principles oriented towards practicality and functionality when selecting materials (Zhai et al., 2024).

5. Discussion

The integration of AI into the craft sector represents a dynamic intersection of tradition and innovation. The reviewed literature highlights four thematic pillars: (i) AI in artisan work, (ii) the evolving concept of the "craftsman spirit," (iii) AI in collaboration with machines, and (iv) broader cultural and educational dimensions.

In the realm of artistic crafts, Kang and Wang (2025) demonstrate how image-generating AI models such as Stable Diffusion can optimize the design of traditional Chinese wood carvings. Their study emphasizes a translational transformation of craftsmanship, aiming to shorten the product development cycle and enhance production efficiency. Similarly, Zhang et al. (2025) address the declining popularity of kite-making by proposing an interactive platform powered by generative AI, enabling users to co-create designs and thereby revitalize public interest.

The notion of the "craftsman spirit" is redefined in contemporary discourse. Ni (2020) outlines five dimensions—psychological characteristics, technical skills, responsibility, energy immersion, and innovation—as essential to modern craftsmanship. This expanded framework is reflected in educational initiatives, such as those described by Meng, Xin, and Fan (2022), which integrate AI into preschool pedagogy to foster technological literacy and creativity from an early age.

The relationship between AI and machine work is explored through both mythological and practical lenses. Mayor (2018) discusses historical myths of self-operating devices, while Li et al. (2024) frame the current era as one of co-creation between machines, scientists, engineers, and skilled artisans. Mousa, Arslan, and Lange (2025) further contextualize this relationship by examining how extreme events—such as the COVID-19 pandemic and geopolitical instability—have reshaped the entrepreneurial identity of Egyptian artisans. Their findings suggest that AI functions not only as a technological tool but also as a stabilizing agent and creative partner.

Craftsmanship also appears as a metaphor in technical disciplines. He et al. (2023) invoke Confucius' adage—"A craftsman must sharpen his tools to do his job"—to underscore the importance of preparation in nuclear data detection. Zhai et al. (2024) highlight the practical ethos of Chinese craftsmen in material selection for mortars used in the Forbidden City, reinforcing the principle of functionality over form.

Collectively, these studies illustrate that AI is not merely an external force acting upon the craft sector but is increasingly embedded within its cultural, educational, and economic fabric. The narratives constructed around AI emphasize future potential, suggesting that its adoption is both a strategic and symbolic act of modernization.

5.1. Economic significance of new technologies within the craft sector

The economic implications of AI and related technologies in the craft sector are substantial and multifaceted. Several key dimensions emerge from the literature:

- Efficiency and acceleration of production AI tools such as SDM facilitate rapid prototyping and design iteration, reducing the time and cost associated with traditional methods (Kang, Wang, 2025).
- Revitalization of traditional crafts interactive platforms and generative design tools help preserve endangered crafts by engaging new audiences and enabling participatory creation (Zhang et al., 2025).
- Entrepreneurial adaptability in volatile socio-political contexts, AI contributes to the resilience of artisan entrepreneurs by offering alternative modes of production and market engagement (Mousa, Arslan, Lange, 2025).
- Expansion of market access digital technologies allow craftspeople to reach global consumers, transcending geographic limitations and fostering cross-cultural exchange.
- Cultural preservation through innovation - the digitization of traditional motifs and techniques ensures the continuity of cultural heritage while allowing for stylistic evolution.
- Human capital development educational initiatives that incorporate AI into craft training programs prepare future generations for hybrid roles that combine manual skill with digital fluency (Meng, Xin, Fan, 2022; Ni, 2020).

These findings suggest that the economic significance of new technologies in the craft sector extends beyond productivity gains. It encompasses cultural sustainability, entrepreneurial resilience, and the strategic modernization of artisanal practices. Future research should explore these dynamics in a comparative international context, considering economies at varying stages of development.

The reviewed literature highlights promising avenues for future research in the intersection of AI and craftsmanship. One key direction involves mapping the phases of AI adoption within specific craft disciplines, particularly in the Chinese context where such applications are rapidly evolving. While the current studies emphasize potential and conceptual frameworks, empirical

research is needed to assess long-term impacts on productivity, cultural preservation, and artisan identity.

Another important trajectory is the comparative analysis of artisan entrepreneurship across different economic environments. Mousa, Arslan, and Lange (2025) suggest that extreme events influence entrepreneurial identity, but further cross-national studies could reveal how AI mediates resilience and innovation in both developed and developing economies.

Additionally, future research should explore the ethical and philosophical dimensions of AI as a “co-creator” in artistic processes. This includes examining how artisans perceive authorship, originality, and value in works partially generated by machines. Investigating educational models that integrate AI into craft training—especially among youth—could also provide insights into shaping the next generation of hybrid artisans.

Finally, interdisciplinary collaborations between technologists, anthropologists, and designers may yield new frameworks for understanding how digital tools transform not only production methods but also the social and symbolic meanings of craft.

6. Conclusions

The research presented in this article focused on the following issues: i) phases of AI application in Chinese crafts, ii) frameworks, aspects, and methodologies that have been applied, iii) identifying future directions for research, and iv) methods of encouraging craftsmen to adopt AI. The analysis conducted allowed us to observe a noticeable increase in interest in AI within the craft sector and a dominance of research in the Chinese scientific community. The analyzed texts did not directly address the phases of AI application in Chinese crafts. However, it is possible to identify phases of scientific interest in AI and crafts related to the terms used by researchers, presented illustratively in Figure 4. It provides a basis for future research directions. Other future directions mentioned by researchers included artisan entrepreneurship dynamics, studied not in the context of representatives of a single country but in an international environment, taking into account economies at different levels of development.

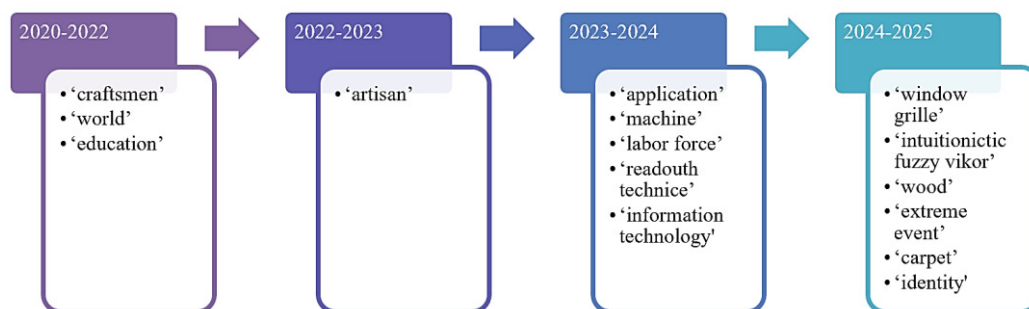


Figure 4. Popularity of terms appearing in the titles and abstracts of the analyzed texts.

Source: own study.

The topics of the analyzed materials are related to four main groups of themes: i) AI + artisans, ii) "craftsman spirit," iii) AI + machines, and iv) other aspects related to crafts. The applied research methods included: case study methodological approach, interviews with artisan entrepreneurs and entrepreneur-craftsmen, classical literature review, and optimization design method. Narratives regarding AI in the context of crafts were built with a clear emphasis not on the present, but on the future. The advantages of its use were associated with improving the design and production process, reaching stakeholders, and bottom-up engagement in the cultural heritage. These aspects can be treated as the first group of methods to encourage craftsmen to adopt AI. Educating the younger generation and increasing their awareness and technological knowledge also play an essential role here.

The above may indicate that research interest in AI within Chinese crafts is growing, as is the case in other economic sectors. Although China is among the countries most intensively developing AI capabilities, its application in crafts is not yet developed enough to allow for the identification of distinct application phases—phases that would enable its adoption within crafts in other economies. Thus, the topic of new technologies in crafts, with particular emphasis on AI, currently constitutes a research gap in itself and an area for further research.

The limitations of this study include its reliance solely on existing data. This limitation is also related to the specific nature of the SLR, which focused on concluding solely from texts indexed in only two databases, including the omission of gray literature, a primary emphasis on analyzing English-language materials, and a review of texts based on very rigorous selection criteria.

Acknowledgements

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FORESIGHT-DRIVEN BRAND STRATEGY: LINKING GENERATION Z SEGMENTATION TO DYNAMIC MARKETING CAPABILITIES

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Purpose: To examine corporate foresight (CF) as an antecedent of dynamic marketing capabilities (DMCs) and demonstrate how a foresight-to-segmentation pipeline informs brand strategy for Generation Z in Central and Eastern Europe (CEE). The paper aims to localise brand positioning for Philips' personal care portfolio by linking psychographic clusters to country-specific strategic options.

Design/methodology/approach: A mixed analytical approach combines secondary horizon scanning with a primary survey of Gen Z respondents across Poland, Romania, and Czechia. A two-stage cluster procedure identifies five segments: Aspirers, Mindfuls, Indulgents, Elementals, and Discoverers. Segment-country profiles are translated into foresight-guided brand implications for Sonicare, Series, OneBlade, and Lumea, within a CF-DMC framework.

Findings: Gen Z psychographics are heterogeneous across CEE. Poland tends to favour messages emphasising authenticity, value, and a balanced life. A preference for prestige/status frames dominates Romania. Czechia Gen Z supports playful, exploratory positioning. Brand-level implications encompass prevention/value (Sonicare toothbrush), Series (grooming and shaving), versatile self-styling (OneBlade trimmer), at-home efficacy and savings (Lumea epilator), tailored to each country's mix.

Research limitations/implications: Cross-sectional, self-reported data constrain causal inference; cluster stability over time and cross-country measurement invariance are not formally tested. The scope is limited to three CEE markets and one corporate context. Future research should employ longitudinal/panel designs, multi-method triangulation with behavioural and digital traces, randomised field experiments for causal identification, and capability-performance models linking CF/DMC maturity to brand and financial outcomes.

Practical implications: Provides a replicable scanning → clustering → foresight → positioning template for multinational brand portfolios, enabling resource allocation, message framing, and innovation road-mapping that reflect national psychographic structures.

Social implications: By aligning offerings with evolving generational values, corporates can foster responsible, inclusive, and health-oriented consumer choices, informing policy dialogues on digital well-being and consumer protection.

Originality/value: Integrates CF and DMC theory with an empirical, country-differentiated Gen Z segmentation to produce actionable, brand-specific foresight in a transitional region, offering both theoretical synthesis and a practical toolkit for managers.

Keywords: corporate foresight, dynamic marketing capabilities, Generation Z, brand strategy.

Category of the paper: Case study.

1. Introduction

Across volatile technological, sociocultural, and geopolitical landscapes, companies are increasingly required to possess capabilities that transcend retrospective forecasting and enable proactive engagement with discontinuous futures. Corporate foresight (CF) has emerged as such a capability: an organisational, routinised capacity to sense weak signals, interpret structural shifts, and translate alternative futures into strategic choices and innovation pipelines (Rohrbeck, Kum, 2018; Hines et al., 2017; Iden et al., 2017). Conceptually, CF extends beyond analytic extrapolation to futures thinking, scenario development, backcasting, and strategic dialogue (van der Heijden, 2005; Wright et al., 2013; Vecchiato, 2015), and is increasingly associated with superior opportunity recognition, risk mitigation, and strategic renewal in turbulent environments (Rohrbeck, Schwarz, 2013; Costanzo, MacKay, 2009).

This paper positions CF as a foundational enabler (antecedent) of Dynamic Marketing Capabilities (DMCs), the higher-order routines through which corporations sense, seize, and reconfigure market-facing assets to sustain an advantage under uncertainty (Eisenhardt, Martin, 2000; Day, 2011). The paper argues that foresight provides the cognitive and organisational infrastructure for DMCs by institutionalising environmental scanning, sensemaking, and reflexive learning, and by embedding future-oriented narratives that catalyse strategic alignment and agile resource recomposition (Wilkinson et al., 2014; Rohrbeck et al., 2015).

The paper interrogates this relationship in a domain where generational change constitutes a first-order strategic variable: brand management in personal care. Generational cohorts (Gen X, Millennials, Gen Z, and emergent Gen Alpha) differ systematically in digital fluency, values, and brand expectations, rendering static positioning increasingly ineffective (Bolton et al., 2013; Djafarova, Bowes, 2021).

Empirically, the Philips draws on direct survey research with 3,000 Gen Z respondents across Poland, Romania, and Czechia, complemented by secondary research of market and expert sources. Using a two-stage clustering approach (hierarchical determination of cluster number followed by k-means partitioning), five salient psychographic segments: Aspirers, Mindfuls, Indulgents, Elementals, and Discoverers – were identified, which structure consumer logics within and across countries. Brand foresight implications for four Philips brands (Sonicare, Series, OneBlade, Lumea) were developed, illustrating how cross-country segment compositions suggest differentiated positioning pathways.

This study contributes by: (1) integrating CF theory with DMCs to articulate a foresight-led brand strategy framework; (2) demonstrating a replicable segmentation-to-foresight pipeline applicable to multinational brand portfolios; and (3) evidencing intra-regional heterogeneity in Gen Z psychographics within CEE – Poland (balance of Indulgers and Mindfuls → value, authenticity, life-balance), Romania (Aspirer dominance → status and recognition), and Czechia (Indulgers and Discoverers → fun, exploration, creative self-expression).

Collectively, the analysis advances both theoretical understanding of foresight-enabled marketing agility and practical guidance for localisation of brand architectures in transitional markets.

2. Literature Review

2.1. Corporate Foresight as a Strategic Capability

In an era of accelerating technological disruptions, shifting consumer expectations, and volatile geopolitical environments, organisations must move beyond traditional forecasting methods to embrace corporate foresight as a dynamic strategic capability. Corporate foresight (CF) refers not merely to predicting future trends based on historical data, but to an organisation's ability to anticipate, interpret, and act upon potential future developments in ways that enable strategic agility and sustained competitive advantage (Rohrbeck, Kum, 2018; Gordon et al., 2020; Iden et al., 2017).

Corporate foresight has been conceptualised as a set of processes and capabilities that enable organisations to detect early signs of change, develop plausible future scenarios, and integrate these insights into strategic decision-making (Rohrbeck, Battistella, Huizingh, 2015). Unlike forecasting, which extrapolates from the past, foresight emphasises futures thinking-imagining alternative, discontinuous, and even contradictory futures (Vecchiato, 2015).

A central theme is the distinction between foresight as an analytical tool and foresight as an organisational capability (Slaughter, 1997; Hines et al., 2017). The latter perspective emphasises corporate foresight as internal capacity building, developing routines, mindsets, and structures that enable organisations to engage with uncertainty and ambiguity continuously. While data-driven trend analysis remains a foundational element (foresight as an analytical tool), leading scholars argue that corporate foresight cultivates a readiness for strategic transformation rather than merely produce predictions (Rhisiart, Miller, Brooks, 2015). This involves embracing uncertainty, surfacing assumptions, and engaging in back casting and scenario planning (van der Heijden, 2005; Wright, Bradfield, Cairns, 2013). Organisations demonstrating high corporate foresight maturity tend to exhibit certain meta-capabilities, such as environmental scanning, sensemaking, strategic dialogue, and reflexive learning (Wilkinson, Mayer, Ringler, 2014). These are not passive capabilities but interactive processes

embedded in organisational routines and culture (Battistella, 2014), focusing on leveraging the potential of heuristic methods, respectively seeking synergies with quantitative methods for predicting the future. Corporate foresight requires a combination of quantitative and qualitative methods, often applied together to generate richer insights (Sedighi et al., 2022; Gordon et al., 2020). Environmental and horizon scanning by continuous monitoring of signals and trends across domains. Uses databases, scientific publications, patent analysis, startup monitoring, industry reports, media, and expert sources. Identification of long-term shifts in consumer behaviour, technologies, demographics, and other factors, which involves bibliometrics, patent landscapes, or big data analytics. Spotting early, fragmented, low-visibility developments that might indicate future disruptions by using text mining, social media analytics, Delphi surveys, and expert interviews. Structured techniques like the Delphi method, interviews, or focus groups are used to gather expert judgment on uncertain or complex issues (expert elicitation). Development of multiple possible future paths, exploring uncertainties and interdependencies, is often visualised with causal mapping, cross-impact analysis, or systems thinking tools (Højland, Rohrbeck, 2018).

Empirical studies increasingly highlight the role of foresight in strategic renewal, innovation, and long-term orientation. Rohrbeck and Schwarz (2013) found that organisations with embedded foresight capabilities outperformed peers in turbulent environments due to better opportunity recognition and risk mitigation. Foresight supports not only strategic alignment but also strategic divergence, enabling firms to reframe markets, explore new business models, and redefine value propositions (Costanzo, MacKay, 2009). Significantly, foresight is being repositioned as a driver of strategic agility – the ability to rapidly reconfigure strategies and resources in response to weak signals and emergent disruptions (Doz, Kosonen, 2010). Internal organisational factors that affect the institutionalisation of foresight include a culture of openness, cross-functional collaboration, and absorptive capacity (Vecchiato, Roveda, 2010). Conversely, cognitive inertia, short-termism, and siloed structures often hinder the translation of foresight into corporate action (Mendonça et al., 2004).

The creation of corporate foresight typically follows a staged process, supported by critical methods of data gathering and analysis. Typical steps encompass strategic intent and commitment, when the senior leadership defines why foresight is needed (e.g., innovation, risk management, resilience, long-term brand competitiveness). In that phase, resources, governance, and responsibility are allocated, often within strategy, R&D, and innovation units. Later, scanning and data collection are carried out, and the organisation gathers weak signals, emerging trends, disruptions, and drivers of change from multiple domains (technological, economic, social, environmental, and political). Both internal and external sources are used. The next step, sensemaking and interpretation, is set. Data is organised, clustered, and interpreted to reveal patterns, uncertainties, and interconnections. The goal is to identify potential future scenarios or an organisation's strategic options. The corporate foresight, the focal point is scenario and vision building (Chermack, 2004), where alternative futures are developed to stress-test assumptions, highlight risks, and reveal opportunities. Desired futures

(visions) may also be articulated as a basis for strategy. Integration into strategy and innovation is an executive stage where insights are embedded into decision-making, R&D priorities, investment choices are made, and business model innovation occurs. The last stage, monitoring and renewal, makes the whole process an ongoing organisational routine.

Foresight is a continuous cycle, not a one-off project, while an organisation monitors signals, updates scenarios, and refines strategies over time.

2.2. Corporate Foresight as a Background for Dynamic Marketing Capabilities

Dynamic marketing capabilities (DMC) are a subdomain of the broader dynamic capabilities framework. They specifically refer to an organisation's capacity to sense, seize, and reconfigure its marketing-related assets and competencies to sustain a competitive advantage in turbulent environments (Eisenhardt, Martin, 2000; Day, 2011). Dynamic marketing capabilities encompass proactive market learning, agile customer engagement, and resource fluidity, enabling firms to respond to both anticipated and emergent changes in market environments. These capabilities are not innate but must be developed through continuous experimentation, strategic learning, and absorptive capacity. Dynamic marketing capabilities operate as higher-order routines that allow firms to not only respond to change but also actively co-create new market conditions (Witczak, Molin, 2024; Witczak, 2023).

The increasing generational diversity of the consumer base magnifies the urgency of cultivating DMCs. Generations X, Y (Millennials), Z, and the emerging Generation Alpha differ significantly in their digital fluency, environmental consciousness, brand expectations, and value systems (Parment, 2013; Djafarova, Bowes, 2021).

- Generation X tends to value authenticity and functional utility.
- Millennials (Y) emphasise experience, transparency, and purpose.
- Generation Z demands speed, inclusivity, and digital-native engagement.
- Generation Alpha is projected to amplify further expectations of personalisation, sustainability, and AI-enabled services.

These generational dynamics require not only new marketing communications strategies but adaptive brand architectures, fluid value propositions, and innovative customer experiences (Bolton et al., 2013). Static brand positioning and rigid marketing processes are increasingly obsolete. Generational shifts are not merely demographic trends but tectonic transformations in consumer logics that necessitate a reconfiguration of marketing infrastructures.

Whereas operational marketing capabilities are oriented toward short-term responsiveness, DMCs require a forward-looking strategic posture and corporate foresight plays a foundational role. Corporate foresight enables organisations to anticipate discontinuous change, envision alternative futures, prepare for long-term adaptation, create innovation capability, and be adaptive and agile solutions (Gordon et al., 2020, p. 22; Rohrbeck, Kum, 2018).

Foresight-informed marketing enables the identification of emerging consumer needs and the simulation of future generational behaviours, which is critical when planning for product development, digital innovation, and brand strategy five to ten years ahead (Vecchiato, Roveda,

2010; Haarhaus, Lienen, 2020). Without such foresight, firms risk short-termism, leading to incremental innovation and brand stagnation. Strategic foresight is not an auxiliary process but a cognitive infrastructure upon which dynamic marketing capabilities must be built (Rohrbeck, Battistella, Huizingh, 2015). Foresight capabilities shape the learning and sensing mechanisms that feed into DMCs. The scenario planning literature emphasises the role of future-oriented narratives in stimulating strategic marketing conversations and organisational agility (Wright et al., 2013; Slaughter, 1997).

Absent long-term foresight, firms often rely on reactive adaptation driven by historical data and short-cycle trends. Limits the depth of insight into fundamental shifts such as the transformation of generational values or the convergence of digital and social platforms. Moreover, operational marketing capabilities, though useful in stable environments, are ill-equipped to address radical discontinuities, such as generational redefinitions of trust, loyalty, and identity. This poses strategic risks as loss of brand relevance due to misalignment with emerging generational values; innovation inertia stemming from an overreliance on past market models, and decreased agility in response to societal or technological disruptions (Dartiguepeyrou, Saloff-Coste, 2024).

Corporate foresight mitigates these risks by embedding a long-term perspective into marketing strategy formulation, thereby enabling firms to not only adapt but thrive in the face of generational and systemic shifts.

As generational values evolve, business models and brand strategies must follow suit. Dynamic marketing capabilities, underpinned by foresight, facilitate the redesign of brand purposes, customer journeys, and engagement ecosystems. This requires continuous brand renewal to align with changing cultural narratives; modular business models that allow for rapid recomposition and cross-generational segmentation strategies informed by foresight scenarios. Organisations that institutionalise foresight into their marketing functions are better equipped to lead rather than follow cultural and technological shifts (Danko et al., 2018).

2.3. Corporate Foresight and Generational Change in Brand Management

Brand management has traditionally centred around differentiation, positioning, and the creation of perceived customer value. However, in increasingly dynamic and generationally fragmented markets, the effectiveness of static brand strategies is eroding. Today's competitive brand landscape demands not only operational excellence and customer-centricity but also the capability to anticipate and adapt to long-term sociocultural transformations – especially those stemming from generational shifts (Kapferer, 2012; Keller, 2020).

Strategic foresight, traditionally viewed as a tool for long-term planning, has evolved into a core marketing capability underpinning effective brand management. It highlights how companies that actively scan for emerging consumer trends, forecast evolving generational values, and prepare for technological and communicative disruptions are better positioned to

build enduring brand equity and maintain relevance in competitive markets (Rohrbeck, Kum, 2018; Beverland et al., 2007).

Brand management has evolved from a communication-centric paradigm to a strategic function embedded within value-creation ecosystems (Keller, Brexendorf, 2019). Brands are no longer seen merely as identifiers but as dynamic assets that shape customer experiences and influence long-term consumer loyalty (Aaker, 1996; Iglesias, Ind, Alfaro, 2013). Central to this evolution is the understanding that brand value is co-created and constantly renegotiated in response to cultural and generational change (Louro, Cunha, 2001). Therefore, effective brand strategies must be continuously refreshed through insight into shifting values, identity constructs, and consumption patterns across cohorts.

Generational cohorts, such as Generation X, Millennials (also known as Generation Y), Generation Z, and the emerging Generation Alpha, differ fundamentally in their digital habits, social expectations, and attitudes toward brands (Bolton et al., 2013; Twenge, 2017). These differences are not transient trends but systemic shifts that demand a more nuanced segmentation and differentiated brand positioning. Millennials prioritise authenticity, purpose, and experiential value. Generation Z expects personalisation, transparency, and alignment with social justice. Generation Alpha is growing up with AI, immersive tech, and ultra-personalised media. The implication for brand managers is clear: a one-size-fits-all positioning strategy is no longer viable. Successful firms must utilise generational insights as a foundation for ongoing brand innovation and the customisation of value propositions (Schewe, Meredith, 2006; Djafarova, Bowes, 2021).

Strategic foresight refers to an organisation's structured ability to explore, anticipate, and act upon future developments in its environment (Rohrbeck, Battistella, Huizingh, 2015). In the context of strategic foresight, brand management extends beyond trend analysis, becoming a capability that underpins marketing agility. Key foresight-driven brand management practices include, among others:

- early detection of consumer and cultural trends (Heger, Rohrbeck, 2012),
- anticipation of shifts in consumer-brand relationships (Witczak, 2018; Beverland et al., 2007),
- proactive adaptation to new technologies and communication channels (Wang et al., 2019),
- building brand equity that is resilient to change (Aaker, Joachimsthaler, 2000).

Rather than reacting to market changes, foresight enables brand managers to design brands for the future – brands that are flexible, values-aligned, and able to maintain relevance across multiple generational lifecycles. Strategic foresight is not a forecasting method but a dynamic capability that enables firms to explore alternative futures and embed that knowledge into strategic brand positioning (Rohrbeck, Kum, 2018).

While many firms possess operational branding capabilities – the routines that support day-to-day brand communication and management – these are often insufficient in volatile contexts.

Without foresight capabilities, branding becomes retrospective and reactionary, vulnerable to disruption. Dynamic brand leaders, by contrast, embed foresight into:

- brand architecture design, allowing for scalable and adaptive brand portfolios,
- narrative development, aligning brand stories with emerging societal discourses,
- platform strategy, and anticipating shifts in consumer interaction with brands via AI, metaverse platforms, or decentralised technologies.

This aligns with the dynamic capabilities framework (Teece, 2007), wherein foresight enhances a company's ability to sense and seize brand-related opportunities before they become mainstream. Brands that fail to track generational expectations risk being seen as tone-deaf or obsolete. Foresight-informed brand management strengthens brand equity by:

- embedding future-proof value propositions aligned with emerging generational priorities,
- investing in long-term cultural relevance, not just short-term campaigns,
- fostering trust and emotional connection, which endure beyond specific touchpoints or platforms.

The importance of integrating strategic foresight into brand management seems to be a core marketing dynamic capability. As generational shifts accelerate and digital ecosystems become increasingly complex, brands must move beyond static identities and embrace foresight-driven agility to sustain relevance and value creation.

3. Philips corporate foresight background – company information, competitive brands, sources of information, and employed research method

Philips (Koninklijke Philips N.V., or Royal Philips NV) is a Dutch technology conglomerate with a global reach, headquartered in Amsterdam. The company has a vibrant history and has undergone a significant transformation – from a manufacturer of light bulbs to a leading company in the medical technology industry. Founded in 1891 in Eindhoven by Gerard Philips, initially to produce light bulbs, Philips has been a pioneer in many fields for decades. It invented, among other things, the cassette tape (1963) and the compact disc (with Sony, 1982), and was also a major player in the development of television and radio receivers. For many years, it was one of the world's largest manufacturers of consumer electronics (televisions, audio equipment, stereos). Philips gradually sold or spun off other divisions to focus on health. Philips focuses on innovations aimed at improving people's health and quality of life by creating impactful innovations that are intended to make the world healthier and more sustainable. Philips is an example of a company that has undergone a significant and highly successful transformation from a consumer electronics manufacturer to a leader in the health and personal care market. One of the company's key areas of focus is strengthening the Philips

brand's market position against its main competitors. To meet market challenges and effectively position Philips products and brands, it is essential to be future-oriented by building the capacity to shape corporate and marketing routines that will meet evolving customer needs. Hence, corporate foresight is the answer to building dynamic capabilities that will strengthen the Philips brand (stage – strategic intent and commitment).

In accordance with the corporate foresight methodology, in the second stage – scanning and data collection, Philips' management, including middle management staff (i.e. marketing, brand managers), identified potential sources of risk and areas of market volatility taking in consideration internal corporate's data and information, trends and forecasts collected from reports and expertises (i.e. PwC Global Consumer Insights Survey, EY Future Consumer Index, Kantar Global MONITOR / BrandZ Reports, Bloomberg Intelligence / Market Research Reports, McKinsey Global Private Markets Report 2025, IBISWorld – Industry Market Research & Statistics etc.).

At this stage, it has been decided to conduct direct research (survey) on a sample of 3000 respondents (Tab. 1) belonging to Generation Z in the Czech Republic, Poland, and Romania.

The direct research results played a pivotal role in the creation of Philips' corporate foresight building. Generation Z is not the core target group for Philips' product categories in the personal care market. Generation Z seems to be the future consumer of Philips products. Therefore, the primary objective of the research project was to prepare an information database about future customers. Based on the collected data and analyses of market and economic reports, corporate foresight has been generated that meets the expectations of Gen Z, who will occupy the target groups of Philips brands in the personal care market in the upcoming years. However, for this to be possible, the organisation must already have corporate foresight in place to meet customer expectations with an appropriate range of products and services in response to changing market conditions, including differences that may arise between the previously treated markets of the Czech Republic, Poland and Romania.

Table 1.

The survey sample distribution

Specification		Country			
		Total	Poland	Romania	Czech Republic
		%			
Country	Poland	33,3	100	0	0
	Romania	33,3	0	100	0
	Czech Republic	33,3	0	0	100
Gender	Male	50,0	50	50	50
	Female	50,0	50	50	50
Age	18-20	29,0	27	30	29
	21-24	39,0	39	40	39
	25-27	32,0	34	30	32
Place of living	Cities	33,0	33	35	30
	Towns and suburbs	30,0	31	26	34
	Rural areas	37,0	36	39	36
Total		100	100	100	100

Source: Philips direct research – internal organisation data.

Table 2.
Identified Gen Z clusters

Country	Aspirers	Mindfuls	Indulgers	Elementals	Discoverers
Poland	23%	31%	40%	42%	32%
Romania	51%	42%	17%	29%	28%
Czechia	26%	27%	43%	29%	40%

Aspirers: a strong orientation toward career advancement, social recognition, and status signalling; consumption is often aspirational, privileging prestige, symbolic value, and professional image-building over functional attributes.

Mindfuls: an emphasis on health, self-care, and family well-being, this group is value-conscious and sustainability-oriented; purchasing decisions prioritise long-term benefits, durability, and authenticity, aligning consumption closely with grounded, ethical lifestyles.

Indulgers: a hedonistic orientation toward pleasure, comfort, and material security. Indulgers are highly responsive to products that promise convenience, enjoyment, and aesthetic appeal, making them strong adopters of lifestyle and personal care innovations.

Elementals are guided by practicality, necessity, and functional utility, tending to value simplicity, affordability, and reliability; often resist unnecessary consumption and focus on essential goods and services.

Discoverers: curiosity and openness to novelty, this segment seeks exploration, experimentation, and new experiences; highly receptive to innovative, playful, and digitally interactive brand engagements, reflecting a more adventurous consumption ethos.

Source: Philips direct research – internal organisation data.

The consumer clusters were derived through the application of cluster analysis, a multivariate statistical technique commonly employed in marketing research to segment heterogeneous populations into more homogeneous subgroups. Using survey data on values, aspirations, and consumption behaviours, variables were standardised and subjected to a combination of hierarchical clustering (to determine the appropriate number of groups) and k-means partitioning (to refine membership allocation). This approach enabled the identification of five distinct clusters – Aspirers, Mindfuls, Indulgers, Elementals, and Discoverers – each representing coherent patterns of motivation and lifestyle orientation within Generation Z. The procedure ensures that intra-cluster similarity is maximised. At the same time, inter-cluster differences are preserved, thus enhancing the interpretive value of the segmentation for foresight and brand strategy development.

4. Gen Z Preferences and Values in the Personal Care Market – Brands Philips Corporate Foresight

Generation Z, those born from the mid-1990s to early 2010s, is rapidly emerging as a powerful consumer group. In Poland, this generation stands out for its digital fluency, economic awareness, and increasing influence over household purchasing decisions. To engage with Gen Z effectively, brands need a deep understanding of their core values, ambitions, behaviours, and decision-making patterns. Polish Gen Zs share a set of values that mix personal freedom with traditional anchors. Much like their peers in Czechia, they emphasise family, honesty, and the importance of enjoying life. Their Romanian counterparts, by contrast,

are more aligned with traditional ideals such as faith, defined gender roles, and a desire for recognition and status. For Polish Gen Z, enjoyment often means doing things simply for the joy of it, a mindset that influences both lifestyle and consumer behaviour.

In terms of aspirations, the top ambitions across Central and Eastern European countries are mainly aligned: financial independence, home ownership, the ability to travel, and professional success. In Poland, however, these ambitions are sometimes framed with a softer touch. While career progress remains essential, many young Poles express a desire for meaningful relationships and more free time, suggesting a greater emphasis on life balance compared to their Romanian peers. This generation is also financially cautious. The rising cost of living, healthcare affordability, and employment stability are among their biggest worries. As a result, Polish Gen Zs are savvy shoppers who look for value and practicality. Whether shopping for a grooming device or a household product, they carefully weigh product durability, cost-effectiveness, design, and brand reputation. Long-term savings and convenience often outweigh short-term appeal. Smartphones play a central role in their purchasing process. In Poland, two-thirds of Gen Zs shop via mobile devices, using them to compare prices, read reviews, check product availability, and locate stores. Their online habits extend to social media, where platforms like YouTube, Instagram, and Facebook dominate. Compared to Gen Z in Romania and the Czech Republic, young Poles are more engaged across a broader range of apps, making digital and mobile-first strategies essential.

When it comes to how they spend their free time, Polish Gen Zs enjoy a mix of digital and offline activities. Streaming content on platforms like Netflix and Spotify is popular, along with spending time outdoors or meeting friends face-to-face—something that's even more frequent in Czechia and among young women. Listening to music, doing chores, exercising, and gaming (especially among males) are also part of their routine. Roughly 40% of Polish Gen Zs meet up with friends weekly, highlighting the continued importance of real-world connections.

Living arrangements also offer insight into their lifestyle stage. Around half still live with their parents, primarily those in the 18-20 age group, while close to 40% live with a partner. Cohabitation is more common than marriage in Poland and the Czech Republic, unlike Romania, where formal marriage is more prevalent. About 20% of Polish Gen Zs are already parents, typically with one child, indicating early-stage family formation.

In terms of work and education, over 40% are employed, while roughly 20% are students. Another fifth manage to balance both, reflecting a generation already juggling multiple roles. Despite their concerns about the economy, most young Poles view their living conditions as stable: two-thirds say they live comfortably or average, while just 20% feel they're struggling. Compared to Romanians, fewer Polish Gen Zs describe themselves as affluent, which may suggest a different benchmark for comfort or financial success.

One of the most striking aspects of Polish Gen Z is their significant role in household decision-making. About 60% say they are the primary voice in choosing personal care items, with another 20% claiming significant influence even if someone else pays. This influence tends

to grow with age, emphasising the importance of capturing their attention early and building brand loyalty over time.

Within this generation, there are three main consumer groups. The largest is the "Indulgers", who make up 38% of Polish Gen Zs. These individuals prioritise pleasure, comfort, and material security, making them exceptionally responsive to beauty and personal care products. "Aspirers" comprising 17%, are career-focused and status-oriented. While they aspire to look good, they often feel conflicted about investing too much in their appearance. The "Mindfuls" at 21%, are more grounded in values such as health, self-care, and family well-being. They show strong intent to purchase grooming and oral care products.

For brands hoping to succeed with Gen Z in Poland, a clear strategy is essential. First, they must speak to Gen Z's desire for authenticity. Marketing that features real stories, user reviews, and relatable content will perform better than polished, corporate messaging. Personalisation, community engagement, and influencer partnerships can go a long way in establishing trust.

Second, brands should encourage creativity and self-expression. Products should not only deliver functional benefits but also enable users to feel more confident and authentic. Campaigns that focus on empowerment and lifestyle enhancement resonate well with Polish Gen Zs. Third, digital visibility is critical. Social media campaigns, YouTube content, and mobile-optimised experiences must be central to any marketing plan. Referral programs, SEO optimisation, and real-time customer interaction, especially on review platforms, are powerful tools to build credibility and engagement. Lastly, products that support family use or shared routines can foster deeper emotional connections. Highlighting durability, warranty, and cost-effectiveness-especially in comparison to pricier alternatives – can help reassure cautious buyers. At the same time, injecting fun and excitement into branding can help distinguish companies from one another.

Gen Z in Poland is a unique blend of traditional values and modern behaviours. They are thoughtful, digitally immersed, and eager to express themselves while managing financial realities. Their consumer power is already significant and will only grow. Brands that understand their mindset, respect their values, and meet them on their preferred platforms are well-positioned to win their trust – and their loyalty.

The comparative analysis of Generation Z consumer profiles across Poland, Romania, and Czechia reveals distinct attitudinal and behavioural orientations that carry significant implications for brand strategy.

In Poland, the generational landscape is characterised by a high share of Indulgers (40%) alongside a substantial proportion of Mindfuls (31%). This combination indicates a balanced consumer base that values both pleasure and self-care, while remaining anchored in family-oriented and health-conscious values. For brands, this suggests that market positioning should emphasise authenticity, lifestyle balance, and long-term value creation, addressing both emotional and practical needs.

In contrast, Romania is marked by a predominance of Aspirers (51%), reflecting a consumer orientation that is career-driven, status-conscious, and recognition-seeking. The comparatively lower presence of Indulgers (17%) highlights a generational focus less on hedonistic consumption and more on social mobility and professional image-building. Effective foresight strategies in this context require brands to appeal to prestige, ambition, and societal recognition, often through premium positioning and symbolic consumption cues.

Meanwhile, Czechia displays a markedly different structure, with a strong representation of both Indulgers (43%) and Discoverers (40%). These signals a generational ethos that prioritises fun, exploration, and enjoyment, indicating greater openness to experimentation than observed in Poland or Romania. Here, brand foresight should highlight playfulness, creative engagement, and exploratory consumption experiences, leveraging digital interactivity and lifestyle-driven campaigns.

Taken together, these findings underscore the heterogeneity of Central and Eastern European Gen Z markets, despite shared regional histories and socio-economic transformations. For multinational firms such as Philips, foresight-driven brand strategies must therefore move beyond uniform regional approaches and instead be calibrated to national consumer psychologies: emphasising value and authenticity in Poland, prestige and recognition in Romania, and exploratory engagement in Czechia.

The foresight analysis of Philips' personal care and beauty technologies across Poland, Czechia, and Romania highlights the extent to which Gen Z consumer clusters shape differentiated brand opportunities.

For Philips Sonicare (oral care), the Polish market demonstrates a strong resonance with the Mindfuls, who prioritise health, self-care, and family well-being. Financial caution among Polish Gen Z emphasises the importance of durability and preventive value, while peer reviews and mobile-first testimonials play a central role in trust formation. In contrast, Czech consumers, with a higher proportion of Indulgers, associate oral care not only with health but also with confidence and lifestyle enjoyment, requiring branding that conveys social benefits and a sense of fun. In Romania, where Aspirers dominate, oral care products are better positioned as enablers of professional image and status, with premium variants likely to perform well.

For Philips Series portfolio (grooming and shaving devices), Polish consumers, particularly Indulgers, value comfort, convenience, and cost-effectiveness, linking grooming to confidence and self-expression. In Czechia, grooming is understood more as an arena for playful experimentation, with opportunities to leverage influencers and socially engaging campaigns. Romanian consumers, however, emphasise grooming as an element of professional recognition and prestige, suggesting the appeal of premium lines and executive positioning.

The Philips OneBlade device aligns closely with younger Polish Indulgers, who appreciate versatility, style, and time-saving solutions. In Czechia, its flexibility resonates strongly with Discoverers, who prize experimentation and playful self-expression, making gamified

and creative digital engagement highly relevant. Romanian consumers are likely to interpret OneBlade as a modern and stylish tool that signals ambition, providing an accessible entry point into premium grooming culture.

For Philips Lumea (hair removal devices), Polish consumers from both Indulger and Mindful segments value comfort and self-care. Still, they are cautious spenders, making it necessary to highlight long-term savings relative to salon treatments. Czech consumers can be reached through narratives of freedom, exploration, and the playful integration of beauty technology into daily routines. By contrast, in Romania, Lumea is most effectively positioned as a symbol of sophistication, elegance, and status, benefiting from premium branding strategies.

Taken together, the foresight exercise reveals distinct national orientations: Poland reflects a balance of practicality, authenticity, and lifestyle management; Czechia emphasises fun, exploration, and creative self-expression; and Romania prioritises status, recognition, and premium aspiration.

These findings illustrate the necessity for brand strategies to be locally adapted within Central and Eastern Europe, even when targeting the same generational cohort.

5. Conclusions, limitations, and future research

The findings substantiate the proposition that corporate foresight operates as a strategic capability that undergirds dynamic marketing by linking weak-signal sensing and scenario reasoning to concrete brand choices. The Gen Z segmentation reveals distinct national psychographic profiles with direct implications for brand orchestration.

Theoretically, the study demonstrates how foresight-informed segmentation can mediate between macro uncertainty and micro positioning, operationalising DMCs through country-specific brand narratives and portfolio choices. Managerially, it offers a templated process – from scanning to clustering to scenario-linked positioning – that multinational marketers can adapt to other categories and regions.

Several limitations temper these conclusions. The reliance on a single wave of survey responses constrains causal inference and may be susceptible to common method variance and self-presentation biases. Psychographic clusters can drift over time, and cross-country equivalence of measurement, while designed for, cannot be fully guaranteed without formal invariance testing. The analysis focuses on three CEE countries and one corporate context (Philips, personal care). Generalisability to other industries, age cohorts, or regions is limited.

The translation from foresight insights to execution (media mix, pricing, retail channel, service design) is not evaluated, leaving open questions about organisational contingencies and capability maturity.

Future studies should follow the same respondents or comparable cohorts across multiple waves to observe how psychographic clusters evolve ("cluster drift") as macro conditions shift – e.g., inflation spikes, labour-market shocks, or platform algorithm changes. Such designs would allow managers to test the durability of foresight-informed positioning and to separate transient sentiment from structural value change. To ensure interpretability across countries and waves, measurement invariance testing (configural, metric, and scalar) should be implemented, so that observed differences reflect substantive change rather than instrument artefacts.

A robust research programme should integrate surveys with behavioural data (e-commerce logs, retail sell-out, usage telemetry), digital trace analytics (social listening, creator ecosystems, app event streams), and qualitative inquiry (ethnography, netnography, in-depth interviews). This triangulation would link stated motives to revealed behaviours, surface the cultural meanings that underlie cluster membership, and detect weak signals that precede measurable behavioural change. Mixed-method designs can also reveal contextual moderators (e.g., local norms, price sensitivities, platform cultures) that are often invisible in single-method studies. The limitations of the presented foresight approach stem from the absence of experimental or longitudinal research designs, which constrain the ability to draw causal inferences. Incorporating panel data or field experiments in future research could substantially enhance the credibility and robustness of foresight-based brand management recommendations.

To move beyond correlation, the research program should embed randomised field experiments in live channels (e-commerce, CRM, social platforms) that test foresight-derived propositions – such as premium vs. playful frames, status vs. authenticity cues, or prevention vs. enjoyment benefits. Outcomes should include both proximal (e.g., click-through rates, engagement) and distal (e.g., conversions, repeat purchases, retention, customer lifetime value – CLV) metrics. Analytically, models should estimate heterogeneous treatment effects by cluster, country, and context (e.g., price bands, device type), clarifying for whom, where, and when foresight-informed strategies are most effective.

Future research should operationalise and validate corporate foresight (CF) maturity and dynamic marketing capability (DMC) strength at the firm or business-unit level, capturing scanning routines, sensemaking practices, scenario use, and learning mechanisms. Structural models can then test whether CF and DMCs mediate the relationship between foresight practices and market/financial performance (brand equity lifts, innovation yield, margin resilience). Multi-source designs – combining leadership surveys, process audits, and performance panels – would help disentangle capability effects from favourable market conditions.

By embedding rigorous foresight practices within marketing systems – and by validating their effects on consumer behaviour and company performance – future work can consolidate the role of corporate foresight as a core dynamic marketing capability, enabling brands to sustain cultural relevance and economic resilience amid accelerating generational and technological change.

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OVERVIEW OF RENEWABLE ENERGY APPLICATIONS FROM PHOTOVOLTAIC PANELS

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Purpose: The study aims to provide an in-depth understanding of current research trends in photovoltaic (PV) applications through a bibliometric approach. Specifically, it seeks to identify the main areas of research, the geographical leaders, the temporal trends, and the recurring themes to guide future development.

Design/methodology/approach: The authors used a five-step procedure based on Hart's methodology, involving data collection, verification, bibliometric analysis, visualization, and results interpretation. The Scopus database was searched using specific keyword combinations, and tools like VOSviewer and Excel were employed for co-occurrence, temporal, geographical, and thematic analysis of publications.

Findings: China, the United States, and India dominate PV application research, with significant contributions in materials science, engineering, and energy fields. Six application domains were analyzed: industry, household, transportation, solar farms, remote locations, and military, with industry and household applications being the most researched.

Research limitations: The study is limited to the Scopus database. This database is broad. However, it may exclude relevant work from other databases. Additionally, studies with unconventional terminology or interdisciplinary scope may be omitted from keyword-based searches.

Practical implications: By mapping PV research trends and dominant regions, the study can guide policymakers, investors, and researchers toward areas with high potential for development and innovation. The identified application domains can help prioritize funding and international collaboration in the most promising PV sectors.

Originality: This research offers the first comprehensive bibliometric analysis explicitly focused on PV applications rather than general PV technology. It contributes to filling the knowledge gap by structuring research areas, identifying emerging topics, and revealing underexplored application domains.

Keywords: renewable energy, photovoltaic panels, application of photovoltaics.

Category of the paper: Research paper.

1. Introduction

One of the most challenging issues facing people in the 21st century is the need to protect the environment (Al Doghan et al., 2022; Arkorful et al., 2024; İnançoğlu et al., 2020). It necessitates a transition to renewable energy sources that are zero-emission during use (Ofstad et al., 2017). Furthermore, considering the entire life cycle of the technology required to generate this energy, its use should result in lower greenhouse gas emissions (Mularczyk, Zdonek, 2022). Consequently, there has been a recent worldwide interest in solar energy, with a particular emphasis on photovoltaic technology (Garcia et al., 2018; Hysa, Mularczyk, 2024; Mostafa et al., 2020).

Photovoltaics (PV) is one of the leading technologies for obtaining energy from renewable sources (All Photovoltaic Barometers Archives..., 2025). It enables the direct conversion of solar radiation energy into electrical energy. A significant increase in PV activity has been observed over the last two decades of the 21st century (Liu, Huo, 2024; Masson et al., 2024; Mularczyk, Zdonek, 2022; Novas Castellano et al., 2024; Stec et al., 2024; Wolniak, Skotnicka-Zasadzień, 2022). It has resulted in a rapid increase in the use of photovoltaic modules in various applications.

Recent research documents a wide range of photovoltaic (PV) applications (Franco, Franco, 2025; Garcia et al., 2018). For example, Vivar et al. (2024) explore water-related PV systems, including floating, submerged, agrivoltaics, aquavoltaics, and PV-integrated water disinfection technologies (Vivar et al., 2024). The integration of photovoltaics with agriculture is described by Qazi (2016), who highlights standalone PV systems for rural, remote, and disaster-prone areas, emphasizing affordability and resilience (Qazi, 2016). Mamun et al. (2022) discuss agrivoltaics as a strategy to enhance rural energy access while supporting local agricultural practices (Mamun et al., 2022). Smith et al. (2013) report on flexible photovoltaic modules for portable device charging, field-deployable arrays, and niche markets (Smith et al., 2013). Hao et al. (2022) focus on PV-powered self-sustaining applications, with particular attention to energy harvesting, maximum power point tracking, and power management for specialized use cases (Hao et al., 2022).

In comparison to the previously mentioned studies, this particular study is distinguished by its contribution to the scientific literature on photovoltaic applications research through the utilization of bibliometric analysis. This study provides an in-depth understanding of current research trends in the use and application of photovoltaics over the years.

Therefore, the main objective of the study is to analyze the key areas and trends in photovoltaic applications. Using bibliometric analysis to identify research trends and knowledge gaps to discover the most promising areas for the development of photovoltaic uses in the world.

Therefore, the article intends to answer the following research questions:

RQ1: What were the main areas/directions of published research?

RQ2: Which countries dominate photovoltaic research?

RQ3: How has research on photovoltaics changed over time?

RQ4: What issues and trends appear most frequently in the analyzed articles?

This article consists of five parts: The first part provides an introduction and justification of the study, as explained previously. The second part discusses the methods used in the study analysis. This section explains the selection of the database, keywords, and tools. The third section of the study presents the results and associated discussions. The final section is intended to provide a concise summary of the conclusions.

2. Methods

There are several literature review methodologies available, including structured reviews, model or framework reviews, meta-analyses, theoretical examinations, hybrid future research frameworks, bibliometric reviews, and systematic reviews (Al Mamun et al., 2022; Azarian et al., 2023; Munn et al., 2018; Oteng et al., 2021; Tawfik et al., 2019). The authors, following the methodology described in the literature (Czako et al., 2023; Kumar, 2021; Vivar et al., 2024), adopted and proposed their own stages of procedure guided by the key principles underlying the Hart methodology (Hart, 1998). The five-step procedure (as shown in Figure 1) ensures the robustness and rigour of the study, eliminating subjectivity in data collection and analysis.

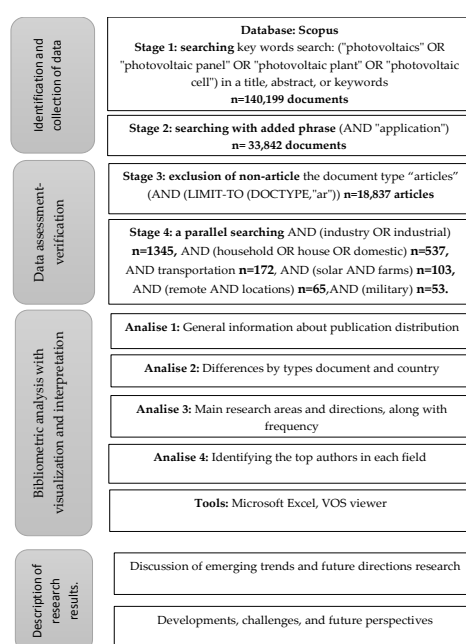


Figure 1. The five-step procedure adopted in the article.

Source: own work.

The methodology consists of the following stages: (1) identification and collection of data, (2) data assessment – verification, (3) bibliometric analysis, (4) visualization and interpretation, and (5) description of research results. The central part of the methodology is bibliometric analysis. Bibliometric analysis is a well-accepted scientific method used worldwide. It uses mathematical and statistical techniques for evaluation. A literature review was conducted to identify articles published on the topic until June 2025. The articles were classified according to the type of study, the authors' region, the main subject, and the application area. Geographic and temporal trends were analyzed. This study is based on the Scopus database because it contains a significant number of publications published over the last four decades on photovoltaic systems. VOSviewer (version 1.6.15) was used to perform co-occurrence analyses on terms from titles and abstracts to visualize the main topics of the publications. Co-occurrence analysis reveals how often two words appear together in the same text as well as the connections between terms. In the resulting visual network, each sphere represents a term, and the size of the sphere is proportional to the occurrence of the term. The links between the spheres represent the association between words: the thicker the line, the stronger the association (co-occurrence). The program identifies clusters of words that are very often cited together and likely refer to the same topic. Time trends, geographical analyzes, and journal analyzes were carried out in Microsoft Excel.

3. Results and discussion

The first three stages were intended to answer the first two research questions (RQ1: What were the main areas/directions of published research? and RQ2: Which countries dominate photovoltaic research?).

The first stage included searching the following terms: ("photovoltaics" OR "photovoltaic panel" OR "photovoltaic plant" OR "photovoltaic cell") in a title, abstract, or keywords. It resulted in 140,199 documents. The main information about the collection is presented in Table 1.

Most of the items found were articles (55%) and conference papers (37%). The main subject areas were engineering (56%), energy (43%), and materials science (30%). The most considerable number of affiliations came from China (19%), the United States (16%), and India (11%). In fourth place was Germany (5%), followed closely by the United Kingdom (5%) and Japan (4%).

Table 1*Main results of the first search*

Description	Results	Description	Results
Main information		Main subject area	
Timespan	1923:2025 (June)	Engineering	78,674 (56%)
Documents	140,200	Energy	59,874 (43%)
Document types		Materials Science	42,675 (30%)
Article	77,640 (55%)	Physics and Astronomy	30,318 (22%)
Conference Paper	51,505 (37%)	Computer Science	23,231 (17%)
Review	5,977 (4%)	Mathematics	18,388 (13%)
Book Chapter	2,714 (2%)	Chemistry	16,730 (12%)
Conference Review	753 (1%)	Environmental Science	11,259 (8%)
Note	465	Chemical Engineering	8,714 (6%)
Book	354	Main country/territory	
Editorial	177	China	27,287 (19%)
Erratum	166	United States	22,434 (16%)
Short Survey	149	India	15,973 (11%)
Retracted	125	Germany	7,045 (5%)
Letter	94	United Kingdom	6,348 (5%)
Data Paper	53	Japan	6,163 (4%)
Report	27	Italy	5,634 (4%)
		South Korea	4,917 (4%)

Source: based on Scopus.

To specify the search scope, the phrase (AND "application") was added in the second step. It resulted in 33,842 documents (Table 2).

Table 2*Main results after the second stage*

Description	Results	Description	Results
Main information		Main subject area	
Timespan	1949:2025 (June)	Engineering	17,957 (53%)
Documents	33,842	Materials Science	13,198 (39%)
Document types		Energy	11,465 (34%)
Article	18,837 (56%)	Physics and Astronomy	8,660 (26%)
Conference Paper	10,281 (30%)	Chemistry	6,082 (18%)
Review	2,866 (8%)	Computer Science	4,603 (14%)
Book Chapter	1,118 (3%)	Mathematics	3,611 (11%)
Conference Review	354 (1%)	Chemical Engineering	2,901 (9%)
Book	205 (1%)	Environmental Science	2,132 (6%)
Note	43	Main country/territory	
Short Survey	25	China	6,557 (19%)
Erratum	24	United States	5,583 (16%)
Editorial	23	India	4,273 (13%)
Retracted	23	Germany	1,916 (6%)
Report	16	United Kingdom	1,646 (5%)
Data Paper	14	Italy	1,526 (5%)
Letter	13	South Korea	1,335 (4%)

Source: based on Scopus.

Once more, most of the items found were also articles (56%) and conference papers (37%). The main subject areas were engineering (53%), materials science (39%), and energy (34%). The most significant number of affiliations came from China (19%), the United States (16%), and India (13%). In fourth place again was Germany (6%), followed by the United Kingdom (5%), and then Italy (also approximately 5%).

In the third step, we decided to limit the document type to articles (AND (LIMIT-TO (DOCTYPE, "ar"))). A total of 18,837 articles were identified (Table 3).

Table 3

Main results after the third stage

Description	Results		Description	Results	
Main information					
Timespan	1949:2025	(June)			
Documents	18,837		Main country/territory		
Main subject area			China	4,442	(24%)
Materials Science	9,083	(48%)	United States	2,931	(16%)
Engineering	8,196	(44%)	India	1,991	(11%)
Energy	6,374	(34%)	Germany	1,190	(6%)
Physics and Astronomy	5,671	(30%)	United Kingdom	1,002	(5%)
Chemistry	4,747	(25%)	South Korea	1,001	(5%)
Chemical Engineering	2,145	(11%)	Italy	878	(5%)
Environmental Science	1,383	(7%)	Japan	740	(4%)
Mathematics	1,130	(6%)	Saudi Arabia	716	(4%)
Computer Science	1,104	(6%)	Spain	697	(4%)

Source: based on Scopus.

The main subject areas of articles in question were materials science (48%), engineering (44%), energy (34%), physics and astronomy (30%), and chemistry (25%). In turn, the countries with the highest number of published articles to date are China (24%), the United States (16%), and India (11%), with Germany (6%), United Kingdom (5%), South Korea (5%), and Italy (5%) following. For comparison, Poland ranked 16th with 375 articles (2%). Figure 2 displays the countries of publication for the articles found.

China, the United States, and India have dominated photovoltaic research. On the one hand, one could argue that the size of these countries compared to most other countries has had a significant impact on this result, but countries such as Russia and Brazil do not confirm this thesis. On the other hand, the explanation is probably the greater number of scholarly centers in these countries, which translates into higher research potential.

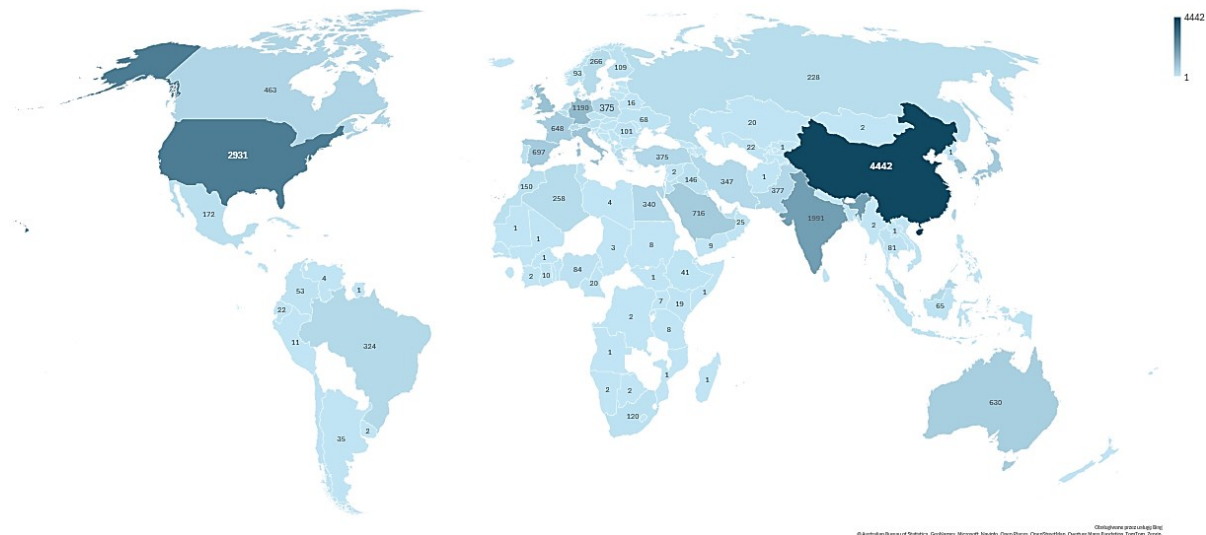


Figure 2. Article affiliation locations.

Source: own calculations.

To answer the third research question (RQ3: How has research on photovoltaics changed over time?), graphs of time series showing the publication dates of the studied publications were constructed and analyzed. Therefore, Figure 3 presents the number of items for all three searches over the years.

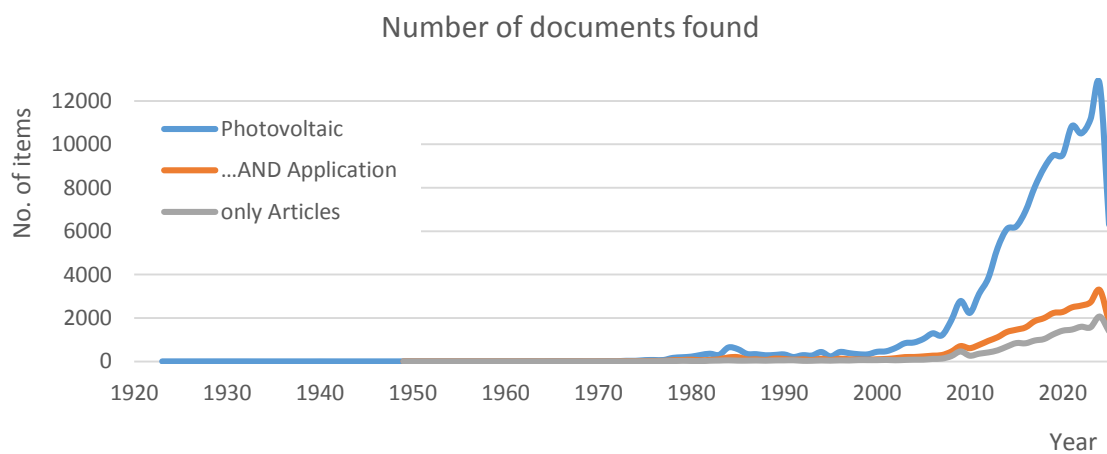


Figure 3. Number of documents in steps I to III over the years.

Source: Scopus.

The earliest document, found at the first stage, was printed in 1923 (Garrison, 1923). Also, in the second and third stages, the oldest document dates back to 1949 (Yurkstas, Manly, 1949). However, it was not until another article from 1957, entitled "Converting Solar Energy into Electricity", that the subject under investigation was presented (Pearson, 1957). Still, the number of works was not at a significant level until the first decade of the XXI century. From that point, the fast-growing trend is visible. This trend is a consequence of the sudden growth of photovoltaic technology worldwide, observed by the authors cited above (Liu, Huo, 2024; Masson et al., 2024; etc.).

Subsequently, to answer the fourth research question (RQ4: What issues and trends appear most frequently in the analyzed articles?), an analysis of the co-occurrence of keywords and terms from titles and abstracts was conducted to examine the subject matter of the articles obtained. Shrivastava, Mahajan (2016) and Oteng et al. (2021) point out that keyword analyses are essential for identifying key research areas within a given field of science (Oteng et al., 2021; Shrivastava, Mahajan, 2016). Keywords characterize the main research of a published article and demonstrate the scope of the research area. A keyword network provides insight into the connections and organization of topics within a research domain, offering a good picture of the research area. We examined the network of co-occurring keywords using VOSviewer software. Figure 4 and Figure 5 display the keywords and their connections for the identified articles, a visualization of keyword frequency and co-occurrence.

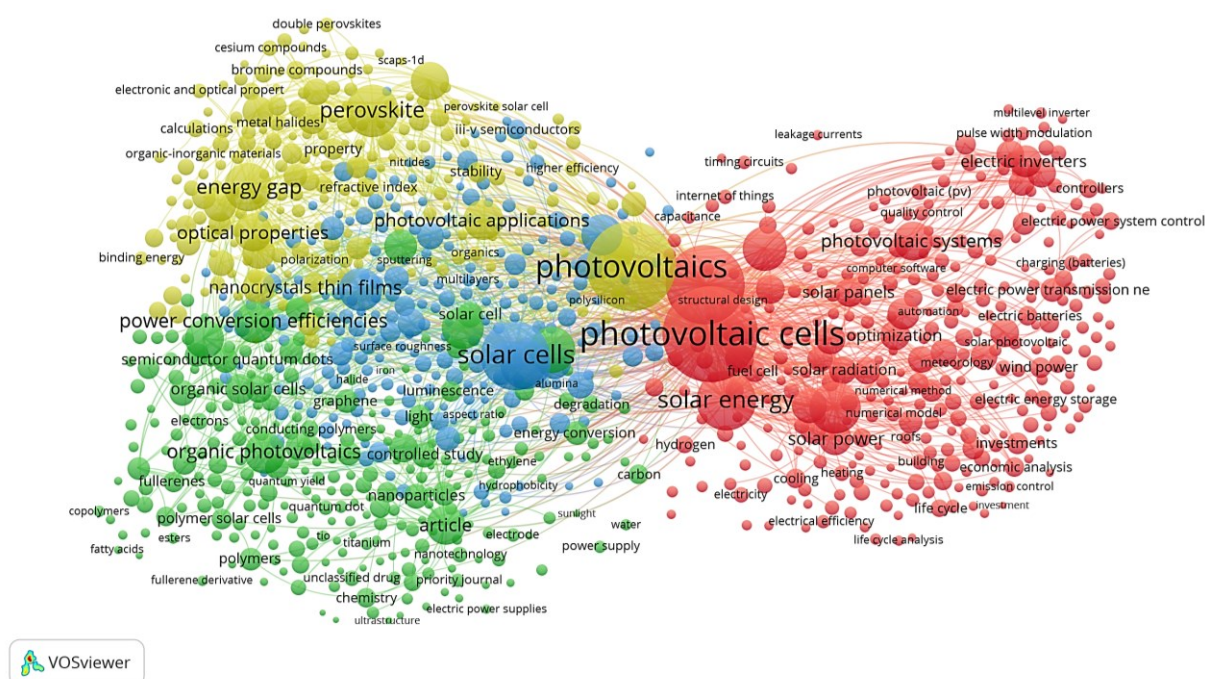


Figure 4. Main keywords in the researched articles consolidated in clusters.

Source: own calculations.

Figure 4 highlights four clusters marked with different colours. On the contrary, the colours in Figure 5 indicate the period in which they appeared in the publications studied. The yellow cluster in Figure 4, as compared to Figure 5, includes the newest keywords, such as perovskite, optical properties, nanocrystals, and other materials. The green one – the oldest. The red cluster contains words associated with solar power, solar energy, batteries, and optimization.

Source: own calculations.

Cont. Table 4.

REMOTELOCATIONS	– PV + wind hybrid systems for telecom. – Islands and military outposts. – Autonomous sensor systems.
MILITARY	– Portable solar chargers for field operations. – UAVs powered by solar cells. – Off-grid base support systems.

Source: own work based on Hao et al. (2022), Saidi et al. (2025), Díaz-Bello et al. (2025), Zhang et al. (2025), Pietrzak et al. (2025), and Hysa, Mularczyk (2024).

Therefore, during the fourth stage of the analysis, parallel search was conducted in six areas according to the following criteria:

1. AND (industry OR industrial).
2. AND (household OR house OR domestic).
3. AND transportation.
4. AND (solar AND farms).
5. AND (remote AND locations).
6. AND military.

In Table 5, the main results are presented.

Table 5

Main results for the fourth stage

Description	Results		Description	Results	
INDUSTRY					
Main information					
Timespan	1965:2025	(June)	Documents	1,345	
Main subject area			Main country/territory		
Engineering	615	(46%)	China	317	(24%)
Energy	549	(41%)	United States	180	(13%)
Materials Science	541	(40%)	India	111	(8%)
Physics and Astronomy	315	(23%)	Germany	105	(8%)
Chemistry	228	(17%)	Australia	77	(6%)
HOUSEHOLD					
Main information					
Timespan	1976:2025	(June)	Documents	537	
Main subject area			Main country/territory		
Energy	322	(60%)	China	67	(12%)
Engineering	294	(55%)	India	63	(12%)
Environmental Science	113	(21%)	United States	50	(9%)
Materials Science	70	(13%)	United Kingdom	46	(9%)
Mathematics	63	(12%)	Germany	32	(6%)
TRANSPORTATION					
Main information:					
Timespan	1977:2025	(June)	Documents	172	
Main subject area			Main country/territory		
Engineering	85	(49%)	China	52	(30%)
Energy	83	(48%)	India	18	(10%)
Materials Science	41	(24%)	United States	17	(10%)
Environmental Science	33	(19%)	Germany	10	(6%)
Physics and Astronomy	29	(17%)	Australia	8	(5%)

Cont. Table 5

Cont. Table 5

SOLAR FARMS					
Main information					
Timespan	1985:2025	(June)	Documents	103	
Main subject areas			Main country/territory		
Energy	64	(62%)	China	52	(50%)
Engineering	55	(53%)	India	18	(17%)
Environmental Science	28	(27%)	United States	17	(17%)
Mathematics	17	(17%)	Germany	10	(10%)
Materials Science	14	(14%)	Australia	8	(8%)
REMOTE LOCATIONS					
Main information					
Timespan	1979:2025	(June)	Documents	65	
Main subject areas			Main country/territory		
Energy	36	(55%)	India	11	(17%)
Engineering	34	(52%)	United States	8	(12%)
Environmental Science	14	(22%)	Australia	7	(11%)
Materials Science	9	(14%)	Malaysia	6	(9%)
Computer Science	7	(11%)	Spain	5	(8%)
MILITARY					
Main information					
Timespan	1984:2025	(June)	Documents	53	
Main subject areas			Main country/territory		
Engineering	37	(57%)	United States	15	(23%)
Energy	17	(26%)	China	11	(17%)
Materials Science	13	(20%)	Poland	6	(9%)
Physics and Astronomy	13	(20%)	Romania	4	(6%)
Mathematics	7	(11%)	Greece	3	(5%)

Source: based on Scopus.

Industry was the subject of 1,331 of the articles found. The earliest item was dated 1965. The main subjects of study were engineering (46%), energy (41%), and materials science (40%). China (24%), the United States (13%), India (8%), Germany (8%), and Australia (6%) were the most frequent countries of affiliation.

In terms of household FV applications, 537 articles were identified (the earliest dating back to 1976). The main subjects of study were energy (60%), engineering (55%), and environmental science (21%). This time, India surpassed the United States, ranking second in terms of the number of affiliations, namely: China (12%), India (12%), the United States (9%), the United Kingdom (9%), and Germany (6%).

There were 172 articles about transportation, with the oldest dating back to 1977. The main subject areas included: engineering (49%), energy (48%), and materials science (24%). The most often affiliated countries were China (30%), India (10%), the United States (10%), Germany (6%), and Australia (5%).

Solar farms were the subject of 102 articles. The first was dated to 1985. The articles were published mainly in three subject areas: energy (62%), engineering (53%), and environmental science (27%). The five countries with the most frequent affiliations were China (50%), India (17%), the United States (17%), Germany (10%), and Australia (8%).

As many as 64 articles were found about the remote locations of PV applications, with the oldest dating back to 1979. Their subject areas were mainly: energy (55%), engineering (52%), and environmental science (22%). The most common countries of affiliation in this case differed slightly from those in previous instances. They were, namely: India (17%), United States (12%), Australia (11%), Malaysia (9%), and Spain (8%).

Finally, only 53 articles addressed the use of PV for various military applications. Military uses were niche but present. The earliest one found was dated to 1984. They were most often published in engineering (57%), energy (26%), materials science, and physics and astronomy (both of 20%). This time, the territory of affiliation also differed, including the United States (23%), China (17%), Poland (9%), Romania (6%), and Greece (5%).

The following two figures (Figure 6 and Figure 7) illustrate the number of articles published over the years in all six areas.

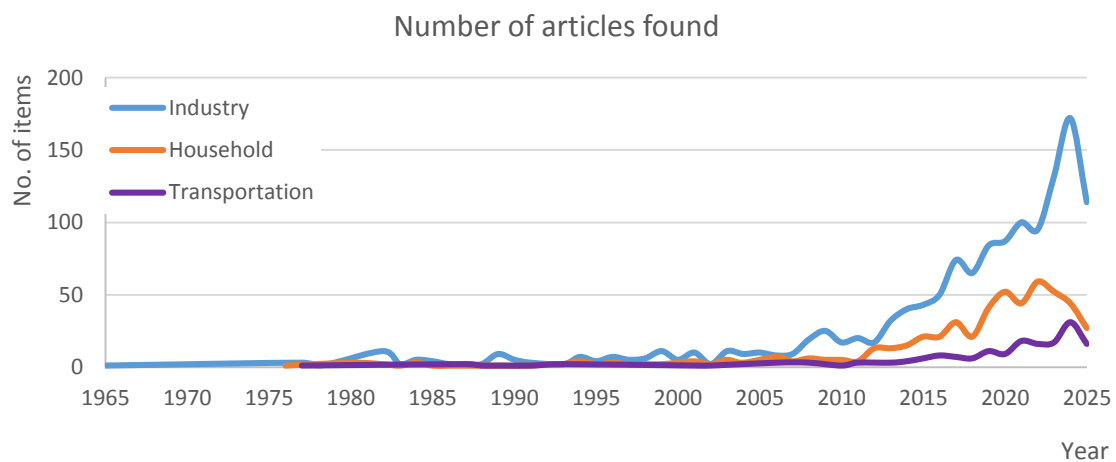


Figure 6. Number of articles in the first three areas published over the years.

Source: Scopus.

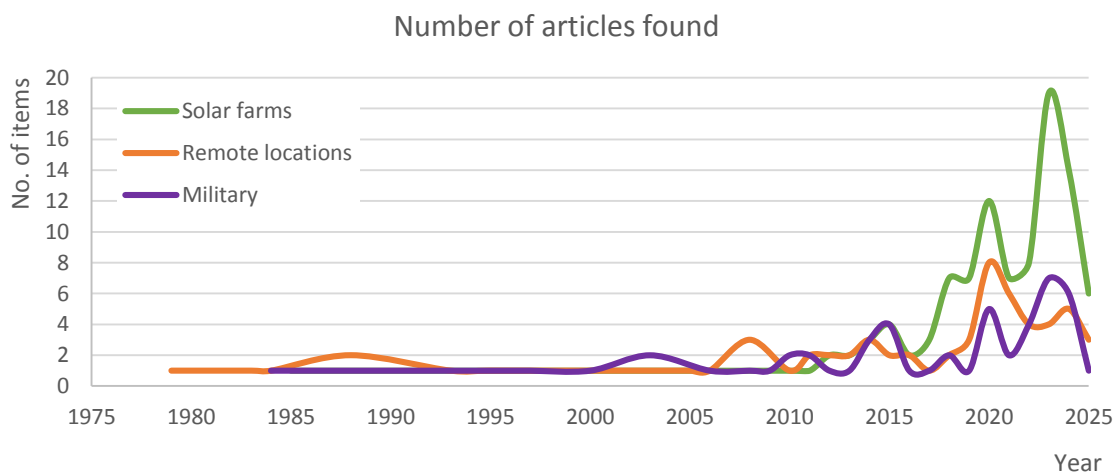


Figure 7. Number of articles in the last three areas published over the years.

Source: Scopus.

When analysing the abstracts and keywords of articles in specific areas, it is clear that terms such as "vehicle", "battery", "hybrid", "charging", and "range" dominate the field of transportation. The field of household highlighted "building", "façade", "rooftop", and "insulation design integration" issues. Papers on remote locations clustered around "off-grid", "island", "rural", and "standalone" topics. Solar farm articles emphasized "utility-scale", "large-scale", "grid", and "cost". Industrial applications focused on "manufacturing and process optimization", as well as "flexible roll-to-roll lines". Keywords in military articles included "tactical", "soldier", "lightweight", and "battlefield power".

Identifying the top authors in each area revealed interesting results presented in Table 6.

Table 6

Top-cited authors in each area

Area	Author	Cited by
INDUSTRY	– Grätzel M.,	41822
	– O'Regan B.,	27196
	– Gao P.,	9544
	– Nazeeruddin M.K.,	9344
	– Moon S.-J.	8881
HOUSEHOLD	– Yang Y.,	2638
	– Li Y.,	2052
	– Li Z.,	1848
	– Yang H.,	1617
	– Wang Y.	1606
TRANSPORTATION	– Li Y.,	6687
	– Wang Y.,	6257
	– Grätzel M.,	5400
	– Zhang J.,	5066
	– Friend R.H.	5056
SOLAR FARMS	– Grätzel M.,	28830
	– O'Regan B.,	27176
	– Zhang J.,	1967
	– Wang Y.,	1885
	– Han Y.	1791
REMOTELOCATIONS	– Das B.K.,	824
	– Wang Y.,	660
	– Hoque N.,	614
	– Mandal S.,	614
	– Hou J.	544
MILITARY	– Kist J.A.,	251
	– Essner J.B.,	251
	– Baker G.A.,	251
	– Polo- Parada L.,	251
	– Würthner F.	219

Source: own work.

Grätzel M. and O'Regan B. dominate in every industrial or solar farm-related context, indicating a close connection between these areas. In contrast, the transport and household sectors appear to be more dispersed, and among authors in the field of applied energy are Yang Y., Li Y., Wang Y. Finally, remote-location initiatives are spearheaded by a distinct set of authors (e.g., Das B.K. et al.), who concentrate on standalone rural electrification and micro-

grids. Military PV remains a niche slice; a single 250-citation paper skews the ranking and places its author group at the top.

4. Summary

Photovoltaics is a broad research area due to its multidisciplinary applications in various fields. However, previous research on photovoltaics has focused on general applications, capacity building, exploring advantages and disadvantages, and side effects. Photovoltaic applications have diversified across key societal sectors. In industry, PV drives innovation and circularity; in agriculture, it powers eco-efficient cultivation; in households, it supports autonomy and resilience; in transport, it enhances mobility electrification; in construction, it promotes sustainable materials; and in infrastructure, it underpins systemic energy transitions. Each sector carries unique integration strategies and benefits.

The analysis of emerging trends in photovoltaics includes perovskite solar cells, nanocrystal integration, optical property optimization, and hybrid photovoltaic systems that combine energy generation with agricultural, water, or architectural functions. Future research directions may include the use of advanced materials, improving photovoltaic performance in diverse environments, and increasing affordability and durability in rural electrification and specialized applications. Challenges for the future of photovoltaics include continued innovation in materials and system integration, greater penetration in developing regions, expanding hybrid applications, and growing synergies between photovoltaic systems and smart grids or energy storage solutions.

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TRANSFORMING PROFESSIONAL PRACTICE WITH CHATGPT: LEARNING AND INFORMATION PROCESSING

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Purpose: The main objective of the present study was to identify differences in how employed and non-employed students evaluate ChatGPT's dual functions – information processing and tutoring.

Design/methodology/approach: A Computer-Assisted Self-Interview (CASI) survey was conducted in the second quarter of 2024. After excluding non-users of ChatGPT, 449 valid responses were analyzed. Instrument reliability and factorability were verified. To assess the intensity of selected variables, a five-point Likert-type scale was applied. Because variables departed from normality, non-parametric tests (Mann-Whitney U) compared evaluations between employed and non-employed respondents.

Findings: Respondents in both groups evaluated ChatGPT positively as a substitute for a traditional search engine, with no notable differences between employed and non-employed students. In contrast, non-employed students assessed ChatGPT's tutoring role more favorably, which may reflect their greater reliance on digital tools for academic support. Overall, evaluations tended to be positive, although the variability in responses suggests differing levels of familiarity with or expectations toward the technology.

Research limitations/implications: This study reflects one point in time, so future research should examine changes over longer periods. The analysis focused only on two main functions of ChatGPT – information processing and tutoring and on general use rather than specific academic tasks. Because the sample consisted solely of Polish students, the findings may not be fully applicable in other cultural contexts. Future studies should therefore involve more diverse populations and explore additional functions and learning situations.

Practical implications: For students and early-career knowledge workers, conversational search with summarized answers can serve as the standard approach. Tutoring and guided support may be especially useful for those with more time for structured learning, such as non-employed students. Universities and organizations should combine AI use with basic training in how to check information, create effective prompts, and evaluate results, while also providing clear source information to ensure that human judgment remains central.

Social implications: Adjusting AI support to students' time and workload can help reduce inequalities in learning. Teaching habits of verification – such as citing sources and signaling uncertainty – can lower the risks of overreliance, bias, and weakened critical thinking, while still allowing users to benefit from productivity gains.

Originality/value: Introduces a two-function framework (interactive retrieval/processing vs. tutoring) linking HCIR-style information work with AI-supported learning, and provides empirical evidence that employment status does not shape evaluations of the search-substitution function but does differentiate evaluations of the tutoring function in a large sample of active users.

Keywords: ChatGPT; conversational search; Human-Computer Information Retrieval (HCIR), AI tutoring.

Category of the paper: Research paper.

1. Introduction

Generative conversational systems like ChatGPT are transforming the way individuals engage with information in their daily work. By leveraging advancements in Natural Language Processing (NLP), these systems can understand and generate human-like text, making interactions more intuitive and efficient (Bansal et al., 2024; Fui-Hoon Nah, 2023; Stock, 2000). As a result, users can retrieve information more naturally through dialogue, enhancing the information retrieval process (Agrawal, 2025; Segeda, 2025; McTear, 2022). Furthermore, the integration of knowledge graphs allows these systems to access and synthesize vast amounts of interconnected data, improving their ability to provide relevant responses (Liu et al., 2019). Chatbots, as a subtype of these systems, are increasingly utilized in various sectors, including customer service, where they automate tasks traditionally performed by humans (Almansor et al., 2019; Io, Lee, 2017; Thorne, 2017). This rapid diffusion of conversational AI is not only reshaping how people find and make sense of information but also revolutionizing learning processes in professional environments. Consistent with the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT), evaluations of conversational tools are driven primarily by perceived usefulness (performance expectancy) and perceived ease of use (effort expectancy), which, in turn, predict behavioral intention and use behavior (Venkatesh, Thong, Xu, 2012; Venkatesh et al., 2003; Davis, 1989). From a human-computer information retrieval (HCIR) perspective, dialog-based search and iterative synthesis reduce cognitive load and increase decision accuracy, thereby providing a mechanism that links the information-processing function to work outcomes (Hauff et al., 2021; White et al., 2013; Marchionini, 2006).

Beyond narrowly defined “writing aid” uses, two functions have become especially salient for knowledge-intensive tasks:

1. Interactive information retrieval and processing, where conversational search and synthesis replace multi-tab keyword querying.
2. On-demand tutoring, where the system explains concepts, scaffolds problem solving, and offers step-by-step guidance.

In theoretical terms, the interactive information-retrieval and processing function operates primarily by increasing performance expectancy and reducing perceived effort (effort expectancy) – thereby lowering cognitive costs within the HCIR framework – whereas the tutoring function depends more strongly on perceived ease of use (effort expectancy) and facilitating conditions (e.g., time and resources), consistent with the Technology Acceptance Model and the Unified Theory of Acceptance and Use of Technology.

Together, these capabilities promise time savings, reduced cognitive load, and faster movement from raw inputs to actionable judgments – while also raising concerns about bias, overreliance, and the erosion of critical appraisal skills.

A growing body of research highlights both the benefits and limitations of LLM-supported tutoring with respect to learning outcomes and the associated improvement in workplace performance. Reviews and experimental studies indicate that such tutoring can enhance motivation, foster higher-order thinking, and improve task performance, even with minimal guidance (Guo et al., 2025; Giannakos et al., 2024; Steinert et al., 2024). In parallel, studies of Human–Computer Information Retrieval (HCIR) and conversational search highlight how iterative dialogue, clarification questions, and retrieval augmentation can improve practical precision and recall relative to traditional search flows (Wang, Ai, 2022; Hauff et al., 2021; Salle et al., 2022). Yet, despite this momentum, we know less about how these two functions jointly structure users’ day-to-day work and which user characteristics systematically shape their evaluations of ChatGPT in each role. Thus, this area reveals a research gap, the exploration of which may constitute a valuable contribution to the development of disciplines such as management sciences, sociology, and pedagogy. This gap matters for organizations and higher-education institutions alike. Many students are already part-time employees or interns and act as “junior knowledge workers” whose tool choices spill over into professional practice. Previous studies indicate that perceptions and adoption vary depending on user characteristics, including age, familiarity with large language models (LLMs), context of use, and other factors (Acosta-Enriquez et al., 2024; Camilleri, 2024; Raman et al., 2024). Employment status, in particular, may shape both time availability and task portfolios, potentially shifting preferences toward rapid information triage (interactive retrieval from LLMs such as ChatGPT) rather than extended, lesson-oriented interactions (tutoring). At the same time, responsible-use frameworks emphasize keeping human judgment central, pairing AI support with provenance cues and light training in verification (Saenz et al., 2024; Marzouk et al., 2023; Dastani, Yazdanpanah, 2023).

Against this backdrop, this paper investigates how professional work is being transformed by ChatGPT, focusing on users’ evaluations of its two primary functions that directly support knowledge work: interactive information retrieval and processing, and tutoring for learning and upskilling. Drawing on a large sample of higher education students in Poland – many of whom are employed alongside their studies – we pose the following research question:

RQ1: How do users evaluate ChatGPT as an interactive tool for information retrieval and processing?

RQ2: How do users evaluate ChatGPT as a tutor that provides explanations and structures learning?

The remainder proceeds as follows. Section 2 reviews related literature and develops hypotheses – building on prior evidence, theoretical frameworks, and the aforementioned research questions, we propose two hypotheses regarding the effects of employment status-one for each function discussed in Section 2.2. To test these hypotheses, we conducted a computer-assisted self-administered interview (CASI) during the second quarter of 2024, yielding 449 valid responses from active ChatGPT users. Section 3 details the methodology. Following assessments of reliability and the data's suitability for factor analysis, we employed non-parametric tests to compare evaluations based on employment status. Section 4 presents the results, including descriptive statistics and statistical tests. Section 5 presents a discussion of the results, their interpretation, and the practical implications for educational and professional contexts. Section 6 concludes with limitations and directions for future research.

2. Conceptual background

2.1. Literature review

Among the most frequently used functions of ChatGPT are its role as an interactive tool for information retrieval and processing, and its role as a traditional tutor supporting educational tasks. Both of these dimensions substantially transform the work performed by contemporary individuals. Consequently, to move beyond descriptive accounts, this review is anchored in the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT). Predictions about the evaluation and adoption of ChatGPT follow from performance expectancy, effort expectancy, and facilitating conditions, moderated by user characteristics. By offloading routine search and synthesis, users can redirect attention to higher-order reasoning and creative problem-solving (León-Domínguez, 2024).

Empirical and review studies characterize ChatGPT as an effective and scalable tutor that provides instant explanations, writing support, guidance, and structuring of the learning process, which is highly beneficial for everyday work and for enhancing professional qualifications (Park, Kim, 2025; Sirisathitkul, Jaroenchokanan, 2025; Pardos, Bhandari, 2024). As a tutor in the workplace, ChatGPT explains complex issues in simple language, provides step-by-step guidance, and offers suggestions for improving texts, code, or analyses. This facilitates faster professional onboarding and the systematic development of skills. It can also simulate typical situations (e.g., a client conversation or a discussion of results)

and propose short exercises (Afzal et al., 2024; Yang et al., 2024). ChatGPT also yields positive effects by reducing the time required for learning, thereby enabling more efficient task performance and minimizing errors (Huesca et al., 2024; Reid, 2024). ChatGPT is also applied as a workplace tutor in cybersecurity and artificial intelligence training contexts (Cong-Lem et al., 2025). Research shows that when employees perceive ChatGPT as an intelligent, self-learning system, they acquire information and knowledge more readily. Consequently, they assess its usefulness more favorably and report a greater willingness to use it – and this willingness is the strongest predictor of actual adoption (Jo, Park, 2023). This, in turn, points to another important function of ChatGPT, namely its role as a tool for information retrieval and processing.

In the workplace and in the performance of everyday tasks, ChatGPT has facilitated a shift from keyword-based queries to conversational search interfaces. This transition is enabled by ChatGPT's natural language capabilities, which enhance user interaction and information retrieval. The conversational approach not only supports more intuitive and efficient searches but also reduces cognitive load, making it a preferred method for information seeking. This shift is observable across various sectors, where ChatGPT is employed for tasks ranging from brainstorming to drafting and proofreading, thereby transforming how information is accessed and applied in professional contexts (Retkowsky et al., 2024; Jo, Park, 2023). At the same time, this reconfiguration of workplace search reshapes information literacy: users increasingly depend on iterative, multi-turn exchanges that allow clarification and domain adaptation (e.g., through retrieval augmentation), thereby improving practical precision and recall (Zou et al., 2023; Kiesel et al., 2021; Liu, 2021). Consequently, the integration of techniques such as retrieval augmentation and interactive classification systems is pivotal in this transformation. These systems support a dynamic search process in which users refine queries and receive feedback that is both contextually relevant and precise. Such iterative processes offered by ChatGPT are particularly important for professionals who require high-quality, task-specific information, often under strict time constraints (Vishwakarma, Kumar, 2024; Al Naqbi et al., 2024; Zeng et al., 2022). Moreover, Human-Computer Information Retrieval (HCIR) enhances cognitive engagement. HCIR systems foster fluid, iterative user interaction and enable users to actively explore and refine search tasks – an ability that is crucial in time-sensitive professional contexts (White et al., 2013). However, in enumerating these benefits, it is essential not to overlook the attendant risks. Overreliance on conversational systems may inadvertently diminish critical-thinking skills, as users may accept AI-generated responses without adequate verification (Glickman, Sharot, 2024; Zhai et al., 2024). Moreover, concerns about bias, misinformation, and data security underscore the need to balance efficiency with responsible use, ensuring that human judgment remains central to information practices (Fecher et al., 2025; Buchanan, Hickman, 2024; Polyportis, Pahos, 2024). In particular, the human-computer information retrieval (HCIR) literature treats the user as an active partner in iterative search, and features such as explainability, source traceability,

and opportunities for clarification serve as mechanisms to reduce cognitive load, thereby strengthening perceived usefulness and effort expectancy (Hauff et al., 2021). Nonetheless, there is no indication that these risks will impede progress in the use of AI as an interactive tool for the acquisition and processing of information. On the contrary, recent studies indicate that, when embedded in HCIR-informed workflows and paired with retrieval augmentation, source attribution, and uncertainty cues, conversational systems can both accelerate sense-making and improve decision quality (Poddar et al., 2022). The strongest gains appear when tools nudge verification (e.g., cite-and-trace, side-by-side evidence views) and users receive light training in prompt and evaluation strategies – positioning AI as a high-leverage partner in knowledge work, under clear provenance, organizational guardrails, and human oversight (Farber, 2025; Järvelä et al., 2025; Robertson et al., 2024; Adam, Benlian, 2023).

2.2. Formulating hypotheses

A growing body of evidence indicates that students increasingly use ChatGPT in their everyday information-seeking activities – such as generating ideas, extracting key points, and identifying scholarly sources – treating it as an interactive interface for information retrieval rather than merely a writing aid (Ravšelj et al., 2025). Patterns of preference between Google and ChatGPT vary depending on user characteristics (e.g., familiarity with large language models, age), suggesting that group-specific attributes – including employment status – may shape how learners assess ChatGPT’s capabilities in information processing (Zhang, Yang, 2025). Researchers also describe LLMs as tools that accelerate access to and filtering of information, while emphasizing that both benefits and risks depend on their design and the surrounding context (Kasneci et al., 2023). Reviews concerning student engagement demonstrate heterogeneous outcomes across different environments and learner profiles, reinforcing the nondeterministic expectation that employment status influences perceptions of ChatGPT as a tool for information retrieval and processing (Lo et al., 2024). According to the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT), evaluations of ChatGPT’s information-processing role increase with performance expectancy and effort expectancy. Within the HCIR paradigm, this effect is mediated by reductions in cognitive costs during dialog-based search. Because employment status shapes available time and task portfolios, we anticipate differences in the strength of these mechanisms across groups. Accordingly, we state Hypothesis 1 (H1) as follows:

H1: Employment status differentiates students’ evaluations of ChatGPT as an interactive tool for information retrieval and processing (a substitute for a traditional search engine).

Research shows that LLM-supported tutoring, particularly when accompanied by explicit guidance or feedback, enhances learning outcomes. A review of multiple experiments revealed improvements in instructional performance, higher motivation, development of higher-order thinking, and reduced cognitive load (Deng et al., 2024). A randomized controlled trial further demonstrated that a guidance mechanism in working with ChatGPT-encouraging learners to

attempt a solution independently before receiving hints – promotes self-regulated learning, higher-order thinking, and knowledge construction more effectively than typical instructional tools (Lee et al., 2024). At the same time, student employment may reduce the time available for activities requiring greater time investment, such as extended study sessions (Darolia, 2014), and meta-analytic evidence shows that effective time management is moderately positively associated with academic achievement (Aeon et al., 2021). Taken together, these mechanisms motivate the expectation that employment status differentiates students' evaluations of ChatGPT's role as a tutor. Therefore, H2 is formulated as follows:

H2: Employment status differentiates students' evaluations of ChatGPT's role as a tutor (a learning support tool).

Considered jointly, H1 and H2 specify two complementary mechanisms – information retrieval and tutoring – by which employment status may influence students' evaluations of ChatGPT.

3. Research methodology

The study employed the CASI (Computer-Assisted Self-Interviewing) methodology. Participants accessed the questionnaire via a QR code or a link to the Webankieta platform. Responses were submitted using mobile phones, computers, or other internet-enabled devices. The collected data were subsequently exported to Microsoft Excel and IBM SPSS Statistics 29 for analysis. The survey was conducted in the second quarter of 2024.

Respondents were recruited from a variety of educational institutions across Poland and thus represented individuals enrolled in higher education. They covered a broad spectrum of academic disciplines, including the social sciences, humanities, natural sciences, and technical fields. Faculty and administrative staff at educational institutions assisted in facilitating student participation (in addition, social media campaigns were used to collect responses from individuals).

For further analysis, questionnaires from respondents who reported not using ChatGPT were excluded. Thus, only those who declared employing ChatGPT in their daily lives were retained. In total, 449 valid questionnaires from ChatGPT users were included in the dataset.

The survey instrument consisted primarily of closed-ended questions. To assess the intensity of selected variables, a five-point Likert-type scale was applied: -2 = "Certainly not," -1 = "Preferably not," 0 = "Uncertain," 1 = "Preferably yes," 2 = "Certainly yes".

Following data collection, a series of statistical tests – including Cronbach's alpha, the Kaiser-Meyer-Olkin (KMO) measure, and Bartlett's test of sphericity – were performed (see Table 1). These results confirmed the reliability of the survey instrument and its appropriateness for factor analysis.

Table 1.*Chat GPT as an information processing and learning tool – basic descriptive statistics*

Cronbach's alpha	Kaiser-Mayer-Olkin tests	Bartlett's test of sphericity
0.872	0.850	Approx. Chi-Square 3461.510 df 378 Sig. < 0.001

Source: own elaboration.

The Kolmogorov-Smirnov test was originally utilized to examine the distributional characteristics of the variables, indicating substantial departures from the normal distribution. As a result, non-parametric statistical methods were subsequently employed. In particular, Mann-Whitney U tests were conducted to assess the disparities among the variables.

4. Results

Table 2 presents basic descriptive statistics on the use of ChatGPT for interactive information acquisition and processing – as a substitute for a traditional search engine – and for its role as a conventional tutor that provides lessons and explains complex course topics. Evaluations of both functions are disaggregated by respondents' employment status (employed vs. not employed). In the search-engine-substitution function, assessments are clearly positive and very similar among students who are not employed and those who are employed (arithmetic mean 1.08 vs. 1.09). By contrast, the traditional tutoring role is stronger among students who are not employed (arithmetic mean 0.93) than among employed students (arithmetic mean 0.64), even though in both groups the median equals one. Additionally, standard deviations exceeding one indicate substantial variability in respondents' individual experiences.

The distributions also exhibit negative skewness across groups (ranging from -0.781 to -1.717), indicating that positive evaluations of ChatGPT were more frequent than negative ones. At the same time, the kurtosis values highlight differences in the shape of the distributions: positive kurtosis in most groups indicates “heavier tails”, whereas the negative kurtosis for employed students in the tutoring role (-0.371) suggests a flatter and more dispersed response pattern. Taken together, these statistics confirm that while central tendencies are broadly similar, the underlying variation in experiences and intensity of use is noteworthy.

Table 2.*Chat GPT as an information processing and learning tool – basic descriptive statistics*

Specification	Information processing – ChatGPT as a Search engine		Learning – Chat GPT as a Tutor	
	Not employed N = 88	Employed N = 361	Not employed N = 88	Employed N = 361
Mean	1.08	1.09	0.93	0.64
Standard error of the mean	0.117	0.054	0.108	0.059
Median	1.00	1.00	1.00	1.00
Mode	1	1	1	1
Standard deviation	1.096	1.018	1.015	1.117
Variance	1.200	1.037	1.030	1.248
Skewness	-1.717	-1.465	-1.347	-0.781
Standard error of skewness	0.257	0.128	0.257	0.128
Kurtosis	2.688	1.745	1.712	-0.371
Standard error of kurtosis	0.508	0.256	0.508	0.256
Min	-2	-2	-2	-2
Max	2	2	2	2

Source: own elaboration.

In order to assess the disparities among the distinct groups, non-parametric tests were employed (as mentioned the distribution was not normal). The Mann-Whitney U tests concerning employed respondents (as opposed to those not employed) and their information processing capabilities do not reveal any significant differences in the contemporary perception of ChatGPT ($U = 15824.500$; $Z = -0.060$, $p = 0.952$). The circumstances concerning the role of the tutor are delineated differently.

The Mann-Whitney U tests, when comparing employed participants (as opposed to those not employed) and their learning experiences, reveal notable disparities in their current perceptions of ChatGPT ($U = 13621.000$; $Z = -2.256$, $p = 0.024$). Consequently, it is possible to dismiss hypothesis 1, whereas hypothesis 2 can be substantiated.

In summary, the findings show that while ChatGPT's role as an information-processing tool is widely recognized, its tutoring function is more sensitive to contextual factors such as time availability and workload. The observed variability further suggests that individual characteristics beyond employment status may play a significant role in shaping adoption and evaluation patterns.

5. Discussion

The findings suggest that students (regardless of employment status – accordingly, hypothesis 1 can be rejected) converge in using ChatGPT as a fast, interactive substitute for traditional search, with virtually identical central tendencies (median = 1; mean $\approx$ 1.08-1.09) and pronounced negative skewness indicating generally positive evaluations. Consistent with the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of

Technology (UTAUT), this pattern implies that when performance expectancy is high and cognitive costs in dialog-based search (HCIR) are low, evaluations converge across employment groups. This aligns with recent evidence that many undergraduates frequently choose conversational tools for academic help-seeking, with preferences varying by user characteristics (e.g., LLM fluency, age) (Zhang, Yang, 2025; Ravšelj et al., 2025).

By contrast, ChatGPT's role as a classic tutor appears more salient among non-working students (mean = 0.93 vs. 0.64), and the Mann–Whitney test confirms this difference ($p = .024$), supporting hypothesis 2. The advantage observed among nonworking students aligns with UTAUT: effort expectancy and facilitating conditions (e.g., time and support) enhance evaluations of the tutoring role, whereas time constraints among employed students attenuate this effect. This pattern is consistent with experimental and review evidence showing that LLM-based tutoring can improve learning when students have time and when guidance is provided (Deng et al., 2024; Lee et al., 2024). A plausible interpretation is that employed students have less time for guided, lesson-like interactions or rely on alternative learning resources at work, whereas non-working students may seek more structured explanations and step-by-step support. At the same time, standard deviations exceeding 1 (on a -2 to 2 scale) and positive kurtosis in three groups – with negative kurtosis in one – indicate heterogeneous distributional shapes, with heavier tails (and a higher chance of extreme responses) in the positively kurtotic groups and a flatter profile in the negatively kurtotic group, mirroring broader literature that finds mixed engagement effects and emphasizes the importance of instructional design and safeguards (Kasneci et al., 2023; Lo et al., 2024). Practically, these results imply that universities could emphasize search-facilitating features for all students, while tailoring tutoring-style scaffolds – especially scaffolded, hint-based use – for those not working, in line with human-centered policy guidance on GenAI in education (UNESCO, 2023).

From a practical perspective, the results point to two distinct modes of using ChatGPT. The first involves quick conversational search, which may serve as the standard approach. The second entails more structured tutoring, which is most appropriate when deeper learning or the acquisition of new skills is required. For working students, brief and targeted support – such as concise hints, short checklists, or rapid feedback – may better align with limited time resources. However, it should be noted that greater time constraints among working students compared to non-working peers represent only one possible explanation; identifying the precise reasons for these differences requires further in-depth research. In contrast, non-working students often have the opportunity to engage in extended, step-by-step learning sessions. In both cases, it is essential to incorporate features that encourage verification of answers, such as source attribution or indicators of uncertainty, alongside basic training in evaluation skills.

More broadly, the findings raise important implications for educational and workplace settings. Institutions could integrate ChatGPT into teaching and training programs in ways that complement, rather than replace, critical thinking and expert knowledge.

The observed differences between employed and non-employed students suggest that support should be adapted to users' time constraints and needs. By tailoring these approaches, institutions can enhance the benefits of ChatGPT while mitigating risks of misuse or unequal access.

6. Conclusions

The findings of this study underscore the dual role of ChatGPT in reshaping professional activities, functioning both as an interactive tool for information retrieval and as a tutor supporting structured learning. Notably, the results indicate that employment status affects evaluations of ChatGPT's tutoring function but not its information-processing role, suggesting the need for differentiated approaches in educational and workplace contexts.

This study has several limitations. First, its static temporal horizon captures only a snapshot of reality at a specific point in time; longitudinal research could offer deeper insights into the evolution of attitudes and usage practices. Second, the analysis focuses on ChatGPT as an information retrieval and processing tool and as an on-demand tutor, functions that are highly relevant but not exhaustive of its capabilities. Third, the study examines only general usage patterns without considering specific application contexts, which may have revealed more nuanced findings. Finally, the exclusive focus on Polish students limits the generalizability of the results; broader cross-cultural and cross-system studies could provide a more diverse and comprehensive understanding of ChatGPT use. These conclusions are consistent with predictions from TAM and UTAUT and with HCIR mechanisms: rapid, dialog-based information processing depends on high performance expectancy under conditions of low cognitive cost, whereas the tutoring function is more sensitive to effort expectancy and facilitating conditions.

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SOCIAL RESPONSIBILITY OF BUSINESS IN THE SHAPING OF FOOD SAFETY QUALITY

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Purpose: The aim of the study is to raise awareness among stakeholders of the impact of corporate social responsibility on the development of food safety quality.

Design/methodology/approach: The study focused, among other things, on the distribution of selected elements of the global food security index measurement indicator in Poland and selected European countries. The focus was on the safety and quality indicator.

Findings: The implementation of CSR activities in this state of affairs to ensure food quality and safety in the food chain by market stakeholders does not improve the Quality and Safety index (74.1) or the Global Food Security Index (75.5). There is a continuous downward trend in the BS index, and in the GFSI it stabilizes at the level of 75.

Research limitations/implications: A new study should be conducted, supplementing the data with the results of entities from individual stages of the food chain “from farm to table” with particular emphasis on rural areas. It would be worthwhile to conduct an analysis broken down by province.

Social implications: The development and expansion of the capabilities of food industry entities, including through improving the quality and safety of food production, contributes to improving the image and quality of life of society. Implementing CSR activities brings tangible benefits to market stakeholders.

Originality/value: The article highlights the poor effectiveness of policies and measures aimed at improving food security in Poland. This applies to both the government and all entities in the food chain.

Keywords: Safety, quality, food security, corporate social responsibility.

Category of the paper: Research paper.

1. Introduction

The activities carried out by food processing entities as part of corporate social responsibility (CSR) are part of a country's food vision and policy. The quality and safety of food offered by entities, as well as declared by the government, are elements of a complex global food production system. Ensuring benefits for all market stakeholders, whether

economic, social, or environmental, requires a significant effort from all entities in the food chain, as well as from consumers themselves. The impact of atmospheric, geopolitical, and economic changes affects changes in agricultural production, the provision of adequate supply chains, and production potential, increasing the level of risk in food processing activities that guarantee food security and sustainable development. As part of their CSR activities, companies are trying to implement changes based on a systematic approach to quality improvement, guaranteeing the minimization of risks of non-compliance, bacterial hazards, or product compliance risks, in order to meet consumer expectations and requirements. Agricultural entities (farmers) are also striving to modernize and properly manage agricultural production so that products are of the highest quality and safety for consumption (processing). All government measures to strengthen production capacity are intended to increase the resilience of the food sector, despite emerging new challenges, threats, and constraints, both in environmental terms (investments in new green technologies, renewable energy sources, etc.), financial (preferential financing, subsidies, and other types of aid) or political (in line with EU policy).

CSR practices and research (in this area) indicate that all these measures are aimed at increasing external, internal, and environmental responsibility as perceived through the prism of food safety awareness identified by various indicators. One of the main indicators determining the state of food security in a given country is the Global Food Security Index. Its complex structure, which assesses various aspects of nutrition in the broad sense, and its annual update provide an overview of the degree to which pro-nutrition tasks are being implemented. Scientific publications most often identify factors threatening food security (Wiśniewska, 2024; Adamczyk, 2019; Muresan et al., 2020; Saha, Manickavasagan, 2021) or condemn actions that minimize the risk of these threats (Agus et al., 2020; Awuchi, 2023; Maziarz 2019; Purwanto et al., 2020), limiting the demonstration of correlations between food safety assessment indices. This results in a research gap that is worth exploring, as CSR activities adopted in contemporary business and food industry enterprises have a significant impact on shaping food safety.

Therefore, for research purposes, the main hypothesis was formulated: (H1) an increase in actions taken to ensure food safety translates into an increase in the global food security index in a given country. Conducting research in this area was also intended to help prove the auxiliary hypothesis (H2): growing awareness and application of CSR does not always translate into systemic support from the state. These research hypotheses emphasize the importance of measures implemented in the country to increase national food security. To this end, in order to reduce the negative impact and minimize the risk of threats in the food industry and in all links of the food chain, stakeholders (entities) must implement tools and good practices that increase the quality and safety of food. My research presented in the article is part of a long-standing discussion on the importance of quality and safety in food (Rudnicka, 2012; Filek, 2013), therefore the aim of the publication is to raise stakeholder awareness of the impact of corporate social responsibility on the development of food safety quality.

2. The essence of corporate social responsibility

Dynamic changes taking place on the market resulting, among other things, from globalization, growing consumer awareness among market participants, the development of national economies and economic entities both domestically and internationally, as well as noticeable changes related to the deterioration of the natural environment and relations between countries, leading to an increase in conflicts, including armed conflicts (geopolitical changes), have forced the implementation of responsible policies based on social considerations. Increasingly, the effects and consequences of decisions made as a result of management practices are causing economic entities to view favorably and implement the idea of responsible business, particularly in the food industry. Corporate Social Responsibility (CSR) is popular among entities focused on social, environmental, and economic balance, taking into account the needs and expectations of stakeholders (Rudnicka, 2012; Filek, 2013).

Social responsibility is a term used in business that is defined and presented in various ways, but is focused on multi-level responsible business conduct integrated with management processes in the company (Cochran, 2007). In the evolution of this concept, the initial focus was on working conditions and commitments to human capital (Adamczyk, 2009). Subsequently, emphasis began to be placed on the ethical conduct of organizations, i.e., business ethics. This is particularly important in the food industry, where food adulteration is a negative phenomenon. A. Smith stated that an individual operating in a competitive market who strives to achieve personal utility in a legal and moral manner also unconsciously fulfills certain social goals, which ultimately shapes the perception of ethical behavior (Dołęgowski, 2005). The European Commission points out that CSR is the voluntary integration of both environmental and social values into an organization's activities (EC, 2001). Other definitions refer to CSR only as an element that helps to achieve economic goals and point to the need to maintain good relations with those stakeholders who may influence the company's performance (Rudnicka, 2012). Still other definitions state that CSR is a way of generating profits and strengthening a company's market position, providing added value for stakeholders (MFIPR, 2020; Dymowski, Szymańska, 2009; Bartkowiak, 2011) by improving the quality of life in social and economic terms (Bratkowski, 2020; Navarro, 1988). In other words, corporate social responsibility is a concept of managing an entity that focuses on the individual, the environment, and market stakeholders, in line with ethical and philanthropic attitudes, compliance with the law, and the principle of maximizing value, including economic value. This definition means that the main objectives of CSR are moral, institutional, and organizational. CSR practices among companies indicate that (Kazojć, 2010) from the point of view of food safety, areas of internal responsibility related to production, products, employees, and improving their quality of life, as well as environmental responsibility (Rok, 2008; Wyszomirski, Olkiewicz, 2020), including a focus on good practices and pro-

environmental activities that reduce the risk of environmental degradation, are becoming very important. The third type, external responsibility (Julewicz, Ejdys, 2009), is important from a business perspective, as it concerns marketing, sponsorship, support for entrepreneurship, education, culture, and the arts for the local community and region.

Corporate social responsibility in food industry companies is a management concept that represents an organization's response to the expectations of sustainable development strategies in all areas of social life (Czernyszewicz, Wiśniewska, 2024). Combining various areas, directions, and objectives of business management, it focuses on the importance of quality and the elements that identify it in the context of food safety.

3. Quality in the food industry

Quality is not clearly defined. However, it is focused on identifying certain characteristics of a product or service and their individual elements that are consistent with the intentions or expectations of satisfying the needs of market stakeholders (Wiśniewska, 2025; Grębowiec, 2015). The perception of quality (Hamrol, 2013) depends on the degree to which needs are met. This means that economic operators take all measures to shape quality, incurring costs to improve various areas of the organization, including: the subject of activity (goods, products, services, processed raw materials), characteristics of the subject of activity (durability, diversity, cost-effectiveness, functionality, compliance), method of execution (efficiency, processes, technologies, procedures), sales, and R&D (Kumar et al., 2016; Adamczyk, 2019; Jeżewska-Zychowicz, 2014). Therefore, researchers in the literature on the subject indicate that quality should be perceived in technical, economic, and statistical terms, focused on customer needs and satisfaction (Myszewski, 2009; Saleem et al., 2015; Rimawan et al., 2017). Economic entities, including those in the food industry, strive to create an appropriate quality standard for a product or service and ways to maintain it (repeatability, standards) (Pawlak-Lemańska, 2019; Cyran, 2014). In the food industry, the term “food quality” refers to food performance that meets customer expectations and needs and shapes satisfaction (Leo et al., 2021; Saha, Manickavasagan, 2021). It is worth noting that the term quality also refers to other elements, such as raw materials, goods, food products, and technological processes. In particular, it refers to areas that meet specific standards (norms) for specific groups of factors characterizing a given product, e.g., organoleptic characteristics, physicochemical properties, nutritional values, or labeling. This is particularly important because the changing environment poses new threats to the food chain. Consumers are sometimes exposed to, for example, chemical compounds (with varying degrees of contamination) found in food, as they are not always aware of what food products may contain. Among the chemical hazards, the most common are those that are commonly found in the environment (heavy metals, pesticide residues, dioxins,

polychlorinated biphenyls, polycyclic aromatic hydrocarbons) and those whose presence in food can be avoided or reduced to an acceptable level through the use of food safety systems (medicines, plant protection products, technical aids and preservatives, substances resulting from improper food storage or processing technologies) (Olkiewicz, Wolniak, 2018).

It is important that the product can be characterized as safe for health, increasingly based on environmental (ecological) parameters, which shape purchasing preferences and a healthy lifestyle (Petrescu et al., 2020). Food industry entities perceive and analyze food quality in terms of health safety (confirmed by relevant institutions, e.g., the Sanitary Inspection or Veterinary Inspection) and economic aspects (cost-effective production ensuring customer satisfaction and increased market share). The entire food chain process (“from farm to table”) must comply with food law articles in terms of safety and meet the quality characteristics of products and services while satisfying customer needs and expectations (Sikora, 2010). This means that the simultaneous creation, maintenance, and improvement of the quality level of a food industry company is necessary and achievable thanks to, among other things, appropriate standards, implemented measures (Kowalczyk, Kwasek, 2020) and quality management systems (Łuczka-Bakula, 2012).

Food industry entities, in compliance with the law, operate in accordance with, among others, the food code (CODEX ALIMENTARIUS), also adopted by the Chief Sanitary Inspectorate, which contains accepted international food standards, as well as recommendations and guidelines. Growing and new threats mean that, in the context of food safety, the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO), as the Codex Alimentarius Commission, are proposing changes to the provisions. The Code is the foundation for other food safety standards such as HACCP, ISO 22000, BRC, and IFS.

HACCP is a control system (Mortimore, Wallace, 2013) designed to ensure the safety and quality of food products by identifying chemical, microbiological, and physical health hazards that may occur during production. HACCP covers the manufacturing process, in which it identifies, analyzes, eliminates, or reduces the risk of critical factors that may affect food safety, for example, in the area of bacterial pathogens (*Escherichia coli*, *Listeria*, *Salmonella*, etc.), viral pathogens (*hepatitis A*, *rotavirus*, etc.), parasitic pathogens (*Cryptosporidium*, *Entamoeba histolytica*, *Trichinella*, etc.), toxic microbial metabolites (*mycotoxins*), etc. (Awuchi, 2023). This system covers all stages of production (Kotsanopoulos, Arvanitoyannis, 2017), i.e., from raw material input, through processing, to product output (Muresan et al., 2020; Maziarz, 2019), to ensure food safety and health protection, as well as to prevent the possibility of foodborne disease outbreaks. This international standard provides the foundation for other instruments to ensure food safety. One of them is the ISO 22000 international food safety management system. This system complies with ISO 22000:2018, which sets out the path that an organization must follow to ensure and guarantee food safety, referring to both the food code and the HACCP safety system (Gil et al., 2017; Segovia et al., 2014).

The scope of the management system covers the entire organization, not just the production (process) area, which guarantees the possibility of adapting both the infrastructure of the organization (warehouses, production, etc.) and personnel (increasing employee awareness and responsibility, improving qualifications, hiring specialists, etc.) to the requirements of the standard as well as business (increasing sales opportunities by gaining trust in the safe product offered, minimizing costs, etc.). The ISO 22000 standard is dedicated to entities in the food chain that can jointly ensure the effectiveness of the food safety system (if all organizations in the chain have and comply with the standard), guaranteeing the integrity of the chain “from farm to table.” Otherwise, the guarantees apply only to a single entity. ISO 22000 is an international standard for food safety management systems that combines the requirements of good practices, HACCP, and the structure of the ISO 9001 standard (management system), providing integrity and ensuring food safety for all links in the food production chain. The ISO 22000:2018 standard focuses, among other things (Purwanto et al., 2020), on the need and obligation to control food safety hazards, becoming an important tool for monitoring the safety of the entire food chain in food industry companies. It should be noted that the system itself is not effective and efficient without adequate commitment to the production of food that is healthy and safe for human life and the acceptance of stakeholders, as factors such as human factors, organizational policy (often correlating with the direction of the country's development), and corporate awareness (in all areas of activity) determine the impact of the food production hygiene environment, food traceability, and the use of labeling (Wiśniewska, 2024). The pursuit of the desired health quality is possible, among other things, through the implementation and improvement of management systems and the organization's compliance with specific requirements, expectations, and standards, e.g., from the ISO or BRC (British Retail Consortium) and/or IFS (International Featured Standards), the application of which will increase its economic and image sphere (Agus et al., 2020; Weyandt et al., 2011; Dzwolak, 2011) as a responsible entity.

4. Research methodology

The aim of the study was to show the distribution of selected elements of the Global Food Security Index (GFSI) resulting from responsible decisions and actions in Poland and selected European countries. For this purpose, a main hypothesis (H1) and a secondary hypothesis (H2) were formulated:

- H1 – an increase in actions taken to ensure food safety translates into an increase in the global food security index in a given country,
- H2 – growing awareness and application of CSR does not always translate into systemic support from the state.

It should be noted that GFSI is an index that comprehensively examines food security in various countries around the world. GFSI consists of a set of indicators and measures food security in most countries around the world, i.e., 113 countries. The index was first published in 2012 and is managed and updated annually by The Economist's analytics department and supported by Corteva Agriscience (a publicly traded company operating in the broadly defined agricultural sector, offering innovations and innovative solutions to global agricultural challenges). Economist Impact is responsible for all content of the index, in particular the methodological and analytical part. The index itself is a dynamic quantitative and qualitative comparative model, built on the basis of 38 unique indicators that measure food security factors in countries in specific areas. The GFSI measures food security compliance in four categories: Affordability, Availability, Quality and Safety, and Sustainability and Adaptation. My study focused exclusively on analyzing variables from the Quality & Safety subgroup, as this group includes variable parameters corresponding to CSR (market stakeholders), e.g.: developing appropriate food safety regulations, food safety mechanisms, the possibility of safe food storage, a national nutrition plan or strategy, food labeling in terms of nutritional value, nutritional monitoring and supervision, and national nutritional guidelines.

The analysis of individual subgroups and their Quality & Safety variable categories, also in relation to selected European countries, allowed us to verify the hypotheses. The verification was carried out as part of a comparative analysis of data from 2012-2022, and trends were identified. The selection of European countries for comparative analysis with Poland was made deliberately, i.e., countries with the highest GFSI index and middle-ranking countries, as well as the Visegrad Group countries, were selected. The study included twenty countries: Bulgaria, the Czech Republic, Spain, Sweden, Slovakia, the United Kingdom, France, Germany, Greece, Hungary, Ireland, Denmark, Finland, Italy, the Netherlands, Austria, Belgium, Poland, Portugal, and Romania. It should be noted that the selected countries also had to show significant volatility in the index between 2012 and 2022.

5. Results and discussion

The responsible actions taken by market stakeholders in individual European countries aimed at food safety quality are reflected in the Global Food Security Index in 2022 (Fig. 1).

The data presented in the chart shows that the distribution among individual European countries is uneven, with all countries except Romania achieving a score above 70%. Poland ranks 21st among the 113 countries surveyed, with a score of 75.5%.

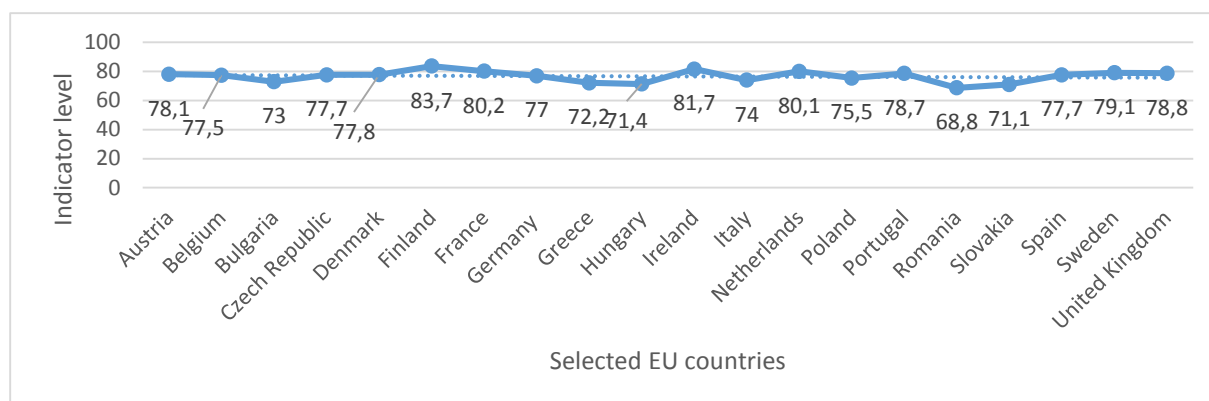


Figure 1. Global Food Security Index in 2022 (scoring).

Source: own work based on: <https://impact.economist.com/sustainability/project/food-security-index/>

This indicates that food security in Poland and the countries presented is at a very good (80+) and good (70-79.9) level. Only Romania achieved an average level. It is worth noting that all countries covered by the index have shaped their current level over many years through various activities in the area of food security. The evolution of the Global Food Security Index has been variable, as shown in Table 1. Although the trend is upward, there are periods of decline (in 2015, 2018, and 2020) and stability in 2021.

Table 1.

Global Food Security Index in Poland (scoring)

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Poland	68,5	71,3	72,3	71,5	72,9	73,2	73,0	75,5	75,0	75,0	75,5

Source: own work based on: <https://impact.economist.com/sustainability/project/food-security-index/>

As shown in Table 1, the rate of growth of the index in Poland is not as fast, as this index comprehensively examines food security. The quality and safety index includes component parameters such as dietary diversity, nutritional standards, micronutrient availability, protein quality, food safety, along with subgroups. The study focused on this parameter of food safety quality assurance.

The changes introduced, both systemic and strategic, tactical, and operational in food industry enterprises, required time and appropriate resources, as well as an appropriate action strategy. This was particularly true given that between 2008 and 2019, the number of annual notifications to the RASFF (Rapid Alert System for Food and Feed) about food “falsification/fraud” increased in Europe (Fig. 2).

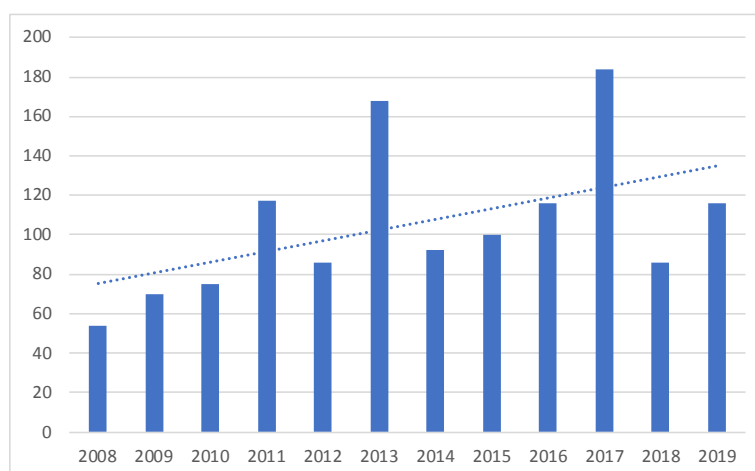


Figure 2. Number of cases of adulteration/fraud reported to RASFF.

Source: Hellberg et al., 2021.

In Poland, this trend was declining (Fig 3), as confirmed by the results of physicochemical tests of food products and labeling. A similar trend was observed in organoleptic tests.

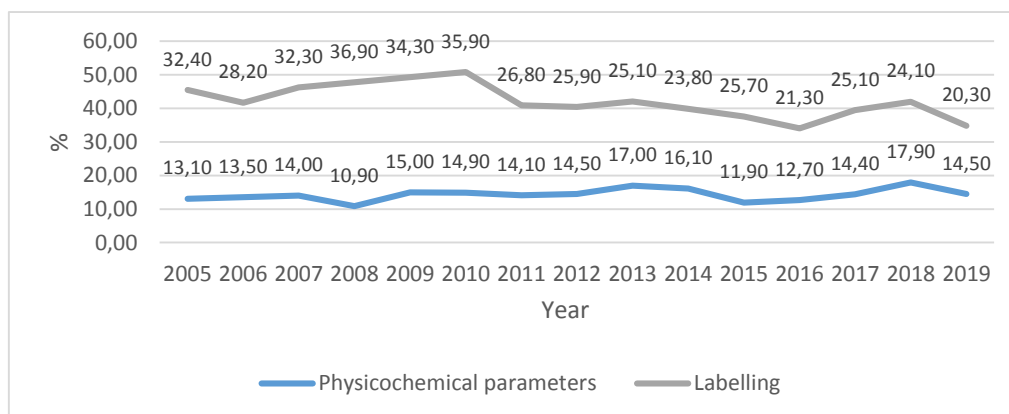


Figure 3. Ratio of food products tested to irregularities found in the area of quality.

Source: own work based on: (Kowalczyk, Kwasek, 2020).

A similar trend was observed in organoleptic tests (Fig. 4).

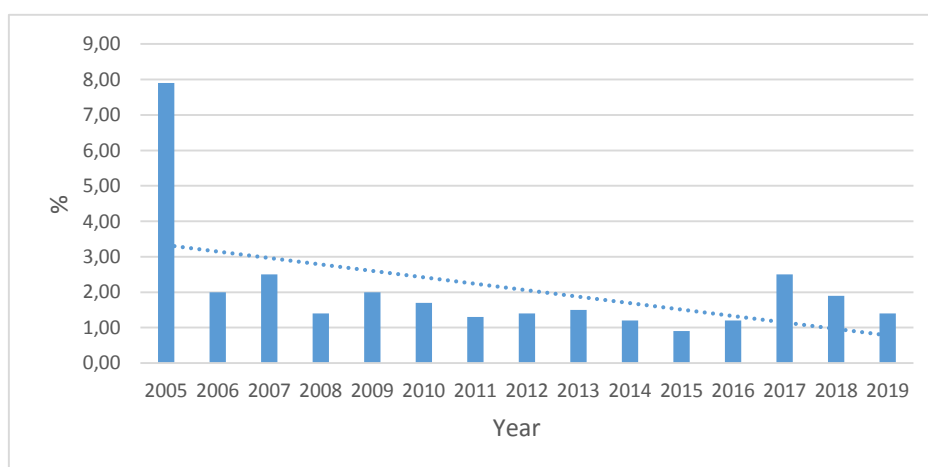


Figure 4. Ratio of food products tested to irregularities found in organoleptic tests.

Source: own work based on: Kowalczyk, Kwasek, 2020.

Analysis of the data from Fig. Xi Y indicates that ensuring the quality and health safety of food production has become a fundamental objective of state authorities, but also of entities in the food chain. To ensure food safety and the quality of food production, governments have established various institutions to control food and the way it is produced. In Poland, these include the State Sanitary Inspection (PIS), the Veterinary Inspection (IW), the Agricultural and Food Quality Inspection (IJHARS), the Trade Inspection (IH), the State Plant Health and Seed Inspection Service, and the Environmental Protection Inspection. Thanks to these organizations, among others, countries, including Poland, have been able to develop nutrition programs and strategies and set national nutrition guidelines (Tab. 2). Development in this area is presented by the composite indicators of the quality and safety parameter of the Global Food Security Index, confirming hypothesis 2.

Table 2.

Evolution of the variability of nutritional standards indicator parameters (scoring)

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
National dietary guidelines	0,0	0,0	0,0	0,0	50,0	50,0	50,0	50,0	100,0	100,0	100,0
National nutrition plan or strategy	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0

Source: own work based on: <https://impact.economist.com/sustainability/project/food-security-index/>.

An important assessment parameter is the food safety index. Although it is on a downward trend in Poland (Fig. 5), it still remains at a high level.

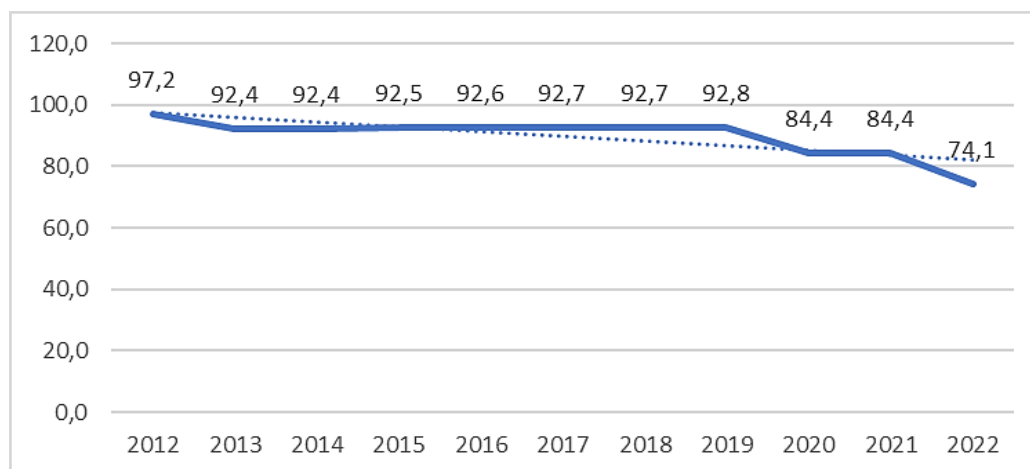


Figure 5. Food safety index in Poland (scoring).

Source: own work based on: <https://impact.economist.com/sustainability/project/food-security-index/>

It is worth noting that the downward trend is visible in almost all of the countries presented (Fig. 6), which may indicate that changes resulting from globalization, increasing urbanization, and expectations and needs have significantly determined the quality and safety index.

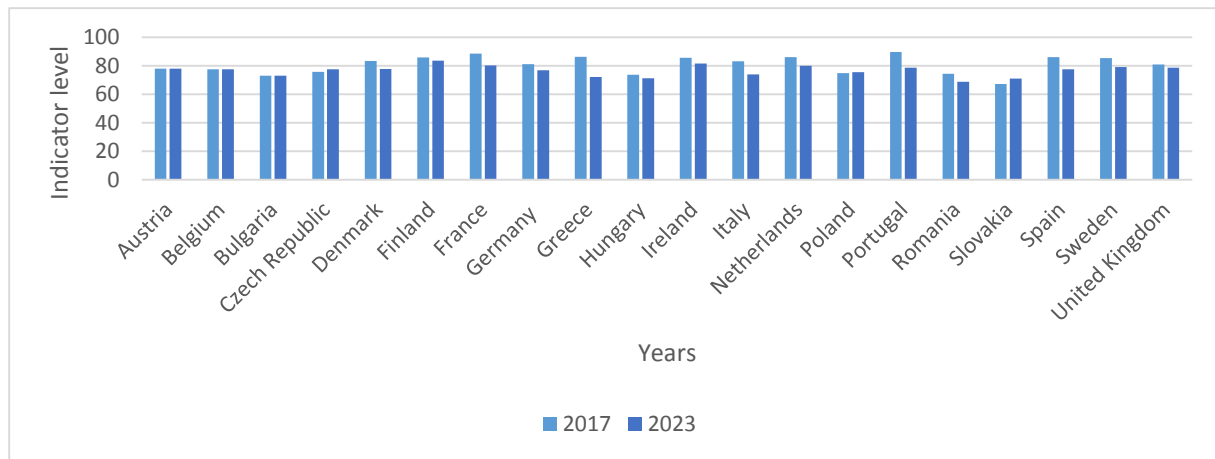


Figure 6. Comparison of food safety indicators in the analyzed countries in 2017 and 2023 (scoring).

Source: own work based on: <https://impact.economist.com/sustainability/project/food-security-index/>

This parameter, together with the variables that shape it, indicates that entities supporting the implementation of food safety policy play an important role in Poland. This applies to both the creation of an appropriate legal framework through mechanisms ensuring food safety and the logistical capabilities related to food storage standards. Responsible management (CSR) is intended to support decision-makers in implementing multidimensional measures that guarantee the safe operation and development of all entities in the food chain and consumers themselves.

Although the analysis of the dependent variables of individual indicators shows increasing and decreasing trends (in the period under review), which affects the variable level of the main indicators of quality and safety, Poland still ranks high in comparison with other countries in the Global Food Security Index, as shown in Fig. 7, confirming hypothesis 1.

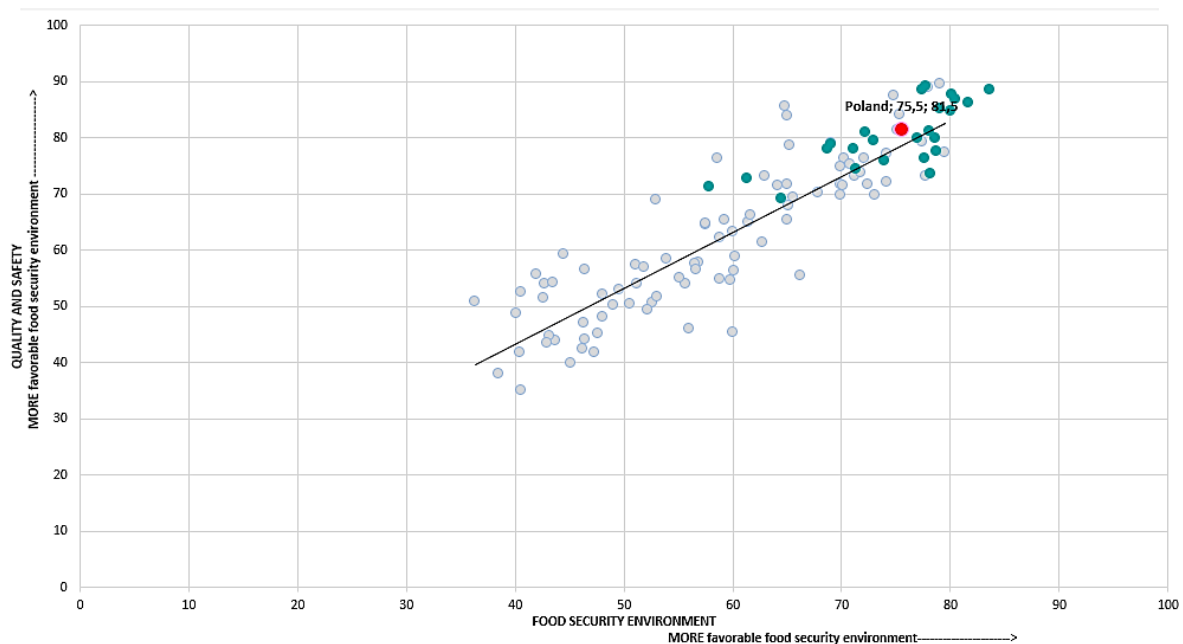


Figure 7. Poland's position compared to the analyzed countries.

Source: own work based on: <https://impact.economist.com/sustainability/project/food-security-index/>

Poland's position in the distribution of other European countries indicates that there are countries with higher rankings, and by increasing our efforts (energy) to improve safety and quality in specific areas, we could improve our position. Analyzing historical data, we can conclude that despite the fluctuating distribution of the safety and quality index in Poland, the GFSI index remains firmly established at 75.

6. Summary

The aim of the study was to raise awareness among stakeholders about the impact of corporate social responsibility on the development of food safety quality. The study aimed to demonstrate that food quality and safety are an integral part of corporate social responsibility activities aimed at ensuring food safety. The identifying parameter for food safety is perceived by the level of the Global Food Security Index in a given country. The study showed that this index in Poland has been growing steadily since 2012, stabilizing at 75.0-75.5 in the period 2019-2022. This is a good level, but unfortunately the elements that shape it do not have such a stable trend. An example is the quality and safety parameter. This parameter in Poland was 97.2 in 2012 and will be 74.1 in 2022. This means that in the case of the quality and safety index, the trend is declining. It should be noted that this situation also occurred in almost all of the 20 European countries compared. This is undoubtedly key information for market stakeholders to take action in specific areas of the food chain to halt this trend and reverse it.

By stepping up CRS activities, all stakeholders in the food chain will be able to feel safe, both in the process of manufacturing and processing raw materials into finished products, and during their consumption. Ensuring quality and safety, e.g., at the production stage, without food adulteration, is a challenge for any organization, given the rapidly changing expectations and requirements of customers. The results of the study confirmed the hypotheses and the objective of the study was achieved.

However, the research has certain limitations, as the lack of data prevented a deeper and broader analysis of the food market in Poland, a comparative analysis of regions (provinces), and a broader identification of CSR activities. It would therefore be worthwhile to conduct such an analysis in the future using a questionnaire (albeit in a single region), which would increase the contribution to the discipline of management and quality sciences. Nevertheless, it should be noted that the growing awareness of market stakeholders and changes introduced by government organizations dealing with food safety are prompting food industry organizations to implement and improve quality management systems, building consumer confidence in high-quality products, minimizing the risk of microbiological, physical, and chemical contamination of the product, and ensuring the reliability of labeling. Therefore, it is important that entities

operating in the free market act in accordance with the idea of responsible business, which in the long term will bring significant benefits in all areas of the company's operations in the food chain.

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DEVELOPMENT POTENTIAL OF EDUCATIONAL FARMS AS EXAMPLED BY THE SILESIAN VOIVODESHIP

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Purpose: The purpose of this study is to identify and analyze the developmental potential of educational farms in the Silesian Voivodeship, with particular emphasis on internal resources. The research aims to contribute to the theoretical and empirical discourse on the role of educational farms in sustainable development, social farming and social entrepreneurship.

Design/methodology/approach: The study employs a mixed-method approach combining elements of strategic self-assessment with participatory action research. The data were subjected to qualitative content analysis with categorical coding to extract dominant themes. Additionally, participatory action research approach enabled in-depth engagement with selected farms through collaborative development of business model components.

Findings: The findings reveal a diverse set of developmental potentials among educational farms in the region, particularly in ecological education, cultural heritage promotion, and social inclusion. Internal motivation among farm owners, combined with local networking and support from rural development actors, emerged as critical factors. Financial constraints, lack of institutional stability, and fragmented policy frameworks were identified as limitations.

Research limitations/implications: The study is limited to a specific geographical context and a non-random sample of educational farms. Future research should consider longitudinal studies and comparative analysis across regions or national contexts.

Practical implications: The study provides evidence-based insights into the strategic needs and capabilities of educational farms, supporting the formulation of targeted development programs and policy interventions. The participatory component offers a framework for building business competencies among farm operators.

Social implications: The research underlines integrative role of educational farms, in providing inclusive environments. The findings suggest that educational farms can serve as platforms for environmental and social awareness.

Originality/value: This study combines strategic self-assessment tools with participatory action research in the context of education, social farming and social entrepreneurship. It offers the interesting methodological contribution and delivers empirically grounded insights into the developmental trajectories of educational farms.

Keywords: strategic potential, educational farms, participatory action research, social farming, social entrepreneurship.

Category of the paper: Research paper.

1. Introduction

Educational farms play an important, though often underestimated, role in the social and environmental ecosystem. Among other things, they provide a space for social and educational interaction between urban and rural communities, especially in peri-urban areas. Through their activities, farms contribute to raising awareness among urban populations about issues such as environmental sustainability, food supply chains, and agricultural production.

Farms are an important entity in the education system for children and young people. Educational activities are often the only way to familiarize younger generations with agricultural practices, rural heritage, and the specific characteristics of ecosystems in non-urbanized areas. Educational farms play an important role in protecting the material and cultural heritage of rural areas.

Educational farms help create a space favorable to the development of social farming and social entrepreneurship in rural areas. They provide social services, including educational, therapeutic, and care services, which have a real impact on improving the quality of life of people in need. They also take an active part in the activation of local communities, including in the context of social and professional integration.

It seems that supporting and developing educational farms has profound social, environmental, and cultural significance. Popularizing scientific research and good practices in the field of creating and strengthening the development potential of educational farms may contribute to a broader discussion on real cooperation in the inter-sectoral environment.

This article is based on the author's research carried out in rural areas of the Silesian region in 2023-2025. It is worth noting that an important part of the research was participatory action research related to social involvement in the development of the potential of educational farms through the design of business model elements dedicated to individual farms. Another element that added credibility and enriched the research process was cooperation with key public policy actors in the field of educational farm development, such as the Silesian Agricultural Advisory Center in Częstochowa and the Association of Educational Farms of the Silesian Voivodeship.

2. Overview of the state of research

As noted by Zawadka, Krzyżanowska, and Gabryjończyk (2021), the issue of educational farms is rarely addressed in scientific literature. At the same time, the concept of providing education with the participation of educational farms in Poland is relatively new. Research conducted on the development of educational farm systems in countries such as Poland, Italy, Switzerland, Austria, and France confirms that “the idea of educational farms in Poland is one

of the youngest...” (Gabryjończyk et al., 2013, p. 72). However, it seems that this area of research is very important due to the need to develop innovative educational tools, ongoing civilizational changes, and the dominant role of technology in the everyday practices of younger generations. After all, the opportunity to learn through practice, participation, and experience is not without significance. Marcysiak points out that “as a report on educational farms in Poland observes, at the farm, students not only discover the origin of food but also experience true rural work” (2025, p. 96).

In an urbanized and media-commercialized society where advertisements are often the main source of information about food products, the role of farms in educating children, young people, and adults seems crucial. It could be argued that the level of knowledge in society about the sources of food is still far from sufficient. Educational farms can play an extremely important role in practical learning processes. The literature emphasizes that educational farms contribute to shaping the image of the world, especially in terms of environmental awareness (Blum, 1999). Rønningen, Renwick, and Burton (2012), in their study of the specifics of multifunctional agriculture in European countries, point to the importance of education provided by educational farms in the field of climate change. The functioning of environmental education through the use of the educational offer of educational farms serves to build environmental awareness and is in line with the concept of sustainable development in European Union countries (Kowalska et al., 2016).

An key aspect of education based on the teaching offer of educational farms is the immersive nature of the participants' experiences. At the heart of this approach is participation in learning processes through personal experience, practical action, and real engagement. It also involves activities that engage and activate children, young people, adults, the elderly, and people with disabilities. Research conducted in the Pomeranian Voivodeship confirms that people with disabilities and Third Age Universities are increasingly taking advantage of individual and group activities conducted by and on educational farms (Wiśniewska, 2021). Taking visual research in sociology as a reference point, it is worth noting the importance of visual experience in education and the multidimensionality of learning processes. “The observed behavior of students participating in activities at the educational farms revealed the complexity of the educational process itself at the farm” (Marcysiak, 2025, p. 94). This seems particularly important from the point of view of building the strategic potential of educational farms and creating a diverse range of social services based on an individual approach to the needs and capabilities of participants. This should take into account specific health, cultural, professional, and other conditions.

Another interesting aspect in the description of educational farms is the motivation of their owners to run this type of business. Referring to the results of research conducted by Zawadek et al. (2021) on a group of 79 farms, the underlying motivation is education related to building environmental awareness and preserving and maintaining the cultural heritage of rural areas. In turn, research by Antunes et al. (2017) in Portugal shows that educational farms effectively

combine the fulfillment of their educational mission with the achievement of financial benefits that are satisfactory to their owners. This approach is in response to the need to seek new sources of income beyond agricultural or agritourism activities. In practice, this results in the diversification of social services provided by educational farms in rural areas. In this regard, the importance of strategic planning for the diversification of activities in rural areas in the context of social and economic transformation is particularly emphasized (Forleo, Palmieri, 2019).

When identifying the factors for success and the conditions for operating such a business, it is worth paying attention to the size of the educational farm, the possibilities of obtaining financial resources, and the ability to function in a networked environment. Undoubtedly, limited financial resources are considered to be the main barrier to the development of educational farms (Markiewicz, 2020; Zawadka et al., 2021). However, more and more attention is being paid to a multidisciplinary approach. The results of research on rural transformation in the Czech Republic (Hrabák, Konečný, 2018) and educational farms in southern Italy (Forleo, Palmieri, 2019) confirm the key importance of the concept of multifunctional agriculture.

Among the main factors of success are the development of multifunctional agriculture and the managerial skills of the owners (Forleo, Palmieri, 2019). As well as the ability of educational farms to conduct innovative activities. However, as Markiewicz notes, “determinants of innovative activity of educational farms vary depending on the size of the enterprises, the level of innovation awareness of the farm's owner and on the financial possibilities...” (Markiewicz, 2020, p. 136). A multidisciplinary approach and innovative practices imply the need to develop skills in functioning within a network of inter-organizational and inter-institutional connections. Gabryjończyk, Zawadka, and Krzyżanowska (2023), in their study of the state of development of educational farms, draw attention to the importance of cooperation networks and legal and administrative solutions supporting the creation of educational farms. The authors attribute an important role to the activities of The National Network of Educational Farms (more: <https://zagrodaedukacyjna.pl/>).

Undoubtedly, the greatest potential for educational farms lies in the heritage of the place, associated with its natural resources, rural landscape, and rich culinary traditions (Forleo, Palmieri, 2019). The implementation of the educational mission based on the professionalism of educational services using own agricultural resources often requires an innovative and non-standard approach from farm owners. At its core is both the ability to co-create and develop social networks and to cooperate with the institutional environment. Research on entrepreneurship in rural areas confirms the importance of network structures in shaping social capital (Moyes et al., 2015). However, the internal motivation of educational farm owners still seems to be crucial for the development of rural areas and the promotion of rural cultural heritage. In addition, it can provide an impulse for the development of social agriculture based on a wide range of social services. As well as social entrepreneurship in rural areas focused on social and professional mobilization.

3. Research methodology and the study sample

For the purposes of exploring the development potential of educational farms, the following research assumption was adopted: educational farms can act as entities implementing the mission of social agriculture and social entrepreneurship in rural areas. The research problem concerned the conditions for building the development potential of farms. The research question was formulated as follows: what elements determine the development potential of educational farms? The aim of the empirical study was to understand the structure of the development potential of educational farms in the context of supporting social agriculture and social entrepreneurship in rural areas.

The study employed a complex qualitative methodological procedure using triangulation (Jick, 1979; Flick, 2018), integrating elements of self-assessment, content analysis, and participatory action research assumptions (Table 1). The research process was carried out in two stages. The first was based on the analysis of data obtained using a questionnaire survey. The second was based on the involvement and engagement of the researcher in the activities of educational farms. The real cooperation between the researcher and the participants allowed for a deeper research understanding and strengthened the development potential of educational farms through substantive support.

Table 1.
Characteristics of the research process

Identifier	Stage I of research	Stage II of research	
Participants	owners of 20 educational farms	owners of 9 educational farms	representatives of non-governmental organizations and institutions supporting rural development
Period	03.2025 – 10.2023	10.2023 – 01.2025	10.2023 – 01.2025
Scope	strategic self-analysis	designing business model components	strengthening development potential
Method	survey	participatory action research	interview
Tool	survey questionnaire	observation form, interview questionnaire	interview questionnaire

Source: the author.

The first stage of the research consisted of analyzing self-assessment questionnaires completed by the owners of twenty educational farms. The research tool used was a structured worksheet designed to identify the development potential of a given farm. The questionnaire contained open-ended and semi-open-ended questions. The questions related, among other things, to the strengths and weaknesses of the business, plans for the future, the scope of resources, and the perception of opportunities and threats to the educational farm.

The self-assessment questionnaire served as a simplified strategic self-analysis tool in a format similar to SWOT analysis (Coman, Ronen, 2009; Panagiotou, 2003; Helms, Nixon, 2010). Strategic self-analysis was the starting point for further analytical activities.

The obtained material was subjected to content analysis (Hsieh, Shannon, 2005; Schreier, 2012; Krippendorff, 2019) using thematic categories identified inductively on the basis of recurring themes and semantic dominants in the respondents' statements. In the course of the in-depth analysis, the data was synthesized into dominant content categories, which made it possible to capture the characteristic features of the development potential of educational farms.

The second, complementary stage of the study was a participatory research procedure, the basic assumption of which was the direct involvement of the researcher in the practical activities of the researched entities (Reason, Bradbury, 2008; McIntyre, 2008; Chevalier, Buckles, 2019). As part of this stage, participant observations, informal conversations, and consultations with the owners of nine educational farms were conducted. These activities were aimed not only at deepening the research understanding of the development potential of educational farms.

However, above all, they consisted of providing real substantive support to the participants of the research process in the development of business model elements. Particular attention was paid to elements such as customer segmentation, communication channels, revenue structure, value propositions in the context of the educational offer, etc.

The adopted research procedure also included activities in cooperation with local and regional actors involved in the development of the educational farm sector. In the second stage of the research, parallel to the cooperation with the owners of educational farms, cooperation was carried out with representatives of non-governmental organizations and institutions supporting the development of rural areas. Representatives of the Association of Educational Farms of the Silesian Voivodeship and the Silesian Agricultural Advisory Center in Częstochowa were included in the research process.

The triangulation of methodological perspectives made it possible to contextualize the source material and draw conclusions (Table 1). The triangulation of qualitative research methodology and the size of the research sample can be considered exhaustive in terms of theoretical saturation (Guest, Bunce, Johnson, 2006). The research covered the area of the Silesian Voivodeship. A total of 20 respondents—owners of educational farms—participated in the survey (the first stage of the research, conducted between March and October 2023). In the second stage (from October 2023 to January 2025), the research was deepened by conducting the research process in the environment of educational farms and institutional support entities.

4. The results of the study

In the group of twenty farms surveyed, all of them engaged in extensive educational activities, mainly in the form of workshops, training courses, lectures, and demonstrations, using their own agricultural and non-agricultural resources. However, educational services

were most often combined with agritourism, recreation, the organization of special events, the production of goods, including handicrafts, and agricultural cultivation, as well as the sale of plants and agricultural products (e.g., vegetables and fruit). The presented characteristics of the activity show a wide range of services. In addition to education, the farms provided accommodation, catering, catering, land rental, etc. Ten farms also produced local and/or regional products. Two of them specialized in the production of handicrafts. The experience of representatives of the Silesian Agricultural Advisory Center in Częstochowa and the Association of Educational Farms of the Silesian Voivodeship shows that education and agricultural production are most often combined with processing and direct sales.

Among the key resources, owners of educational farms pointed to technical and social infrastructure. They mentioned, among other things, buildings, equipment used in agriculture and rural work, educational and health-promoting paths (e.g., sensorimotor) orchards, gardens, meadows, and forests located on or near the farm. However, they emphasized the importance of social capital first and foremost. The responses included the following characteristics: commitment, communication skills, respect for nature, tradition, and rural history, etc. In the context of skills, attention was drawn to creating, maintaining, and using interpersonal relationships, caring for the quality of emotional bonds, and building a climate conducive to learning, play, recreation, and experiencing nature.

The study participants identified the potential of the place in terms of the resources necessary for production and services. According to most owners, it is the potential of the place that constitutes the main and unique value of running a business in rural areas. Hence, they pointed to, for example, the number and type of animals on the farm, an orchard with a variety of trees and shrubs, an organic garden, or historic buildings characteristic of the region. They also emphasized the importance of maintaining long-term relationships with customers and building the image of an educational farm in a broader socio-economic environment (beyond the local community). Two out of twenty respondents considered maintaining relationships with regular customers and market recognition to be key strategic resources for an educational farm.

The conclusions from the observations, informal conversations, and substantive consultations between the researcher and the owners of nine educational farms correspond with the results of the self-assessment of resources. Tangible and intangible resources are a valuable and often unique attribute of educational farms. However, the perception of the resources possessed is not always directly reflected in operational activities. This belief is often based on the insufficient exposure of the farm's infrastructure and the landscape and tourist attractions of the location in the range of products and services on offer. In some farms, resources that are widely recognized as valuable due to their tradition, history, and culture are still not fully recognized and utilized by owners as a business attribute.

Strengthening awareness and motivating owners to discover new dimensions for the use of tangible and intangible resources can provide a significant impetus for the development of educational farms. Representatives of institutions and organizations supporting rural development emphasized the particular importance of knowledge and experience in agricultural work, as well as commitment, passion, and openness to new alternative solutions in the process of designing an attractive range of products and services. However, the available infrastructure, i.e., buildings, machinery, equipment, and technologies, was also important.

In the survey questionnaires, people were indicated as the strongest asset. The owners of as many as thirteen educational farms considered qualities such as creativity, entrepreneurship, professionalism, commitment, empathy and openness, passion for life, competence, experience, and willingness to develop to be particularly valuable.

Most respondents identified proximity to nature and accessibility of services for people with disabilities as strengths of educational farms. In addition, the responses included the following: location, land development with buildings (including historical and characteristic of the region) and equipment, diversity of services and attractiveness of the offer, flexibility in meeting the needs of individual and group customers.

A holistic view of an educational farm can complement the description of strengths identified in the self-assessment questionnaire. The researcher's experience of working with owners during the design of business model elements shows that there is a need to change the perception of educational farms. Where diversified activities, a variety of products, services, and resources, and the richness of nature, culture, and community create a unique atmosphere for work, learning, play, and rest. Each of these areas becomes complementary to the whole. At the heart of this approach is the opportunity to acquire and use knowledge, mutual learning, and experience. In turn, the prospect of involving the institutional environment in the development of educational farms encourages the addition of a willingness to cooperate in partnership and increase competence to the set of strengths.

When identifying weaknesses, the study participants mainly pointed to problems with the coordination of business activities. However, there were also references to technical and architectural barriers, especially in the context of organizing events for the wider community and the accessibility of services for people with disabilities. The context of seasonal activity, diversification of income sources, and the distance of the educational farm from urban centers as a factor hindering the acquisition of new customers was also significant. Interestingly, four educational farms reported advertising and the use of social media in promotional activities as weaknesses.

In the process of real involvement in the activities of educational farms, the issue of investment financing was the most frequently mentioned. Difficulties in accessing external sources of financing, as well as insufficient grant support, determine the possibility of wider development. This was also pointed out during informal discussions with representatives of non-governmental organizations and institutions working for rural areas.

When visualizing the future of educational farms, the vast majority of respondents focused on expanding or reorganizing their current activities and promoting their products and services. In particular, they strongly emphasized the need to strengthen activities aimed at raising environmental awareness and supporting the local ecosystem and rural heritage. The description of the farm's vision included, among other things, the production of organic products, the expansion of the educational offer to include pro-ecological topics and those related to rural culture (i.e., farming methods, traditions, etc.), creating water reservoirs using river water, developing gastronomy with a focus on regional cuisine, creating organic gardens and rural tradition rooms.

The vision of an educational farm includes the aspect of promotion in the broad sense. Improving the website, launching an online store, and using social media are the most common suggestions. According to the respondents, it seems necessary not only to change the use of new promotional tools. Above all, it is necessary to identify the target group and the specifics of the market. This, in turn, implies the need for continuous improvement of the range of services.

An important area for future activities is considered to be the design of services that respond to the current and individual needs of individuals and social groups, including those dedicated to foreigners, people with disabilities, and seniors. Particular attention was paid to expanding the offer with products and services provided in foreign languages, outside the season and outside the farm in a stationary form (e.g., field workshops) and online, but using own agricultural and non-agricultural resources. This may be a response to cultural diversity and spatial limitations (in the context of, for example, distance from urban centers, special customer needs, etc.) and time limitations (due to, for example, low customer interest in the winter).

During informal discussions and expert consultations, the owners of educational farms formulated a vision for slightly more detailed solutions for the future. They declared, for example, their intention to equip the educational area with innovative teaching aids and furniture, purchase new species and breeds of animals to diversify the offer, including the launch of therapeutic classes, modernization of buildings and facilities (e.g., expansion of parking lots), etc. During the discussion with institutional representatives, the topic of promotion and advertising also came up. The need for local authorities, education authorities, training and tourism organizations to actively participate in activities promoting educational services was recognized.

According to the vast majority of respondents (80% of survey participants), cooperation with others provides an opportunity for the development of educational farms. The importance of neighborhood, inter-organizational, and inter-institutional cooperation in a multi-sector environment was emphasized. Among the partners in joint activities, the owners of educational farms most often mentioned local action groups, municipal cultural centers, and rural housewives' clubs. In addition, they pointed to universities of the third age and clubs for retirees and pensioners, with cooperation in this area most often involving the provision of paid

services. A small number of educational farms also had experience in cooperation with the Rural Youth Association and the Polish Association of Cereal Producers. In turn, the implementation of social activities for local communities most often involved cooperation with non-governmental organizations, including foundations and associations. The educational farms surveyed appreciated the advantages of operating within a network of inter-organizational links. All of them operated within the National Network of Educational Farms and had the right to use the name “educational farm” (for more information, see: <https://zagrodaedukacyjna.pl/>).

Interestingly, none of the surveyed farms cooperated with the academic community. Research collaboration with the owners of nine farms during work on business models confirmed not only the possibility of implementing activities jointly with organizations from other sectors. But most importantly, according to the respondents, it significantly increased their level of knowledge and competence. This was also noted by representatives of institutions and organizations working for rural development. They particularly emphasized the importance of cooperation with universities in the context of mutual learning and improving the quality of services. In turn, with regard to the promotion of educational farms, they drew attention to the role of local governments, local action groups, non-governmental organizations, agricultural advisory centers, and municipal cultural centers.

Further identification of opportunities and threats was carried out against the background of the characteristics of the location of the educational farm. Owners of farms operating in areas with a high concentration of tourist attractions saw opportunities for business cooperation and mutual promotion of products and services among neighbors. This was also achieved through the involvement of local authorities in designing joint solutions, such as a consolidated local tourist offer, thematic educational programs, etc. On the other hand, negative experiences in cooperation with, for example, the head of the municipality or a local action group were perceived as a threat limiting the further development of the educational farm. Similarly, as in the case of locations far from urban centers or local spatial development plans that do not fully regulate issues of environmental protection and cultural heritage of the countryside.

Representatives of institutions supporting rural development recognized an opportunity in diversifying the services provided by educational farms towards tourism, recreation, and social services, including care and therapy. They emphasized the importance of multifunctional agriculture in terms of combining food and raw material production with services that respond to social needs. They also emphasized the importance of including educational farms in “historical” tourism activities with elements of learning, fun, recreation, and experiencing nature. However, it is worth noting that an excessive focus on increasing the attractiveness of the offer may result in the loss of the educational farm's identity as a provider of educational services using its own agricultural resources.

When describing their social activities, the owners of twenty farms jointly declared that they carried out unpaid activities for the benefit of the local community. Most often, they acted as co-organizers of local events, such as festivals, fairs, and harvest festivals. They were actively involved in initiating and implementing free educational activities for children, young people, and adults. They also provided neighborhood education on organic plant cultivation and animal farming, and actively supported fundraisers for the poor and people in need. It is worth noting the conscious involvement of three educational farms in activities promoting social and professional integration and activation in rural areas. Among the practices observed were the free provision of infrastructure, the preparation of free meals, and the employment of people at risk of social and professional exclusion. It is also worth noting the local support in the form of barter exchanges or the use of local raw materials in the production of goods and services.

Agriculture is increasingly evolving towards multifunctional and, most importantly, socially engaged activities. Research experience with landowners confirms a high sensitivity to the needs and problems of local communities. Social agriculture, as also pointed out by representatives of institutions and non-governmental organizations, responds to the problems of an aging society, the development of lifestyle diseases, and professional and social dysfunction.

Table 2.

Structure of the Development Potential of Educational Farms

Elements of Development Potential		
Skills	Resources	Opportunities
intergenerational communication	technical resources: buildings, machinery, equipment, and technologies	multifunctionality of agriculture
cooperation and collaboration	natural and landscape values of the location	social farming
interpersonal relationships	social capital	development of the educational services market
quality of emotional bonds	competence, experience, and motivation	environmental awareness in society
atmosphere of immersive experiences	traditions and cultural capital	development of institutional and financial support (local, regional, national, and EU)

Source: own elaboration based on empirical research.

The empirical research conducted leads to an attempt to provide a synthetic description of the development potential of educational farms. Admittedly, the first stage of the research involved strategic self-analysis based on a structured questionnaire. The scope of available resources, strengths and weaknesses, and plans for the future were identified. Particular attention was paid to the perception of opportunities and threats to the functioning of educational farms in the socio-economic environment. As well as to the owners' experiences in conducting social (non-profit) activities for the local community. In the second stage of the research, the characteristics were deepened with observations resulting from the researcher's direct involvement in the activities of nine educational farms in the design of business model elements. As well as from cooperation with entities supporting the development of educational

farms in rural areas. The conclusions from the research formed the basis for developing the structure of the development potential of educational farms (Table 2).

5. Discussion

In the academic literature, the issue of multifunctionality of farms operating in rural areas is explored through both theoretical and empirical research. As noted by Sikorska-Wolak and Zawadka (2016), “research interest in the multifunctionality of agriculture emerged alongside the growing importance of agriculture’s non-productive functions” (p. 99). Within this context, an important and interdisciplinary area of research has emerged, wherein educational farms play a significant role as sources of practical knowledge and as key actors in preserving the material and cultural heritage of the countryside.

Referring to studies conducted in the Czech Republic, it is worth highlighting the concept of social farming as a form of entrepreneurship that combines the provision of social services with opportunities for socio-professional integration in rural areas (Hudcová, 2022). Interestingly, the practices and scope of activities undertaken by educational farms can also be linked to the concept of civic agriculture, which promotes local community participation and sustainable development (Lyson, 2024).

Scientific research increasingly underscores the importance of integrating educational farms within the broader systems of social farming and social entrepreneurship in rural areas. This is supported by the fact that socially oriented and entrepreneurial behaviors confirm that socially engaged agriculture-combining care and educational functions in rural settings-can play a vital role in social and professional inclusion. It may also contribute to the creation of new forms of rural entrepreneurship. As Czapiewska (2020) observes, “socially involved agriculture is an idea combining the multifunctionality of farms... with care and health services, as well as social entrepreneurship” (p. 308). Furthermore, “social farming is a valuable response to social problems not adequately addressed by existing solutions” (Wojciechowska-Solis, Martínez Cortijo, Ruiz-Canales, 2023, p. 69).

On the one hand, social farming and social entrepreneurship can be seen as mutually reinforcing phenomena-closely interconnected and, crucially, contributing to synergistic outcomes. Social farming models foster the development of social entrepreneurship practices by supporting the activation of individuals at risk of exclusion and facilitating the growth of institutional networks and informal relationships. This, in turn, is essential for the advancement of social entrepreneurship in rural areas (Wojciechowska-Solis, Martínez Cortijo, Ruiz-Canales, 2023).

On the other hand, as indicated by Bański (2015), and Wojcieszak-Zbierska and Sadowski (2024), the development of entrepreneurship in rural areas encounters barriers primarily associated with a complex support system, weak social capital, and limited cooperation among local actors. In this context, institutional conditions appear to be of critical importance in uncovering the social dimensions of agriculture, education, and sustainable development.

Equally important is cooperation within a multi-sectoral environment, including the genuine involvement of actors from various sectors in organizational, substantive, and technical support processes.

In Western European countries, the development of educational and care farms is grounded in robust institutional foundations, encompassing both legislative frameworks and organizational infrastructure. In the Netherlands, where the care farming sector includes over one thousand actively operating farms, public institutions play a key role (Hassink et al., 2020). In Italy, by contrast, the development of educational farms is based on a more decentralized model rooted in the social economy and social cooperatives. This model is less formalized than the Dutch one and more inclusive of individuals at risk of socio-professional exclusion (Moruzzo, 2022).

In Poland, the development of educational farms providing social and care services faces greater institutional barriers. Notably, scholars emphasize the lack of adequate legal regulations and the inconsistency of support systems (Wojcieszak, Wojcieszak, 2018). Additionally, there is an insufficient level of development in national quality standards and advisory-financial infrastructure, which in turn limits the scalability and sustainability of such initiatives (Zajda, 2022). As a result, these activities remain fragmented and heavily reliant on the involvement of local leaders, as well as on short-term, project-based funding systems (Łuczka, Kalinowski, 2020). It seems that many assumptions can be made for recommendations for the development of a support system for educational farms in the context of capacity building. First of all, support efforts are isolated, and individual models (institutional, financial, non-institutional) of assistance operate without synergy. It would therefore be advisable to first map the systems in order to design mutually reinforcing interventions. Furthermore, it seems that the promotion of the performance and role of farms is very limited and has an insufficient impact on the use of their potential by various social groups.

6. Conclusion

Educational farms remain a relatively unexplored area in management and quality sciences, despite their growing role in environmental and social education, especially in the context of contemporary civilizational and technological challenges. In scientific literature, the issue of how farms function in the socio-environmental ecosystem remains largely unrecognized.

It is worth noting that in an era of increasing urbanization and mediatization, educational farms can play a key role in shaping environmental and social awareness. After all, the development of educational farms fits into the broader context of rural transformation, where multifunctionality is a key element of development strategies.

Previous studies, including those presented in this paper, point to the need for an interdisciplinary approach that takes into account local natural, cultural, and social resources, recognizing them as the foundation for building the development potential of educational farms. The basis for the use of resources is the design of an attractive and innovative range of social services, including educational, therapeutic, and care services provided by educational farms.

The methodological approach used in the study allowed us to expand our knowledge about how educational farms work and how they can grow in the region, taking into account both internal conditions and external factors. Using a triangulation strategy for qualitative research, especially elements of participatory action research, also created space to bring stakeholders into the research process. The involvement of stakeholders in the process of co-creating knowledge is in line with the assumptions of the participatory research model. It is worth pointing out certain research limitations here. It seems that the area under study probably avoids quantitative research, as it concerns a sensitive social fabric and involves the analysis of attitudes and behaviors. Therefore, the necessary dominance of qualitative strategies may constitute a certain limitation.

Empirical research indicates that the development of educational farms depends in particular on the use of a set of potentials. The managerial and social competences of the owners seem to be key, including, among others, cooperation and communication skills, social sensitivity, willingness to act for the common good, etc. The ability to recognize and use local natural and landscape resources and cultural heritage is also considered important. Of course, this does not exhaust the set of factors determining the development of educational farms, including the design and implementation of solutions for social agriculture and social entrepreneurship in rural areas. It seems that further research in this area is needed, especially in the context of growing socio-environmental imbalances, biodiversity issues, and climate change. Above all, it is necessary to shape conscious pro-social and pro-ecological attitudes among the younger generations. Future research directions could take a very holistic approach to the development of educational farms as specific micro hubs of rural entrepreneurship and centers of knowledge on ecology, food production and food logistics systems, as well as micro centers for community empowerment. It seems that such research, which appears to have been rather neglected so far, could bring many practical social, ecological, and economic benefits. In addition, it is worth considering research on the importance of leadership in rural social networks, especially at a time when there is a need to build more cohesion and security.

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ATTRIBUTES OF LISTED COMPANIES THAT AFFECT GENDER DIVERSITY ON CORPORATE BOARDS

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Purpose: The purpose of the article is to identify the key factors affecting the representation of women on the boards of companies listed on the main market of the Warsaw Stock Exchange.

Design/methodology/approach: Data exploration was conducted using cluster analysis. Its application enabled the identification of homogeneous groupings with maximum similarity based on specified attributes of the analyzed listed companies. The sampling of companies for the study results from the fact that these organizations hold particular economic importance and are expected to serve as models of good practice for other entities, which is emphasized in legal regulations concerning employment parity.

Findings: A retrospective analysis of the scientific literature indicates that the representation of women on company governing bodies depends on several factors, with varying degrees of significance. The result of the conducted study is the identification of homogeneous clusters of companies with maximum similarity, based on certain attributes.

Research limitations/implications: It should be noted that due to the situational context (socio-cultural or legal and political environment) affecting the representation of women in socio-economic life in different countries, the formulation of universal recommendations or unambiguous conclusions regarding gender diversity in organizations may prove problematic.

Practical implications: The research results can contribute to the formulation of targeted recommendations and actions tailored to the Polish context in the field of gender equality, which is one of the objectives of sustainable development.

Social implications: Diagnosing the situation concerning the structure of women's employment at the highest levels of management and identifying the determinants of this situation are essential issues both for the implementation of the guidelines of EU directives and for the quality of management and the implemented diversity policy. Increasing the number of women in senior positions is not only an issue of social justice, but also a step towards a more modern and sustainable society. As a result, popularizing these issues is of considerable social significance.

Originality/value: The study contributes to understanding the extent to which the underrepresentation of women at the highest levels of management (on corporate boards) can be related to such attributes of companies as their size, ownership structure, and sector.

Keywords: gender employment structure, diversity, gender parity.

Category of the paper: Research paper.

1. Introduction

Gender balance on company governing bodies is an issue that is becoming increasingly significant in public debate and business strategies. However, the participation of women in making strategic decisions within companies remains limited. The impact of legal regulations, such as EU directives, among other things, can be of great relevance to the development of gender equality policies on company governing bodies.

Equality and non-discrimination are firmly grounded in the EU Treaties and the EU Charter of Fundamental Rights. The European Commission has placed equality at the core of its agenda, aiming to build a Union of Equality that is free of discrimination. Furthermore, reducing inequalities and vulnerabilities that leave people behind constitutes a guiding principle of the 2030 Agenda for Sustainable Development, adopted by the United Nations (Eurostat, 2024). The pace of changes required to achieve Goal 5 of the 2030 Agenda, titled “Gender Equality”, is regarded as insufficient for its realization within a reasonable timespan. Equality in managerial roles will be achieved in 176 years (UN, 2024). What is more, according to the report (UN, 2024), while women make up 40% of the global workforce, in 2022, they held only 27% of managerial positions. The percentage was identical to that recorded in 2016 (UN, 2024).

Issues of equality and non-discrimination are not only a significant part of employment policy making and monitoring, but are also of interest to NGOs and the public. Popularizing these issues may ultimately contribute to improving the situation of women in the labor market.

The purpose of the article is to analyze the current situation and identify the key factors affecting the representation of women on the boards of companies listed on the Warsaw Stock Exchange. The issue raised has a significant practical dimension, as the EU Women on Boards directive requires increasing gender diversity on corporate boards by 30 June 2026. As a result, the underrepresented gender in companies (and in all EU countries it is women) is supposed to make up a minimum of 40% of non-executive director positions or at least 33% of all director positions (executive and non-executive) (Directive of the European Parliament and the Council EU 2022/2381). Gender diversity regulations are amplifying interest in the issue and the ongoing scientific discussion (Martinez-Garcia et al., 2024). Considering the fact that just a few years ago in Poland the gap between the number of women and men with a university degree was estimated at almost 19 percentage points in favor of women (Biuletyn, 2023), it is difficult to attribute the lower percentage of women in managerial positions merely to a lack of supply of suitable female candidates for such positions (Stainback et al., 2024). Therefore, an attempt was made to establish to what extent the underrepresentation of women at the highest levels of management (on corporate boards) can be linked to such attributes of companies as their size, ownership structure, or sector. The research results can contribute to the formulation of targeted recommendations and actions tailored to the Polish context in the field of gender equality, which is one of the objectives of sustainable development.

2. Literature review

A review of the available research results on the issue at hand constitutes the starting point for the considerations undertaken. The theoretical findings to date are multifaceted, however, the perspective of institutional theory, according to which women's participation in economic life is shaped by the broader social context, cultural context or transformations in the institutional environment, has been adopted as the theoretical framework of the conducted own research (Abadi et al., 2020; Rakowska, 2021).

The authors emphasize the complexity of mechanisms that affect women's representation in decision-making bodies (Tyrowicz et al., 2020). What is significant, the results of the literature review are not unambiguous and frequently contradict each other. Some authors indicate the positive impact of women on boards on a company's performance (Hamdan et al., 2022; Nielsen, Huse, 2010; Singh, Vinnicombe, Johnson, 2001). Gender diversity is emphasized as contributing to value creation (Nguyen et al., 2020), supported by a strong business case.

The Deloitte Global Report (2024) on gender diversity on boards and women in leadership positions states that companies with more diverse boards tend to demonstrate better financial performance. Moreover, organizations that are more gender diverse as a whole, from executives and board members to managers and employees, tend to have better performance than those that are less gender diverse.

As a result, legislative initiatives are being undertaken and regulations are being implemented to increase the participation of the underrepresented gender on company management. An example of specific action is the development of the European Commission's Gender Equality Strategy 2020-2025. The strategy sets out policy objectives and initiatives to achieve significant progress by 2025 toward a gender-equal Europe (Strategy 2020-2025). Its objective is a Union in which women and men have equal development opportunities and can equally participate in and lead our European society. One of the core elements of this strategy is the directive on gender equality on corporate boards (Women on Boards), which seeks to improve the gender balance in decision-making at the EU's largest listed companies. After 10 years of negotiations, the directive was ultimately adopted on 22 November 2022. The directive was to be implemented into Polish law by 28 December 2024. The first obligations under the directive, such as the development of a diversity policy, became effective in 2025. The subsequent steps in its implementation are presented in Figure 1. Notably, for SOEs, certain requirements must be met sooner, by 31 December 2025 (Piątek, Przedpelska, 2025).

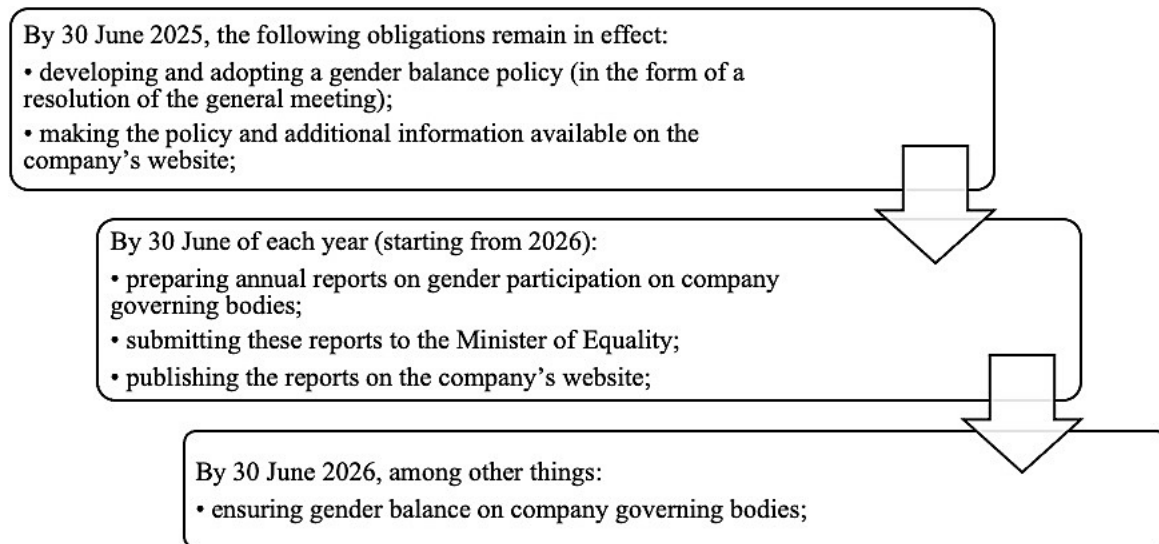


Figure 1. Stages of implementation of the directive on gender equality on corporate boards.

Source: own elaboration, based on (Piątek, Przedpelska, 2025).

The implementation of the Women on Boards directive is not only a matter of compliance, but also a chance for real change in the management structures of Polish companies. This new EU legislation is ultimately intended to help break the glass ceiling on the boards of listed companies and provide women who qualify for top managerial positions with a real chance to obtain them.

Another example of efforts promoting gender equality is the adoption, in March of this year, of the Roadmap for Women's Rights (2025). The plan sets forth a long-term vision for achieving gender equality based on the core principles and policy objectives outlined in the Declaration of Principles for a Gender-Equal Society. However, the document emphasizes that the full implementation of the goals set out in this plan is beyond the EU's competence and needs to rely on actions at the national level. This requires adequate commitment, cooperation, and close partnership with the member states. That is why it is vital to analyze the situation in individual markets.

In 2023, the Polish Economic Institute, based on data from Eurostat, reported that women in Poland accounted for 43% of persons occupying managerial positions (Oksiuta, 2023). On the one hand, Poland performed better than such countries as the Netherlands and Cyprus, where these proportions amounted to 26% and 21%, respectively. However, already on the boards of listed companies, women's representation amounted to 24%, while the average rate for the European Union is 32% and for France as high as 45% (Oksiiuta, 2023). The above justifies further consideration of the extent to which the position of women in the labor market is becoming equal, and to what extent there are still processes that hinder, or even make it impossible for women to occupy top managerial positions.

Data from EU member states indicate that increasing women's representation in the statutory bodies of companies is yielding several positive effects, particularly where the rate was lowest before the introduction of relevant regulations. The report *Diversity Wins*.

How inclusion matters (Hunt et al., 2020), prepared by McKinsey & Company on a sample of 1039 companies from 15 countries, indicated that the penalty associated with a lack of diversity on corporate boards deepens over time.

This, however, stands in contrast to research findings suggesting that women's representation has a negligible impact on, among other things, the financial performance of Italian innovative SMEs (Schifilliti, La Rocca, 2024), and that the very innovativeness of a particular sector is difficult to link to the presence of women on corporate boards (Tyrowicz et al., 2020). Kompa and the team (2016) indicate that the presence of women on company governing bodies is not linked to their efficiency and financial standing. Appointing more women as directors has also not had a significant impact on the solvency of Norwegian companies (Garcia-Blandon et al., 2023).

According to Roffia and Dabić (2024, p. 1366), the presence of women on the boards of Italian companies, had “slightly significant ($p < 0.1$), but with a negative sign” impact on SME resilience (this effect, however, the authors were prone to explain primarily by the fact that female respondents were more cautious when answering questions about the strength of their organizations). Meanwhile, Hurley and Choudhary (2020) indicate that increasing the number of women on boards decreases financial risk.

In light of such disparate research findings, it is all the more significant to identify organizational attributes that determine gender diversity in companies.

Table 1 synthesizes selected studies on the perspective of gender diversity. Researchers recognize the co-occurrence of certain company characteristics (i.e., sector, company size, industry, company maturity) with the presence or absence of women on supervisory or management bodies. The multiplicity of features concerning the companies studied makes the research area of gender diversity in the composition of management and supervisory boards complex and multifaceted.

As it is shown in Table 1, over the years, various attributes of companies have been studied in connection with the issue of women's employment. These include:

- the sector in which the company operates,
- ownership (dominant shareholder),
- size of the supervisory board and gender of the chairman,
- size of the company,
- period of operation in the market.

However, it should be noted that, most frequently, studies indicate simultaneously several attributes that affect the employment of women, which suggests the complexity of the issue being addressed.

Table 1.*Gender diversity on company governing bodies – a summary of selected studies*

Organizational attribute – potential grouping factor	Author	Country	Findings
Sector/industry +digital transformation and automation	Simionescu et al. (2021)	Technology sector (USA)	Women improve P/E ratio-positive board diversity impact.
	Tasnim et al. (2024)	Healthcare industry (USA)	The proportion of female directors and the Blau and Shannon diversity indices exhibit a robust and positive correlation with the intensity and quality of sustainability reporting .
Institutional ownership	Fernando, Schneible, Zhang (2024)	U.S. public firms – the S&P 1500 index	The institutional ownership is linked to a higher proportion of top female executives.
Gender of the chairman of the supervisory board	Samborski (2024)	Poland	An essential factor that increases the gender diversity of supervisory boards in SOEs is the chairperson of the board (a woman).
Company size, age, and duration of operation	Bukalska et al. (2024)	The Visegrad Group Countries	Larger, more mature and well-established companies tend to appoint women to company governing bodies more frequently, diversifying their management methods.
	Singh, Vinnicombe, Johnson (2001)	Great Britain	More women in director roles can be found in companies with a greater number of employees, higher turnover, and profits .
	Nekhili, Gatfaoui (2013)	France	The presence of women in French listed companies is also related to the size of the company or board, as well as to family ownership , women's skills, and network ties.
Board size	Dimovski, Lombardi, Cooper (2013)	Australia	Women directors are more commonly employed on boards of directors in larger entities and entities with larger boards .

Source: own elaboration.

To synthesize, the analysis of the research output on gender diversity reveals that the rationale behind initiatives aimed at improving the situation of women is not limited to business considerations. Moral arguments also play an important role. For example, from the perspective of stakeholder theory (Freeman, 1984), appointing women may be perceived as fulfilling a moral obligation in response to stakeholder expectations (Moraka, 2023). One might also take into account that the significance of transformations in the institutional environment can lead to differentiated outcomes depending on intra-organizational conditions and the principles guiding individuals in managerial and other roles. It is also worth noting, among other things, the so-called trickle-down effect, which refers to the idea that changes in the gender composition of top management should immediately affect changes in lower managerial positions. However, the occurrence of this effect has not been conclusively confirmed in the literature (Stainback et al., 2024). One of the main explanations for this effect may be the empirically proven (Stainback et al., 2024) issue of women in managerial positions feeling a sense of obligation to help other women. A similar effect was observed as early as the 1970s by Kanter (1977), who noted that men tended to prefer hiring only men for managerial

positions. The trickle-down effect, portraying women as agents of change, is not the only possible explanation. Attention is drawn to the possibility of signaling (e.g., to investors) unobservable characteristics of companies, such as the significance attributed to social values through the presence of women in top managerial positions (Stainback et al., 2024). This perspective reflects the assumptions of the abovementioned institutional theories (e.g., Scott, 2001), according to which organizations, to be seen as legitimate, should act in accordance with social expectations outlined by laws, regulations, and value systems (Moraka, 2023). From this point of view, the implementation of legal requirements discussed in the previous section that prescribe specific steps to be taken to improve the situation of women seeking top managerial positions, amplifies institutional pressures targeted at companies, for which compliance with rules and acceptance of norms (Oliver, 1991) in such a situation should serve as the primary strategy for responding to institutional processes.

However, taking into account the aforementioned multifaceted nature of the considerations carried out in the selected topic, it is worth pointing out other theoretical positions, such as social capital theory (Burt, 1992) or social identity theory (e.g., Turner, Haslam, 2001). Taking these into consideration may prompt the opposite question, i.e., whether women employed in senior positions might be more prone to maintain the status quo and, in doing so, contribute to the continued underrepresentation of women on supervisory boards and in company management teams. The first theory referred to draws attention to the fact that board directors bring significant resources to the organization in the form of their links to the business world. Therefore, the mere lack of invitation to such networks may turn out to be problematic for women applying for managerial positions (Moraka, 2023). The other theory points to existing categorizations among members of top management (Moraka, 2023). In this way, it is feasible to consider whether, for instance, a minority group of women, pursuing alliances with influential directors (Huse, Grethe Solberg, 2006) to overcome potential marginalization, might act in such a way at the expense of engaging with women at lower levels of the organizational hierarchy. A premise that could increase the probability of such phenomena occurring might be situations where the expected relationships discussed in Table 1 – between company size, its sector of business activity, or the chairperson of the supervisory board, and the involvement of women in top managerial positions – when studied in light of groupings concerning companies listed on the Warsaw Stock Exchange could be regarded as less likely.

3. Research method

Data exploration was conducted using cluster analysis. Its application made it possible to extract homogeneous groups with maximum similarity based on specified attributes.

Clustering can be understood as “grouping observations based upon their proximity to each other on multiple dimensions” (Ho Yu, 2010, p. 13). It can be assumed that the null hypothesis in cluster analysis states that no significant clusters exist in the data and that all observations belong to a single homogeneous group (spssanalysis.com).

A two-step cluster analysis was used because, unlike the k-means and hierarchical clustering methods, this approach accepts not only continuous variables but also categorical variables. The algorithm also demonstrates resilience to violations of assumptions regarding the distribution of variables taken into consideration in the analysis, i.e., the normal distribution for continuous variables and the multinomial distribution for categorical variables. This algorithm can also automatically determine the correct number of clusters, so contrary to the k-means method, it does not require prior knowledge of this. The advantage of this method is also its scalability. Unlike hierarchical cluster analysis, it can successfully analyze even thousands of observations (Ho Yu, 2010, p. 13).

The original study included all 410 companies listed on the main market of the Warsaw Stock Exchange as of 7 March 2025 (WSE, 2025). However, the final result base did not include Comarch S.A. and Ovostar S.A. due to the Polish Financial Supervision Authority’s Decision to authorize the withdrawal of the companies’ shares from trading on the regulated market of the Warsaw Stock Exchange on 26 March 2025 and 14 March 2025, respectively. Ultimately, the study was exhaustive and covered 408 companies listed on the regulated market of the Warsaw Stock Exchange. A non-random sampling method – purposive selection – was used. An analysis was conducted on secondary data obtained from the Notoria database for the period from 31 March 2025 to 14 April 2025 (Department of Business Management, 2025)¹.

The sampling of entities for the study results from the relative ease of access to information about listed companies and the fact that the companies are of particular economic significance, and are expected to serve as a model of good practice for other entities, which is emphasized in legal regulations (Directive (EU) 2022/2381 of the European Union and the Council, 2022).

Ultimately, the analysis of the empirical material obtained enabled us to achieve the objective of the study, which is to diagnose the situation and to identify the basic attributes shaping the participation of women in the company governing bodies of the companies listed on the Warsaw Stock Exchange. Table 2 provides detailed information on the research sample.

¹ The study is part of a broader research task entitled “Women in the Bodies of Companies Listed on the Warsaw Stock Exchange”, conducted in 2025-2026, by the Department of Business Management at the University of Economics in Katowice.

Table 2.*Characteristics of the surveyed companies – measures of frequency*

Items and category	Frequency	Percentage
Company size (employees)		
small	157	38,5%
medium	104	25,5%
large	147	36,0%
Leading sector (WSE classification)		
finance	89	21,8%
fuel and energy	22	5,4%
chemistry and raw materials	28	6,9%
industrial production and construction	85	20,8%
consumer goods	69	16,9%
trade and services	41	10,0%
health care	34	8,3%
technology	40	9,8%
Company headquarters		
country	17	4,2%
small town – up to 20 thousand inhabitants	24	5,9%
medium city 20-100 thousand inhabitants	61	15,0%
large city – over 100 thousand inhabitants	306	75,0%

Source: own elaboration.

As shown in Table 2, small companies (157), employing up to 49 people, were dominant. They accounted for 38.5% of the surveyed sample. There were slightly fewer large companies (147), employing more than 250 people, 36%, while medium-sized companies accounted for 25.5% of the research sample (104). The most numerous group included entities that have operated in the market for more than 20 years. Their share amounted to 45.8%, while the least numerous group included companies that have operated in the market for up to 10 years (79).

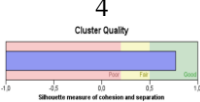
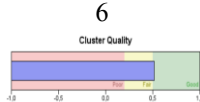
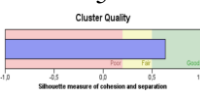
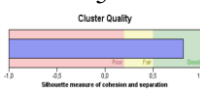
Given the presented characteristics of the research sample (Table 2), it should be noted that company size is formally linked to corporate governance standards. Large companies, which account for 36% of the research sample, are usually more exposed to regulatory or social pressure. A clear example of this is, among other things, the Women on Board Directive, whose provisions do not apply to all companies but are particularly relevant for large entities. Patel and Yates (2023) also point out that the proportion of women among decision-makers increases with company size. The impact of company size on the diversity of its governing bodies is analyzed, among others, by Saeed et al. (2016). Within the governing bodies of small companies, pressure to achieve gender diversity may be inconsistent or stem mainly from limited availability of resources rather than regulatory requirements (Owalla et al., 2021). Consequently, the bimodal composition of the Warsaw Stock Exchange (with 38.5% small and 36% large companies) suggests that the studied sample may actually include two populations with different management styles. Data on the dominance of small and large companies in the research sample are more than mere statistics. They indicate, even at an early stage, diverse management requirements that ultimately directly affect gender diversity patterns.

From a research standpoint, the share of companies operating in the financial sector (21.8%) and in industrial production and construction (20.8%) is also of particular relevance. Due to its specific nature and strict regulations, the financial sector may display distinct patterns compared to other industries. The existing sector-specific characteristics may shape both the baseline level of gender diversity and the potential barriers to women's representation on corporate boards. Among others, Torchia et al. (2010) point to real obstacles that not only hinder women's access to boards but also their ability to perform effectively once appointed.

4. Results

The results of our own research indicate that in 30 of the surveyed companies (less than 8%), the CEO is a woman. In the remaining 375 companies, however, it is a man who holds this position (92%). Even the preliminary data (as of the first half of 2025) indicate the scale of challenges relating to the implementation of the recommendations on the underrepresentation of women on company governing bodies. The application of a two-step cluster analysis made it possible to distinguish specific clusters within the dataset. This analysis was conducted four times. Each time, the Silhouette score (cohesion and distinctiveness of the developed model) indicated a good quality of the identified clusters. As shown in Table 3, the quantitative variable taken into consideration in each case was the number of women on the management board. Depending on the variant, different qualitative variables were applied. The qualitative variable considered each time was the gender of the company's CEO, and complementarily: company size (variant I), sector according to the WSE classification (variant II), dominant shareholder (variant III), and company headquarters (variant IV). Company size was determined based on the number of employees. The analysis results are presented in Table 3. The initial findings (based on the qualitative variable: CEO, and the quantitative variable: the number of women on the management board; Silhouette measure: good) made it possible to state that the largest cluster (260 companies) consists of companies led by male CEOs and with no women on the management board. On average, more than one woman was present on the board in the remaining two clusters, with a larger cluster (114 companies) including companies where the CEO was male. The fact that the position of CEO was occupied by a woman did not seem to have a significant impact on the composition of the companies' boards of directors.

Table 3.*Overview of qualitative and quantitative variables and outcomes of the cluster analysis*

Variant	Variables considered		Number of clusters extracted / Silhouette measure	Cluster characteristics
	qualitative	quantitative		
1	a) CEO (W / M) b) size of the company	number of women on the management board	4 	On average, the highest number of women on the management board is seen in companies where the CEO is a woman (most frequently, a female CEO is the only woman on the management board – cluster size is 33 companies, in 90.9% of cases the CEO is a woman, and the average number of women on the board is 1.27), and the situation occurs regardless of the size of the company (both in large, medium-sized and small companies). In companies where the CEO is a man, on average, a higher number of women is seen in large companies (in the cluster of 136 large companies, where the CEOs are exclusively men, the average number of women on the board is 0.56., whereas in the cluster of 140 small companies, where the CEOs are exclusively men, the average number of women on the board is 0.27).
2	a) CEO (W / M) b) sector according to WSE classification		6 	In the group (comprising 33 companies) with the highest average number of women on the management board (1.27), the CEO is a woman (in 90.9% of cases), and the majority of companies operate in the financial and consumer goods sectors. Companies in the financial sector with a male CEO (cluster size: 77 companies) have an average of 0.44 women on the management board, while a slightly higher average, i.e., 0.46, is observed in companies operating in the trade and service sectors as well as the healthcare sector (cluster size: 68 companies).
3	a) CEO (W / M) b) dominant shareholder		5 	Among the groups where the CEO is exclusively or commonly a man, the highest average number of women on the management board (0.64) can be observed in companies where a financial institution is the dominant shareholder (cluster size: 56 companies). In companies where the CEO is mainly a woman and the average number of women on the management board is the highest (1.07 – cluster size: 29 companies), the dominant shareholder is (most frequently) a natural person or another entity.
4	a) CEO (W / M) b) company headquarters		5 	The highest average numbers of women on the management board (1.27 and 1.25, respectively) were recorded in groups where either the CEO is a woman (in 90.9% of cases) and the company is based mainly in a large city (cluster size: 33 companies), or the CEO is a man and all companies in the group have their headquarters exclusively in large cities (cluster size: 85 companies). On the other hand, there is a group of companies where the CEO is a man, all companies in the group are based in large cities, and the average number of women on the board is 0 (cluster size: 192 companies).

Source: own elaboration.

Discussion

A retrospective analysis of the scientific literature indicates that the representation of women on company governing bodies depends on several attributes, with varying degrees of significance, which is at least to some extent indicated by the conducted analyses. Referring to the theoretical findings concerning the occupation of top-level positions by women, it can be pointed out that intra-organizational conditions do not appear to be the most significant. In other words, the fact that a woman occupies the position of the CEO did not co-occur with an increased number of women on the management board. Frequently, a female CEO is the only woman on the management board. The literature in the women on corporate board debate concludes that there must be at least three women on a board before the women really make a difference (Torchia et al., 2010, p. 42). Given the above, it is impossible to assert that the previously mentioned triple-down effect occurs in the companies studied. This also does not mean that women holding board positions focus above all on building relationships with other board members at the expense of promoting other women. However, the perspective of social identity theory could provide greater explanatory potential for the phenomena discussed. According to the assumption of institutional theory regarding companies' pursuit of legitimacy, the presence of women may be associated with efforts made to meet external expectations. Although the results do not conclusively prove this, it is possible that regulatory pressure constitutes the main factor determining the representation of women on corporate boards (rather than reasons rooted in the system of values). Referring to previous remarks, the fact that the presence of women is highest in companies in the financial sector can be regarded as consistent with this suggestion. Of particular interest is the result of theoretical research on the difficulty of women developing adequate social capital (Gabaldon et al., 2016), and the fact that divisions exist among top executives, with gender being one such dividing factor. The fact that city size is not a significant factor for 192 companies, in terms of women holding board positions, can be viewed as potentially challenging the significance of arguments based on Burt's social capital theory (1992). Women developing their careers in large cities should potentially have greater opportunities to build relationships in the business world, which should translate into more opportunities to apply for board positions. However, the lack of female representation in such a large number of companies suggests that interpersonal relations are unlikely to be the main reason for this situation. Nevertheless, the clustering results presented do not make it possible to reach a definitive conclusion on this matter.

The multifaceted nature of this issue makes it difficult to unambiguously identify the attributes of companies that determine gender diversity on their boards. The dynamics of the changing environment are forcing a new perspective on gender diversity on corporate boards. In light of inconsistent theoretical findings resulting from diverse cultural, social, legal, or political conditions, the interplay of the experience and expertise is the key, because

the minority women might face a “token” status (Makkonen, 2022). A comprehensive comparative analysis of an international nature is a challenge for future research. However, conducting such an analysis is impeded by the impact of various factors, including political (in some countries, appointments to company governing bodies, especially in state-owned companies, are made based on political affiliation), as well as legal and socio-cultural factors. However, gender equality remains an objective we are pursuing, although, as previously highlighted in the literature, there are positions that question the impact of women’s participation on corporate boards on, for instance, the financial performance of companies (i.e. Garcia-Blandon et al., 2023).

That said, one needs to bear in mind that achieving gender parity is not and should not be an end in itself, and the mere fact of appointing women to managerial positions does not yet prove their actual participation in decision-making processes. In its absence, the participation of women on boards may merely function as a signal of the company’s commitment to social values (Stainback et al., 2024). The fact that the number of women on boards increases with company growth and the growing need for board expansion may indicate that their participation in decision-making is not a priority.

Furthermore, one should bear in mind that in addition to gender diversity, there are other dimensions of diversity, such as age, or, for example, cultural diversity, which further contribute to the multifaceted nature of the issue and make it an ongoing research challenge.

Conclusion

The obtained results of the cluster analysis make it possible to formulate certain conclusions. Firstly, companies seeking to meet legal expectations and social norms that are changing in this area build their legitimacy by appointing women (usually one) to the management board. It can be presumed that an appointed woman can encounter constraints if she wishes to promote greater inclusiveness within the company. As the results indicate, such constraints can exist in companies regardless of their size. On the other hand, these are large companies with male CEOs that may feel the greatest pressure to have women on their boards. Therefore, there is a justified concern that the actions undertaken may bear the hallmarks of diversity washing, rather than reflect a genuine commitment to diversity, motivated, for instance, by an awareness of the benefits resulting from broader and more diverse team competencies. This is due to the fact that Polish managers, at the declarative level, manifest a moderate positive attitude towards diversity management (Moczydłowska, 2017), and existing initiatives in this field are frequently undertaken for image-related goals (Rakowska, 2018).

Secondly, the dominant shareholder may also constitute a significant factor in shaping the composition of management boards. In companies with male CEOs, the highest average number of women is observed in those where a financial institution is the main shareholder. Therefore, based on the results, it can be assumed that financial institutions express interest in developing diversity policies. Moreover, women occupy CEO positions primarily in organizations where natural persons are the main shareholders. Simultaneously, while it is true that companies whose headquarters are located in large cities have, on average, the highest number of women on boards, the analysis also made it possible to identify a group of companies where, despite all being located in large cities, there are no women on boards. This suggests that it is not necessarily the general (diffuse) sense of social pressure to implement diversity policies, which is presumably stronger in large cities, that determines the presence of women on corporate boards. The source of such pressure can be identified and originates from the company's main shareholder. Thus, it is also doubtful that in organizational hierarchies, a greater number of women in managerial positions can have an impact on filling top managerial positions. This is supported by research to date, which indicates that the effects of diversity management in a broad sense (including in the field of gender) are moderated by perceptions of ethical climate, managerial commitment, and motivation (Leslie, 2019) or cultural conditions (Mehing et al., 2019).

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FEIGNED DIGITAL INCOMPETENCE AND DIGITAL MISFIT – A PILOT STUDY

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Purpose: This study examines the relationship between digital misfit and employees' feigned digital incompetence, focusing on the moderating roles of digital self-efficacy and coworkers' similar behaviors. It aims to test adapted self- and other-reported scales and explore these relationships preliminarily.

Design/methodology/approach: This pilot study is based on primary data collected using the Computer-Assisted Web Interviewing method from 79 employees across various sectors in Poland. Both self- and other-reports were used to evaluate the reliability and validity of newly adapted measures.

Findings: Results indicate that greater digital misfit increases the likelihood of feigned digital incompetence, especially when digital self-efficacy is low and coworkers exhibit the same behavior. This suggests feigned incompetence acts as a coping strategy against technological stress.

Research limitations/implications: The use of self-reports may introduce social desirability bias, whereas other-reports showed more balanced distributions and may better capture the phenomenon. Future studies should refine measurement tools and examine workplace culture effects in larger samples.

Practical implications: The findings confirm that feigned digital incompetence can impede digital transformation. Validated tools, particularly other-reports, can help managers detect and address these behaviors early through targeted support and training.

Social implications: Understanding employees' responses to digital pressure supports inclusive transformation strategies, emphasizing the importance of promoting digital self-efficacy and organizational support to reduce technostress.

Originality/value: This study offers a novel conceptualization and measurement of feigned digital incompetence, highlighting digital misfit, digital self-efficacy and social influences as key factors. Its insights are valuable for researchers, HR professionals, and managers involved in digital change initiatives.

Keywords: feigned digital incompetence, digital misfit, technostress, techno-complexity, digital self-efficacy.

Category of the paper: Research paper.

1. Introduction

Although technological changes are often willingly introduced in organizations to enhance productivity and innovation, they bring not only opportunities but also potential threats and challenges. Research has shown that employees may experience significant stress when faced with a complex and uncertain technological environment, particularly when they feel pressured to continually update their skills and competencies (Tarafdar et al., 2007). In such cases, a technological environment that is intended to support employees' work can paradoxically become a source of stress and inhibition.

According to the Job Demands–Resources (JD-R) model (Demerouti et al., 2001) and Conservation of Resources (COR) theory (Hobfoll, 1989), this additional technological stress may increase perceived job demands. As a result, it can influence employee behavior by triggering coping strategies aimed at conserving personal resources. These theoretical frameworks help explain how individuals manage the strain of digital transformation and its impact on performance and well-being. These models also have the potential to explain a related but distinct phenomenon, feigned digital incompetence, which refers to situation when an employee is pretending to lack digital competences necessary to perform tasks (Stadnicka, 2024). Although anecdotal evidence of this behavior has appeared on social media, it remains largely under-researched. In management literature, a somewhat similar concept, playing dumb, has been studied (Connelly et al., 2012). This construct refers to a form of knowledge hiding in which employees pretend not to possess knowledge they actually have. "Playing dumb" typically occurs within interpersonal interactions, particularly when a coworker directly seeks information, and is considered a dyadic, response-based behavior.

In contrast, feigned digital incompetence is a broader phenomenon that extends beyond employee-coworker interactions. It does not require a direct request for information and may occur in the presence of supervisors or passive observers. This behavior involves pretending to lack digital competencies, not only in terms of knowledge, but also technical skills or a willingness to use digital tools. Despite these differences, both constructs represent deceptive strategies for withholding intangible resources that are essential for effective task performance.

Research indicates that such behaviors can be detrimental, not only from the managerial perspective but also in terms of coworker relationships and overall organizational performance (Stadnicka, 2024). For example, they may undermine team collaboration (Serenko, Bontis, 2016), reduce trust (Arain et al., 2020), lead employees to turnover intentions (Haq et al., 2022; Offergelt et al., 2019) and negatively affect employees' wellbeing (Khoreva, Wechtler, 2020) and work outcomes (Ain et al., 2022; Chatterjee et al., 2021; Jahanzeb et al., 2020; Khoreva, Wechtler, 2020; Mharapara et al., 2022; Nguyen et al., 2022; Rong, Liu, 2021; Zhang, Min, 2019).

Given the increasing reliance on digital technologies in contemporary workplaces, and the stress employees may experience in adapting to these changes, further investigation into feigned digital incompetence is warranted. This article contributes to the literature by exploring how employees' perceived digital misfit influences their tendency to engage in this behavior. In this study, digital misfit is defined as a perceived mismatch between an employee's digital skills and competencies and the technological demands of their work environment.

By addressing the phenomenon of feigned digital incompetence, this pilot study represents a preliminary attempt to understand the underlying mechanisms that contribute to its occurrence, mechanisms that could potentially hinder digital transformation initiatives and limit the effective use of digital tools and resources in organizational settings. The insights derived from this research aim to provide valuable guidance for managers striving to foster a work environment that supports employees in navigating a rapidly evolving technological landscape. In doing so, organizations can help reduce the likelihood of deceptive behaviors that mask intangible but critical capabilities.

This pilot study is based on data collected through Computer-Assisted Web Interviewing (CAWI) from a sample of 79 employees across various workplace settings.

The structure of this article is intended to guide the reader through the key components of the study in a logical and coherent manner. It begins with the theoretical background, where the concept of feigned digital incompetence is positioned within broader discussions of technostress and relevant sociological theories. This is followed by the formulation of research hypotheses. The methodology section outlines the research design and data collection process. The results section presents the main empirical findings, which are subsequently interpreted and discussed in relation to the theoretical framework. The article concludes with a discussion of both practical and theoretical implications, particularly for organizations navigating digital transformation, alongside the study's limitations and suggestions for future research on this still underexplored phenomenon.

2. Theoretical Background and Hypotheses

2.1. Digital misfit and feigned digital incompetence

The adoption of new digital technologies within organizations is often intended to enhance employee efficiency and overall productivity. However, the inherent complexity of these technologies, coupled with the rapid pace of technological change, can create ongoing pressure for employees to continuously update their technology-related knowledge and skills (Tarafdar et al., 2007). This pressure may negatively impact their well-being, potentially

offsetting the intended benefits of digital transformation (Nayak et al., 2025; Ragu-Nathan et al., 2008; Tarafdar et al., 2007).

The complexity associated with technologies, referred to as techno-complexity, can lead users to feel inadequate in terms of their skills, compelling them to invest additional resources, such as time and effort, to improve their competencies (Tarafdar et al., 2007).

In line with the Job Demands-Resources (JD-R) model (Demerouti et al., 2001), techno-complexity can be seen as increasing job demands, which may lead to strain unless employees can draw upon sufficient job resources, such as cognitive, emotional, physical, and social capacities, to mitigate the negative effects.

Complementarily, according to the Conservation of Resources (COR) theory (Hobfoll, 1989), employees are motivated to protect and conserve their valuable resources. Thus, when faced with increased job demands and a threat of resource loss, they may engage in adaptive or protective behaviors to preserve their remaining resources and manage stress within a challenging work environment.

Studies have shown that playing dumb, pretending to lack knowledge (Connelly et al., 2012) can be such defense mechanism in conditions of stressful environment (Agarwal et al., 2023; Shen et al., 2024). In particular, studies on job crafting, the changes employees make to align their job demands and resources with their personal abilities and needs, indicate that avoidance behaviors may serve as a way for employees to reduce hindering job demands (Tims et al., 2012; Tims, Bakker, 2010).

Therefore, it can be assumed that feigned digital incompetence, a situation in which an employee pretends to lack the digital competence required to perform a task (Stadnicka, 2024, p. 234), may constitute a response to technostress resulting from a perceived mismatch between the employee's digital competencies and the demands of a technologically complex work environment (hereinafter referred to as *digital misfit*).

The assumptions concerning the influence of digital misfit on feigned digital incompetence also appear to be supported by Social Exchange Theory, which posits that an individual's engagement in interpersonal interactions is based on a calculation of the associated costs and benefits (Blau, 1967; Cropanzano, Mitchell, 2005; Homans, 1958). Increasing stress levels and growing demands placed on employees due to technological changes may negatively affect their perceived cost-benefit ratio of admitting digital competence or performing certain technology-related tasks. In light of social exchange theory, feigned digital incompetence can therefore be interpreted as a covert form of refusal to participate in an exchange perceived by the individual as unequal or unfair.

Accordingly, the following hypothesis is proposed:

H1: Digital misfit leads to feigned digital incompetence.

By testing this relationship, the author assumes that pretending to be digitally incompetent can serve as a coping mechanism for employees experiencing technological overload. Given that digital misfit is influenced by employees' perceived digital competence, and that feigned

digital incompetence may serve to manipulate such perceptions, it is reasonable to expect that the tested relationship will be especially moderated by digital self-efficacy.

2.2. Moderating role of digital self-efficacy

Digital self-efficacy refers to an individual's perception of their own efficacy in performing tasks related to the use of digital systems (Ulfert-Blank, Schmidt, 2022, p. 8). From the perspective of job demands, it can reflect an individual's perceived capacity to manage technological demands. Thus, individuals with lower levels of this perception may feel less capable of dealing with technological complexity compared to those with higher levels. As a result, they may be more likely to avoid using technology.

On the one hand, studies have shown that low levels of digital self-efficacy are negatively associated with the use of digital systems, even when individuals possess high levels of technological competence. Digital self-efficacy influences both the perceived ease of use and the behavioral intention to engage with such systems (Hsia et al., 2014). These findings underscore the importance of self-efficacy in shaping attitudes and intentions toward the use of various new technology use. For example, users with high technology self-efficacy tend to show more positive attitudes toward anthropomorphic technology (Gupta, Nagar, 2025), while general, Internet, and healthcare technology self-efficacy influence attitudes toward healthcare technologies (Manuel III, Capistrano, 2025). Consequently, low perceived self-efficacy may lead to avoidance of technology-dependent tasks, for example, by creating exaggerated barriers.

On the other hand, according to the Transactional Model of Stress and Coping (Lazarus, Folkman, 1984), an individual's perceived ability to cope with challenges plays a key role in determining their choice of coping strategies. This is further supported by the concept of self-efficacy, which associate stronger perceived self-efficacy with more active coping efforts (Bandura, 1977a, 1982, 1997). Thus, individuals with low self-efficacy are more likely to adopt emotional or avoidant coping behaviors, rather than engage in active problem-solving strategies.

Therefore, low digital self-efficacy can be expected to intensify the impact of digital misfit on the occurrence of avoidant behaviors, such as feigned digital incompetence. Accordingly, the following hypothesis is proposed:

H2: Digital self-efficacy moderates the relationship between digital misfit and feigned digital incompetence, such that the positive effect of digital misfit on feigned digital incompetence is weaker at higher levels of digital self-efficacy.

This hypothesis emphasizes how behavior stems from employees' expectations. It assumes that employees who perceive their own efficacy as high are likely to expect that they can cope with challenges posed by a technological environment, and therefore will be less inclined to choose avoidant-type behaviors.

The expectations influencing behavior in this framework concern the resources employees believe they possess to deal with a given problem. However, they may also relate to the anticipated outcomes of specific behaviors. When employees choose to feign digital incompetence, they expect particular results. Such expectations are shaped by their previous experiences, including observed workplace behaviors and their consequences.

Consequently, the occurrence of this phenomenon in the surrounding environment may have a similar effect to that of digital self-efficacy. Therefore, a potential moderator worth considering could also be coworkers' feigned digital incompetence.

2.3. Moderating role of coworkers' feigned digital incompetence

Feigned digital incompetence, as a form of deceptive behavior that potentially hinders task execution by introducing unnecessary obstacles, can be perceived as negative workplace conduct. Given its covert nature, it is likely to be observed, or even recognized, only infrequently. As such, this behavior constitutes a departure from normative expectations and may therefore be classified as workplace deviance, defined as "voluntary behavior that violates significant organizational norms and, in so doing, threatens the well-being of the organization or its members, or both" (Bennett, Robinson, 2000; Robinson, Bennett, 1995). This type of behavior can have significant consequences not only for employees who are directly targeted, but also for those who witness it or work in environments where deviant coworker behavior is collectively present (Robinson et al., 2014).

According to Social Learning Theory (Bandura, 1977b), employees learn behaviors by observing and imitating others, particularly when those behaviors are perceived as normal or rewarded within the workplace environment. For this reason, the frequent occurrence of feigned digital incompetence may serve as a behavioral model for coping with excessive performance demands. When such behavior is regularly witnessed, especially within specific organizational or technological contexts, employees may be more likely to adopt it in response to increasing technological pressures.

It is also plausible that, in line with the norm of reciprocity (Gouldner, 1960), feigned digital incompetence may function as a retaliatory strategy, particularly when the employee has previously been the target of such behavior. Moreover, when this behavior becomes widespread and begins to influence task allocation, it may be used as a self-protective mechanism aimed at preserving a sense of distributive justice.

Therefore, the frequency of feigned digital incompetence among coworkers should be considered a key factor in understanding the relationship between digital misfit and employees' own engagement in such behavior. Accordingly, the following hypothesis is proposed:

H3: Coworker's feigned digital incompetence moderates the relationship between digital misfit and employee feigned digital incompetence, such that higher frequency of coworker's feigned digital incompetence is associated with a stronger positive relationship between digital misfit and employee feigned digital incompetence.

Based on the above hypotheses, a model was proposed (Figure 1) that aims to explain the mechanisms through which digital misfit, the perceived mismatch between an employee's resources to meet the demands of the technological environment and the demands themselves, contributes to the emergence of feigned digital incompetence.

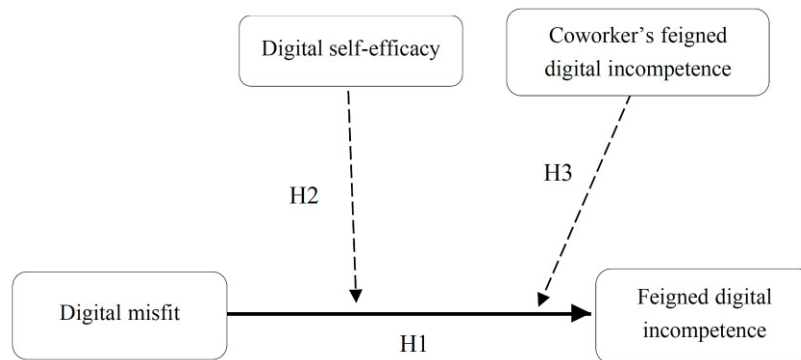


Figure 1. Research model of relationships between digital misfit and feigned digital incompetence.

Source: developed by the author.

The model presented in Figure 1 is based on an assumption that employee's high perception of digital misfit lead employees to engage in feigning digital incompetence. This tendency may be further reinforced when such behavior becomes normalized within the workplace context and when employees perceive their own digital efficacy as low.

3. Methods

3.1. Data Collection

Data for this study were collected using Computer-Assisted Web Interview (CAWI) method. The sampling was convenient and consisted of working adults from various workplaces across Poland who volunteered to participate. This approach was appropriate given the pilot nature of the research. The final sample consisted of 79 participants (34 men and 45 women), aged between 20 and 71 years (Median = 29), with work experience ranging from 0 to 47 years (Median = 9). Most respondents (81%) held higher education degrees. No missing data were reported.

The questionnaire consisted of Polish adaptations of validated scales in form of self-reported measurements. These scales were translated using the back-and-forth translation method. Respondents were asked to rate how much they agreed with each statement on a scale of 1 to 7. Employee's feigned digital incompetence and coworker's feigned digital incompetence were measured using adapted versions of a 4-item *playing dumb* scale (Connelly et al., 2012) and three selected items from the *social loafing* scale (George, 1992). The same sets of items were used to assess both constructs, but were phrased differently to

capture two perspectives: performed behavior (self-reported by the employee) and perceived behavior (ascribed to coworkers). Cronbach's alpha coefficients for both instruments indicate high internal consistency, with values of 0.859 for the employee scale and 0.931 for the coworker scale. Digital misfit were measured using a 5-item adaptation of *techno-complexity* scale (Tarafdar et al., 2007). Cronbach's alpha coefficients for this instrument indicates high internal consistency, with values of 0.832. Digital self-efficacy was measured using a 27-item adaptation of the *digital self-efficacy* scale (Ulfert-Blank, Schmidt, 2022). The instrument showed high internal consistency, with a Cronbach's alpha coefficient of 0.910.

3.2. Data analysis

The dataset was prepared in Excel, and all variables were carefully collected, verified, and coded prior to analysis. As an initial step, a reliability analysis was conducted to examine the internal consistency of the applied measurement instruments using Cronbach's alpha. The results, presented above, confirmed acceptable reliability levels for all scales. Subsequently, basic descriptive statistics were calculated. For hypothesis testing, linear regression analyses were performed. First, simple linear regression was used to test direct effect (H1). Then, moderation effects (H2 and H3) were tested using an interaction regression model – Classical PROCESS model accessible in JASP as module. All analyses were performed using JASP software.

4. Results

4.1. Descriptive statistics and correlations

The initial analysis of the distribution (Table 1) indicates that only one variable, Digital Self-Efficacy (DSE), meets the assumption of normality ($p = 0.715$). Overall, respondents report high levels of digital self-efficacy. The distribution of employee's Feigned Digital Incompetence (FDI) is right-skewed, with a clear floor effect, indicating that most respondents report minimal engagement in this behavior. This may suggest that FDI is genuinely rare or potentially underreported due to social desirability bias. In contrast, Coworker's Feigned Digital Incompetence (CFDI) appears to be more evenly distributed across the response scale, though with a slight right skew. This suggests that respondents observe this behavior among coworkers with varying frequency, or that they may be more willing to report such behaviors in others than in themselves, possibly due to reduced social desirability bias when evaluating others. The distribution of Digital Misfit (DM) is also slightly right-skewed, with most respondents reporting moderate levels of perceived misfit.

Table 1.*Descriptive statistics for each variable*

Variable	Mean	SD	Skewness	Kurtosis	Shapiro-Wilk test	p
FDI	2.15	0.96	1.05	0.65	0.9	<0.001
DM	3.13	1.29	0.6	- 0.04	0.96	0.002
DSE	4.75	0.99	- 0.01	- 0.49	0.99	0.72
CFDI	3.54	1.43	0.03	- 1	0.97	0.05

FDI – (employee's) feigned digital incompetence; DM – digital misfit; DSE – digital self-efficacy; CFDI – coworker's feigned digital incompetence.

Source: own work.

Although three out of four variables are not normally distributed, the sample size of 79 respondents ($N > 50$) is sufficient for stable estimation of regression parameters. However, knowledge about the distribution of the variables informed the choice of data analysis methods.

In the subsequent analyses comparing groups by gender, only the DSE variable significantly differentiates the groups in terms of gender: men achieved higher average scores than women, and this difference is statistically significant ($p = 0.002$ for the t-test and $p < 0.001$ for the Mann-Whitney U test), with a moderate effect size. For the other variables – FDI and TU – no statistically significant differences between the sexes were found. This means that in terms of these characteristics, women and men differ only in terms of DSE, while in terms of FDI and TU their scores remain comparable.

Analysis of correlations (Table 2) indicates that FDI is positively associated with higher levels of DM, negatively associated with DSE, and positively correlated with the frequency of observing this behavior in coworkers (CFDI). This preliminary evidence supports the assumption that FDI tends to occur in contexts characterized by technological complexity, perceived low digital competence, and a higher occurrence of this behavior in the workplace. Furthermore, there is no significant correlation between CFDI and either DM or DSE, which is logically consistent. However, the lack of correlation between DM and DSE suggests that individuals' feelings of digital misfit are independent of their perceived digital efficacy. Since DM was measured through perceptions of techno-complexity, this lack of correlation suggests that external factors like technological complexity have a stronger influence on feelings of digital misfit than individuals' self-assessed digital competence.

Table 2.*Spearman's Correlations*

Variable	Statistics	FDI	DM	DSE	CFDI
FDI	Spearman's rho	-			
	p-value	-			
DM	Spearman's rho	0.336**	-		
	p-value	0.002	-		
DSE	Spearman's rho	-0.310**	-0.151	-	
	p-value	0.005	0.183	-	
CFDI	Spearman's rho	0.341**	0.005	-0.034	-
	p-value	0.002	0.963	0.763	-

FDI – (employee's) feigned digital incompetence; DM – digital misfit; DSE – digital self-efficacy; CFDI – coworker's feigned digital incompetence; * $p < .05$, ** $p < .01$, *** $p < .001$.

4.2. Hypotheses testing

A simple linear regression was conducted to test the hypothesis that DM positively predicts FDI (H1). The model was statistically significant $F(1, 77) = 16.45$, $p < .001$, and explained 17.6% of the variance in FDI ($R^2 = .176$). DM significantly and positively predicted FDI ($B = 0.314$, $SE = 0.077$, $t = 4.06$, $p < .001$; $\beta = 0.420$), indicating that individuals who perceive a greater mismatch between their digital competence and the demands of the technological environment are more likely to engage in feigning digital incompetence. Therefore, hypothesis 1 was confirmed.

To test the hypothesis that DSE moderates the relationship between DM and FDI, a moderation analysis was conducted using an interaction regression model in JASP (PROCESS module). Bootstrapped standard errors and 95% confidence intervals based on 1,000 resamples were used to account for potential violations of normality and heteroscedasticity. The results revealed that DM had a significant positive effect on FDI ($b = 1.047$, $SE = 0.296$, $p < .001$), whereas the main effect of DSE was not significant ($b = 0.238$, $SE = 0.199$, $p = .233$). However, the interaction term ($DM \times DSE$) was statistically significant but negative ($b = -0.159$, $SE = 0.060$, $p = .008$), indicating that the strength of the relationship between DM and FDI varies depending on the level of DSE. A conditional effects analysis (Figure 2) showed that at low levels of DSE (16th percentile), the effect of DM on FDI was strong and significant ($b = 0.457$, $p < .001$). At medium levels (50th percentile), the effect was still significant but weaker ($b = 0.284$, $p < .001$), and at high levels of DSE (84th percentile), the effect became statistically non-significant ($b = 0.119$, $p = .213$).

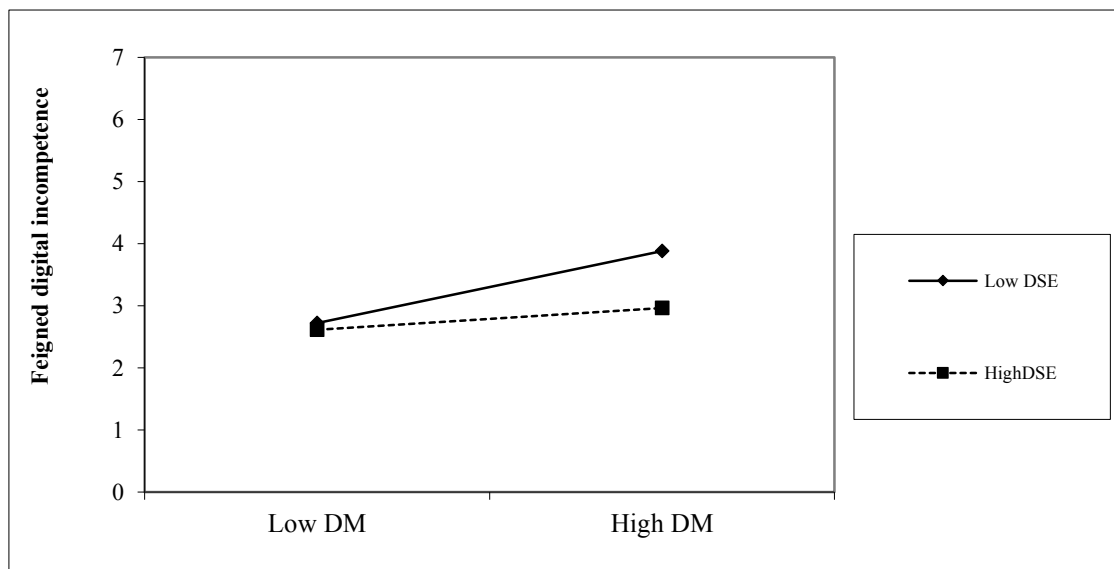


Figure 2. Moderation.

These findings suggest that DSE attenuates the positive effect of DM on FDI, with the effect becoming non-significant at higher levels of DSE. Therefore, hypothesis 2 was confirmed. The model explained 29.3% variance in FDI ($R^2 = 0.293$).

An analogous analysis was conducted to test the hypothesis that CFDI moderates the relationship between DM and FDI, such that higher levels of CFDI strengthen this relationship. The moderation analysis revealed that CFDI significantly moderates the relationship between DM and FDI. The interaction term (DM×CFDI) was marginally significant ($b = 0.084$, $SE = 0.043$, $p = .051$), indicating that the strength of the relationship between DM and FDI varied depending on CFDI levels. Conditional effects analysis (Figure 3) showed that at low levels of CFDI (16), the relationship was weaker but still significant ($b = 0.200$, $p = 0.031$), whereas at medium (50) and high (84) levels, it became progressively stronger and more significant ($b = 0.320$ and $b = 0.463$ respectively, both $p < 0.001$).

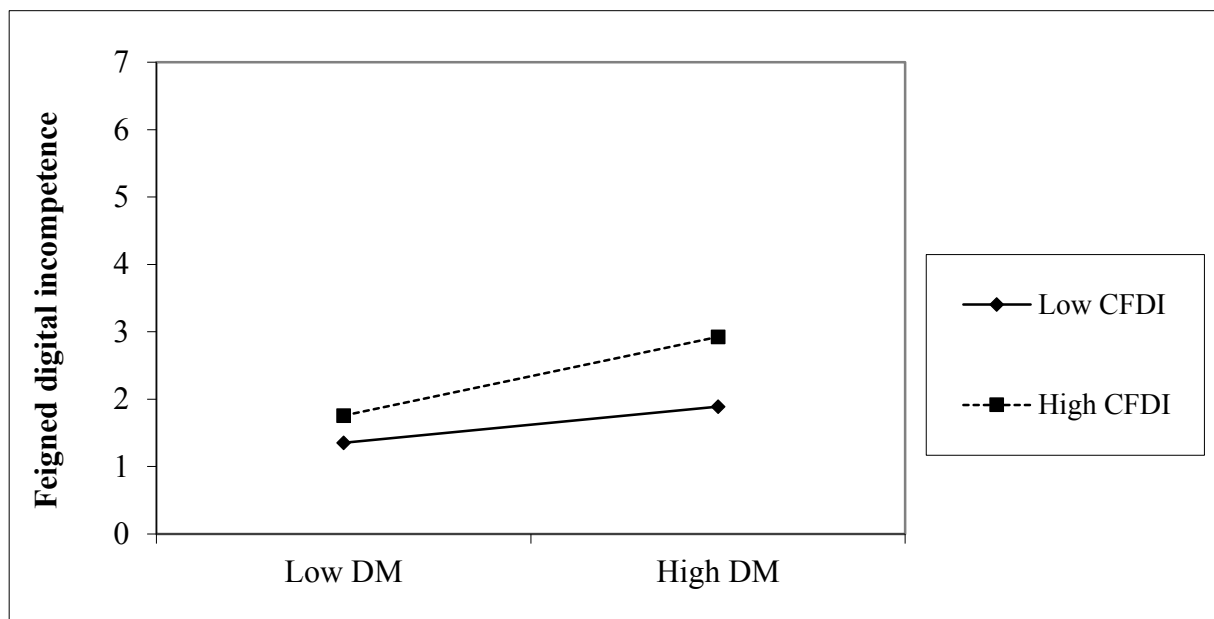


Figure 3. Conditional effects analysis.

These findings suggest that CFDI enhances the positive influence of DM on FDI, with the effect being most pronounced at higher levels of CFDI. Therefore, hypothesis 3 was also confirmed. The model explained 33.9% variance in FDI ($R^2 = 0.339$).

5. Discussion

This pilot study aimed to preliminarily test adapted scales to measure feigned digital incompetence and to examine hypotheses linking this behavior with digital misfit, low digital self-efficacy, and the frequency of coworkers' engagement in similar behaviors.

Findings suggest that the "playing dumb" scale (Connelly et al., 2012) and selected items from the social loafing scale (George, 1992) can be successfully adapted to capture aspects of feigned digital incompetence. However, a particular limitation of the instrument was observed. Measuring socially undesirable behaviors through self-report methods can be problematic due

to individuals' tendency to provide socially desirable responses in self-description (Edwards, 1957; Paulhus, 1991). This may occur either because the respondent genuinely believes their positive self-reports or deliberately falsifies them (Paulhus, 1984). Regardless of the motive, this tendency typically results in the underreporting of deceptive behaviors. In line with this, the present study observed a floor effect in self-reported feigned digital incompetence, with most responses clustering at the lower end of the scale. Conversely, reports of coworkers' behaviors were more evenly distributed across the scale. This suggests that other-report measures (e.g., evaluating coworker behaviors) may provide more valid data when investigating behaviors perceived as socially undesirable. Nevertheless, when studying antecedent factors, particularly individual ones such as digital misfit, using self-report measures appears to be justified. Other-report measures, which rely on observed behaviors or subjective evaluations by others, seem less appropriate in this context. Conversely, they may be more suitable for assessing outcomes, as the way employees subjectively perceive their work environment and colleagues' behavior influence their own behavior.

Furthermore, the study confirmed the association between feigned digital incompetence and the employee's perceived mismatch between their digital skills and the demands of a complex technological environment (digital misfit). This supports the assumption that employees working in technologically demanding environments may intentionally downplay their digital competence as a coping strategy. The mechanisms underlying this relationship can be explained through the Job Demands–Resources (JD-R) model (Demerouti et al., 2001) and Conservation of Resources (COR) theory (Hobfoll, 1989). The ongoing need to keep up with evolving technological requirements may indirectly increase job demands. Increased job demands can further lead to strain or even exhaustion, which can negatively affect in-role performance (Bakker et al., 2004). In response to rising demands, stress, and the risk of resource depletion, employees may engage in resource-conserving behaviors as a protective mechanism (Hobfoll, 1989). Thus, digital misfit may contribute to workplace stress and exhaustion, potentially triggering avoidant behaviors, such as feigned digital incompetence, that serve to protect employees' resources by avoiding responsibilities involving digital tasks. This potential avoidant motive aligns with the concept of “weaponized incompetence” popularized on social media, where similar behaviors are used to evade tasks or responsibilities. Further research, especially qualitative studies involving individual interviews, would be valuable to explore and better understand the underlying mechanisms of this behavior. This is particularly important given that the literature suggests feigning incompetence situations is a multifaceted phenomenon. It occurs not only as a strategy to limit expectations and responsibilities but also for purposes such as managing relationships, seeking gains, saving face, or entertaining others (McLuhan et al., 2014).

This pilot study also confirmed the moderating role of digital self-efficacy, whereby lower levels of self-efficacy strengthened the relationship between digital misfit and feigned digital incompetence. The effect diminishes at higher levels of perceived self-efficacy. This suggests

that employees with low confidence in their digital abilities may be more prone to constructing unnecessary barriers to technology use. When confronted with technological complexity, they may be more likely to adopt avoidance-oriented behaviors if they perceive themselves as incapable of coping with digital demands. These findings are consistent with theoretical perspectives linking higher perceived self-efficacy to more active coping strategies and reduced avoidance in stressful contexts (Bandura, 1977a, 1997). Although no direct effect of digital self-efficacy on feigned digital incompetence was observed, its moderating role suggests that self-efficacy may buffer the impact of digital misfit. This interpretation aligns with prior research showing that computer self-efficacy positively influences individuals' behavioral intentions to engage with digital systems, particularly in challenging or unfamiliar settings (Hsia et al., 2014). Therefore, in light of the pilot study, digital self-efficacy emerges as a psychological resource that mitigates the negative influence of technological stressors on employee behavior. Supporting its development may serve as a potential intervention to reduce the occurrence of feigned digital incompetence and support digital transformation.

The moderating role of coworkers' feigned digital incompetence was also confirmed, indicating that it strengthens the relationship between digital misfit and an employee's own feign digital incompetence. When such behavior becomes common in the workplace, it appears to be normalized, thereby reinforcing it as a socially acceptable coping strategy in response to technological demands. This phenomenon can be explained through Social Learning Theory (Bandura, 1977b), which posits that individuals learn behaviors by observing and imitating other, especially when these behaviors appear to be effective or widely accepted. As more employees engage in feigned digital incompetence, others may adopt the same behavior as a learned response to similar stressors. Another explanatory framework is Social Exchange Theory, which suggests that employees evaluate their engagement and responsibilities based on the perceived balance between costs and benefits. As technological demands increase, raising the "cost" of work, employees may engage in withdrawal behaviors to restore a perceived equilibrium. Feigning digital incompetence can serve this function by reducing task demands or responsibilities. It is also possible that the behavior is driven by the norm of reciprocity (Gouldner, 1960). Employees may reciprocate such behaviors when they perceive that others have previously hindered their work or manipulated the distribution of tasks at their expense. However, this potential dynamic requires further investigation. A more comprehensive model should consider contextual factors such as task interdependence, psychological contract breach, and the level of technological support, especially in cases where the behavior is reciprocated not just between coworkers, but also toward the organization or its management. Given the complexity and subtlety of these dynamics, exploratory qualitative research is recommended to deepen understanding of the situational and interpersonal factors that shape feigned digital incompetence in the workplace.

6. Theoretical implications

In light of the findings, this pilot study presents several implications worth considering. From a theoretical perspective, one key methodological contribution is the validation of adapted instruments that can be used to measure the insufficiently explored phenomenon of feigned digital incompetence. These adaptations provide a foundation for future research aimed at empirically investigating this behavior across various workplace relationships and contexts.

Furthermore, the study contributes to the theoretical development of the feigned digital incompetence construct by framing it as a coping mechanism in response to digital misfit, employees' perceived mismatch between their digital competencies and demands of technological environment. This perspective broadens the understanding of how employees may strategically respond to digital pressures in the workplace, an insight that is particularly important in light of the exponential advancement of emerging technologies, such as artificial intelligence. Based on the findings of this pilot study, feigned digital incompetence may be interpreted as a form of avoidant behavior that serves a protective function in response to technostress. It may be particularly likely to occur when employees lack confidence in their digital abilities and when such behavior is frequently observed among coworkers.

These findings also point to potential avenues for further research on the phenomenon.

First, it may be valuable to explore individuals' attitudes and orientations toward such behavior, particularly in relation to the normalization of workplace behaviors, as addressed in this study. The pilot study focused solely on the frequency of behavior and confirmed that individuals were more likely to engage in (or report) such behavior when it was perceived as common. Reporting that others behave this way also seemed to facilitate the willingness to disclose similar behaviors themselves.

Second, the motivations underlying feigned digital incompetence warrant further investigation, especially to examine the assumed avoidant nature of the behavior. Its occurrence in the context of elevated technostress levels suggests that it may function as a coping mechanism. In this light, feigned incompetence could serve as an indirect plea for help, seeking additional support, training, or assistance from colleagues, or signaling a sense of overload in a subtle way. However, it would be important to explore whether this barrier-setting is genuinely a response to technological strain, or rather a form of responsibility avoidance, as it is sometimes portrayed on social media, where technological change may be used as an excuse for underperformance.

Third, it may be fruitful to examine the task-specific context of the behavior. Understanding the situational nuances could help clarify whether feigned digital incompetence serves as a strategic response to increasing workload demands or to mitigate engagement in repetitive and redundant tasks. It would be valuable to explore whether this behavior is more prevalent in group settings, where task redistribution and shared responsibility are possible, and to assess

how high task interdependence influences both the use and consequences of this strategy. Accordingly, research on job design, particularly with regard to task characteristics (e.g., Hackman, Oldham, 1975; Morgeson, Humphrey, 2006), would offer important insights.

Fourth, considering the individualistic nature of this coping strategy, future research should explore relevant individual differences. Factors such as levels of individualism (Singelis et al., 1995), digital competences (Vuorikari et al., 2022), and locus of control orientation (Rotter, 1966) may influence the likelihood of engaging in such behavior and the specific contexts in which it is employed. These individual traits may play a crucial role in how individuals cope with technological uncertainty and shaping their willingness to feign incompetence as a strategy for managing demands or avoiding responsibility.

7. Practical implications

From a practical perspective, the study highlights that feigned digital incompetence is a real and observable phenomenon in the workplace, and one that may carry harmful consequences. It can contribute to the normalization and spread of such behavior among coworkers. As a form of placing unnecessary obstacles in the way of adopting new digital technologies, it may hinder digital transformation and act as a subtle form of resistance to organizational change. Therefore, it should not be dismissed as a humorous or anecdotal issue, as it is sometimes portrayed on social media, but rather recognized as a serious workplace phenomenon. This is especially relevant considering the research on related behaviors such as knowledge hiding, which has been shown to negatively affect trust, collaboration, and overall team performance.

Importantly, the findings suggest that the occurrence of such behaviors may serve as an early warning signal for managers, pointing to a potential gap between employees' digital competencies and the increasingly complex demands of the technological work environment. This digital misfit may cause employee overload, stress, and negatively impact their wellbeing and productivity. As such, it should prompt further organizational analysis, both at the individual and team levels, to identify underlying causes and implement targeted interventions. Feigned digital incompetence can stem from factors such as the rapid pace of new technology implementation, insufficient training or technical support that leaves employees feeling under-resourced to manage technological demands, or fear of negative evaluation in environments with poor feedback culture or ineffective problem-solving practices.

Managers seeking to assess the presence of this phenomenon may consider using the proposed measurement tools, particularly other-reported instruments, which appear to be more effective in capturing these types of behaviors in workplace settings. However, these instruments may be better suited for scientific contexts, where greater anonymity can be

ensured. In practical organizational settings, identifying feigned digital incompetence may prove challenging, as the behavior is often subtle and context-dependent. Managers may therefore need to rely on indirect behavioral cues within teams, such as recurring patterns of avoidance or inconsistent engagement with digital tools.

Efforts to prevent this phenomenon should focus not only on enhancing employees' digital skills but, more importantly, on strengthening their digital self-efficacy, for instance, through positive reinforcement and targeted feedback. Implementing digital mentoring programs could be particularly beneficial in this regard, as they provide personalized support for employees and assist in resolving ongoing problems or uncertainties. Guidance from an experienced mentor can serve as a stable point of reference in an uncertain technological work environment.

Under such stressful conditions, microlearning may also prove to be an effective method for developing employees' digital competencies and self-efficacy. Microlearning refers to a form of digital learning of short duration that, using various multimedia, enables action-oriented learning with immediate relevance (Beste, 2023). This approach allows employees to acquire missing knowledge before or during specific tasks, apply it in practice, and gradually become familiar with the presence and use of new digital technologies in a non-overwhelming manner.

The consistent acquisition of knowledge, its practical application, and the experience of small successes seem to be a valuable approach for employees in developing digital self-efficacy.

Furthermore, addressing the observed behaviors requires avoiding task redistribution based on perceived "incompetence" and encouraging open communication about difficulties and a collaborative problem-solving. Such an approach may help discourage the perception of feigned incompetence as a viable coping strategy and promote more constructive alternatives.

8. Limitations

The pilot study, based on 79 responses, served as a foundation for the preliminary evaluation of the measurement instruments and the initial testing of hypotheses. It also provided valuable insights that inform the direction of future research in this emerging area. At the same time, the study's design and scope also highlight several limitations that should be addressed in subsequent research.

As previously noted, an important limitation pertains to the choice of measurement tools. The findings suggest that measuring feigned digital incompetence through self-report instruments is inherently challenging, particularly due to the influence of social desirability bias. While the observed floor effect may reflect a genuinely low frequency of the behavior, it is equally plausible that the phenomenon is underreported. Given its covert nature and

the potential reputational risks associated with admitting to such behavior, especially within organizational cultures that prioritize digital competence and proactivity, participants may have been reluctant to disclose their engagement in it. Although anonymity was ensured and no data were collected regarding participants' companies or professions, the risk of underreporting cannot be entirely ruled out.

Another limitation related to the choice of measurement tools concerns the impact of questionnaire length on participants' willingness to take part. Although the 27-item *Digital Self-Efficacy* scale (Ulfert-Blank, Schmidt, 2022) demonstrated excellent internal consistency and yielded a normal distribution of responses, several participants reported that the survey was too long. This may have contributed to the relatively small sample size, as the length could have discouraged participation. To improve response rates and enhance participant engagement, it may be worth considering the use of a shorter scales to measure the digital self-efficacy scale in future studies. For example, the 10-item *Technology Self-Efficacy* scale developed by Thatcher and Perrewé (n.d.), which has consistently demonstrated acceptable reliability (Cronbach's $\alpha > 0.70$) in recent technostress research (e.g., Chen et al., 2024), could be a suitable alternative. This recommendation is further supported by follow-up research conducted by the author, in which participants also expressed greater willingness to complete shorter instruments.

Another limitation relates to the sampling context. The study was conducted solely among participants from Poland, which may limit the generalizability of the findings. Cultural differences in dimensions such as individualism, power distance, and uncertainty avoidance, identified by Hofstede's cultural framework may reduce the cross-cultural applicability of the results (Hofstede, 1984; The Culture Factor, n.d.).

Feigned digital incompetence appears to be a behavior potentially associated with the pursuit and protection of individual interests, although this hypothesis still requires empirical validation. In highly collectivist cultures, such as Colombia (individualism score = 29, The Culture Factor, n.d.), where group harmony and collective well-being are emphasized (Hofstede, 1984), such behavior may be less socially accepted or even discouraged due to its self-serving nature. In contrast, Poland's more moderate level of individualism (score = 47, The Culture Factor, n.d.) may allow for greater personal boundary-setting and support the occurrence of such behaviors as a form of subtle self-interest or workload management in the workplace.

Furthermore, Poland scores relatively high on power distance (score = 68, The Culture Factor, n.d.), indicating that hierarchical relationships in organizations are more pronounced (Hofstede, 1984). In this context, feigned digital incompetence may serve as a strategy to manipulate task allocation or exert indirect control when formal authority is limited, functioning as a covert mechanism for negotiating workload or maintaining a hidden advantage. In countries with lower power distance, such as Denmark (score = 18, The Culture Factor, n.d.), where organizational hierarchies are flatter and autonomy is more widely distributed (Hofstede, 1984),

such behaviors may be less about power dynamics and more about alternative motivations, or may occur less frequently.

Poland also exhibits high uncertainty avoidance (score = 93, *The Culture Factor*, n.d.), reflecting a cultural tendency toward discomfort with ambiguity and rapid change (Hofstede, 1984). This may amplify the impact of technological transitions on employee stress levels and foster more strategic, long-term coping behaviors, such as feigned digital incompetence, as a way to delay or avoid engaging with unfamiliar tools or workflows.

Therefore, future research would benefit from the inclusion of culturally and geographically diverse samples to better explore potential cross-cultural differences in the manifestation and interpretation of feigned digital incompetence.

The study is also limited by the chosen methodological approach – quantitative research – which, while suitable for testing straightforward models, may not be the most appropriate at the stage of preliminary investigation. Exploratory, qualitative methods, particularly in-depth interviews, would offer a more nuanced understanding of the phenomenon. At the preliminary stage, qualitative research could enable scholars to explore how feigned digital incompetence is perceived by employees, assess the extent to which social desirability bias affects self-reports, and, crucially, investigate the underlying mechanisms, situational triggers, and potential consequences of the behavior. Such insights would be instrumental in advancing both theoretical development and practical understanding of this emerging construct.

9. Conclusion

The findings of this pilot study demonstrate that feigned digital incompetence, a phenomenon in which employees pretend to lack digital competence that are necessary to perform a task, can serve as a response to digital misfit, the gap between technological demands and individual's digital competence. The results also underscore the role of digital self-efficacy and social learning, highlighting how personal confidence and peer behavior shape employee's likelihood to engage in such avoidance tactics.

Although subject to several limitations, these findings provide initial evidence for the relevance of this emerging construct and provide a foundation for future research exploring its underlying mechanisms, motivational drivers, and workplace consequences. Future studies could validate measurement instruments, examine cultural variations, and investigate the specific contexts and individual differences that predict the occurrence of feigned digital incompetence.

From a managerial perspective, observing this phenomenon can serve as an early warning indicator of potential challenges in implementing new digital technologies, particularly those arising from insufficient consideration of employees' individual needs related

to skill development and adaptation to technological change. Organizations can proactively address this risk by offering targeted support for digital competence development, such as microlearning resources, digital mentoring, and structured feedback, while fostering a collaborative climate that encourages open communication, mutual support, and joint problem-solving

As digital demands continue to intensify, understanding subtle forms of resistance like feigned digital incompetence is increasingly relevant for theory and practice alike. By recognizing and addressing this behavior, organizations can better align technological initiatives with employee capabilities and promote more effective, inclusive technology adoption.

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CONVERGENCE OF EXPENSES ON RESEARCH AND DEVELOPMENT AS A DETERMINANT OF INNOVATIVENESS – COMPARATIVE ANALYSIS

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Purpose: The purpose of this paper is to analyze the economic convergence of expenses on research and development and researching the trends of this convergence in the European Union states with the division into countries that joined the EU before and after 2004.

Design/methodology/approach: The trial was made to research the economic convergence to verify the influence of the factor determining the amount of R&D expenses at the national level the most. The research was conducted for the groups of the European Union states on the data from 2005–2023 from the Eurostat database. The variables were converted according to PPS and given in fixed prices of 2015 in order to avoid wrong conclusions.

Findings: The conducted research showed that the decisive parties wanting to increase their innovativeness have to pay attention to the level of economic growth and a significant role of human resources in creating innovativeness and in obtaining high competitiveness in the market. The periods of convergence (falling, the period of sustainable growth) and divergence can be noticed both in so called ‘old’ and ‘new’ European Union states. However, the pace is different in both groups and when it comes to both changes. It results from the fact that even though the Scandinavian countries lead in the field of innovativeness, the states of South-Eastern Europe are developing faster when it comes to innovativeness. Should such a tendency remain, the situation would be optimistic. In the ‘new’ EU states the average annual rate of GERD convergence towards GDP is 1.9 percentage point higher but calculated per capita is 1.4 p.p. lower. Thus, in the second case, the situation of the states that joined the Union in 2004 is not profitable especially considering the aging of the society.

Research implications: The following analyses should include more affecting the R&D expenses so that it was possible assess the convergence of the tested value in particular states in a more detailed way. The next important suggestion concerning the future analyzes is to extend them not only to the EU member states but it is necessary to use one source of information to provide reliable data.

Practical implications: Paying attention to all the factors affecting the innovativeness may contribute to the changes in companies and thanks to that improve the competitiveness of the whole economies in the international area.

Value: The convergence research affects efficient management in order to make the companies or countries competitive. The continuous raising of the innovativeness level and thanks to it, obtaining high efficiency, is the main source of competitive advantage.

Keywords: convergence, divergence, σ -convergence, absolute β -convergence.

Category of the paper: Research paper.

1. Introduction

The convergence of innovativeness refers to both the phenomenon of convergence process to the balance state as well as to the process of equalizing the development level of various countries (Strahl, 2011). So, talking about the convergence of structures, it is possible to use the term of convergence to almost every situation in which the forces encouraging people or social groups to achieve the common aim occur (Kluth, 2023).

Thus, analyzing the economic growth, the effect of approaching innovativeness levels is considered through the convergence of particular countries. It refers to the process of assimilating the less developed economies of countries (regions) to the more developed economies (Rapacki, Próchniak, 2019) by implementing new technologies, production processes (Hammar, Belarbi, 2021). Thus, it is possible to talk about the convergence of nations among other considering the GDP in the macroeconomic field. It is visible among others in the investments in research and development which are ones of the main factors affecting the management and competitiveness of companies or the support of their R&D activity by the state (Szymański, 2017; Celli, Cerqua, Pellegrini, 2024).

Due to this fact, considering the convergence of R&D expenses in this paper, they were referred not only to the population but also the GDP was used as a measurement factor used most often in the analyses to assess the economic convergence. Undoubtedly, it is connected with the fact of measuring the economy wealth with the use of GDP (Szajt, 2010).

However, the existence of differences between countries, e.g. various level of economic growth, makes it difficult to introduce new technologies and to adapt to common solutions. Nevertheless, it is not impossible to meet some standards, especially that the EU supports the member states actively in the scope of wider political, social and economic integrity, which contributes to the functioning of companies in the dynamically changing surroundings.

So, the fact that the financial means, and in particular possessing them, are undoubtedly the main element affecting the innovative activity especially in small and medium-sized enterprises, causes that the issue should be considered from the economic point of view (Baj, Pietucha, 2006; Ciupek, 2014; Lisowska, 2017; Perez-Alaniz et al., 2022; Ostrowska, Lipska, 2023). The % of GDP spent on R&D may be a significant (deciding) factor supporting the introduction of new solutions, services or products to the market and consequently contributing to the proper management in the companies. As it is widely known, this process is connected with high costs as the existence of a new product in the consumer's awareness needs a wide range of analyses and preparations (Rutkowski, 2021).

Due to the fact that the expenses on research and development play one of the most important roles in creating innovativeness and innovations, and that the EU supports economic convergence through various instruments, the question arises about the existence of connections of the expenses on research and development in the states that belonged to the Union before and after 2004 in respect to the mean of the given group of the EU states.

The answer to this question is aimed to help verify the following research hypothesis: The results of the research of convergence of expenses on research and development constitute a reference point to building greater competitiveness between ‘old’ and ‘new’ EU member states and it may support to manage the means assigned on innovations in particular countries.

Taking the above into consideration, the purpose of this paper is to assess the convergence of expenses on research and development as an external economic factor affecting the innovativeness.

Thus, this paper constitutes an attempt to satisfy the purpose and is the contribution to paying attention to the consistence of expenses assigned on research and development as a factor deciding about the competitiveness of companies in the international markets indirectly.

2. Method

In the long-run all countries pursue to achieve the common level of sustainable growth (Ciolek, 2003). Taking it into consideration, it is possible to state that with the time the economies with the similar level of income per capita show the tendencies to achieve the similar status at the domestic level or at the level of companies.

The information about the R&D expenses and the GDP, which affect the considered determinant of innovativeness and the management of companies significantly, were used to assess the situation in the analyzed EU states.

Due to the fact that the author’s interests are focused on the economic convergence in the EU, the σ -convergence and unconditional β -convergence were tested in this paper as a necessary condition but insufficient for σ -convergence (Wójcik, 2018). It was assumed that the tested countries pursue to equalize the level of their economic growth among others by decreasing the differences among them concerning the expenses on research and development.

The coefficient of variation or its logarithm were used to assess σ -convergence (Rosiek, 2011). Thanks to this coefficient, it is possible to test how e.g. the levels and relations of R&D expenses change in particular countries towards the mean for the analyzed group of countries. Lower values of the measures of dispersion of the data i.e. logarithms of the coefficient of variation for countries show the greater connection of the tested values confirming the existence of the convergence phenomenon. Moreover, the analysis of variance of data going through two points was performed during testing the σ -convergence. It was performed by raising a hypothesis $H_0: \sigma_{2005}^2 = \sigma_{2023}^2$ towards $H_1: \sigma_{2005}^2 > \sigma_{2023}^2$. The verification of H_0 was conducted with the use of the test:

$$F = s_{2005}^2 / s_{2023}^2 \quad (1)$$

where:

s_{2005}^2 – variance of R&D expenses indicated for group i for 2005,

s_{2023}^2 – variance of R&D expenses indicated for group i for 2023.

The rejection of H_0 for the benefit of H_1 means the confirmation that the convergence effect exists, i.e. the phenomenon in which the variation of a given value decreases in a tested group with the time.

Whereas, the concept based on the assumption that all the analyzed countries pursue to the same status of development (balance) was used to test the existence of the absolute β - convergence which exists in the case of the decrease in discrepancies concerning the income per capita. The model of this convergence was created as follows:

$$\frac{1}{T}(\ln WBR_{iK} - \ln WBR_{i0}) = \alpha + \beta \ln WBR_{i0} + \varepsilon_{it} \quad (2)$$

where:

$\ln WBR_{iK}$ – $\ln$ of R&D expenses in country i in the final year,

$\ln WBR_{i0}$ – $\ln$ of R&D expenses in country i in the beginning year,

α – constant term,

β – structural parameter used to determine the pace of convergence(π): $\beta = (-1 + \exp(-\pi T))/T$,

ε_i – random component,

T – number of years for which the growth rate is calculated,

$(\ln WBR_{iK} - \ln WBR_{i0})/T$ – the mean annual growth rate of R&D expenses in country i in time K .

The negative value of β parameter means the existence of convergence, the positive value higher than one, the value of this parameter is equal to the existence of the divergence phenomenon.

The data from the EUROSTAT database were used in the analyses and the time series coming from one source were used to avoid the differences in the method of data collection in the paper. The sample covered the years 2005-2023 and among others the GRETl package was used during the analyses.

3. Results

Analyzing the convergence, the R&D expenses calculated per capita (in euro according to PPS) and measured as a % of Gross Domestic Product were tested in the research. The author divided the Union states depending on the moment of joining the EU in order to achieve the aim.

The results for sigma (σ) convergence are presented in the charts below showing the shaping of the ln of coefficients of variations in years 2005-2023.

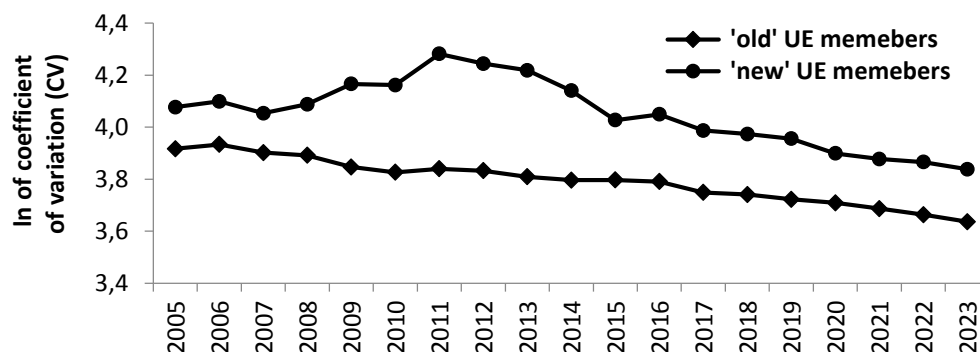


Figure 1. The values of ln of coefficients of variation for research and development expenses for the analyzed groups of the EU states in the mean of these countries (per capita, PPS).

Source: own study based on Eurostat.

Analyzing figure 1, both the periods of convergence as well as divergence were noticed. The phenomenon of convergence between so called 'old' and 'new' EU member states is visible in the case of GERD per capita in years 2005-2006, 2011-2015 and since 2016, whereas the phenomenon of divergence in the period 2007-2011 and 2015-2016. However, considering the whole period of the research, the percentage of the standard deviation in the means of the tested groups of the EU states decreased. Nevertheless, it is slight and amounts to about 0.26 percentage point. Examining the GERD of particular countries, we notice that it is possible to talk about the biggest share of the mean differentiation in the case of Poland (59%), Croatia (49.9%) and Bulgaria (47.2%), whereas the lowest indicator was noticed in Luxembourg (6.84%), Finland (10.4%) and France (12.8%). When it comes to the average pace of changes, the highest value of the geometric mean was observed in Poland (111.1%), Bulgaria (109.1%) and Romania (108.5%) and the lowest in Finland (101.9%), France (102.5%) and Sweden (102.7%).

A bit different situation can be seen in the figure in which GERD was compared to GDP, thus to the relations which the companies consider while taking strategic innovative decisions.

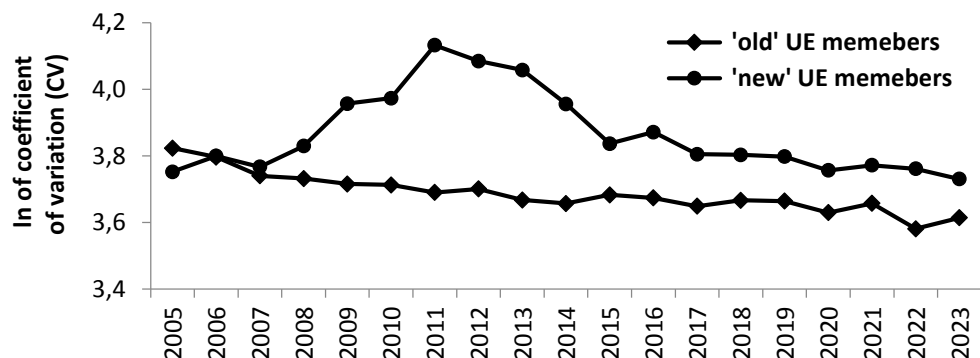


Figure 2. The values of ln of coefficients of variation for research and development expenses for the analyzed groups of the EU states in the mean of these countries (the GDP percentage).

Source: own study based on Eurostat.

On the basis of the information presented in figure 2, it is also impossible to talk only about convergence or divergence. The convergence was observed in two periods: 2005-2006, 2012-2021 and from 2022 to 2023. In the other years, the divergence is visible in both groups. It is possible to notice the fall in $\ln$ of CV in both groups in the tested period but in the case of the states belonging to the EU before 2004 this fall was bigger by about 20.6%. Considering the difference between these measurements in the whole period, it is possible to state that it shaped on average at the level of 3.7 $\ln$ and it was for the benefit of the countries in the Southern and Eastern Europe. Whereas, in 2023 the percentage of the standard variation in the mean of a given group amounted to 12.3% being also more beneficial for these countries. Considering the relative measurement of differentiation in a given group of the EU, its highest value was in Greece (35.8%), Poland (33.3%) and Cyprus (23.9%) and the lowest in France (3.2%), Denmark (7.2%) and Spain (7.5%). However, the order of countries is different when it comes to the average rate of changes. Here the highest value of the geometric mean was observed in Greece (105.3%), Portugal (104.5%) and Slovakia (104.1%) and the lowest in Finland (96.6%), Luxembourg (97.6%) and Sweden (100.4%).

Moreover, comparing the information included in both figures, it should be noticed that the values of R&D expenses vary from the mean in the tested groups much more in the case of expenses calculated per capita in the states belonging to the EU from 2004 in the whole tested period. Even though it is possible to observe the advantage of 'old' countries in comparison to the 'new' ones only in 2005 when it comes to R&D expenses in % of GDP, it could have been assumed due to the possibilities of development including economic and historical conditions, which is usually connected with other ways of management. However, independently of shaping the expenses, it is possible to state that there is a decreasing tendency in the whole analyzed period. Four trend functions were assessed in order to present this direction of changes. The first two indicate the changes of the tested expenses measured in euro per capita, PPS, the other two the average periodic rate of changes also calculated as the percentage of GDP. Thus, functions (3) and (5) refer to the countries belonging to the EU before 2004 and (4) and (6) to countries joining the structures of the Union from 2004:

$$\hat{y}_1 = 0,513 - 0,007 \cdot t \quad (3)$$

$$\hat{y}_2 = 0,674 - 0,009 \cdot t \quad (4)$$

$$\hat{y}_3 = 0,438 - 0,004 \cdot t \quad (5)$$

$$\hat{y}_4 = 0,516 - 0,003 \cdot t \quad (6)$$

where:

y_i – coefficients of variation GERD for the group i of the EU states in the period 2005-2023,
 $i = 1, \dots, 4$.

The negative value of the coefficient with the time variable shows the decreasing differentiation of the taken factor in the whole period, which confirms the direction of changes.

Moreover, while analyzing test (1), for $\alpha=0,20$ test F shows that there are no reasons to reject H_0 for the benefit of H_1 in the case of the GDP percentage assigned for R&D expenses but it should be rejected for GERD per capita. It confirms the existence of convergence in years 2005-2023 in respect to the expenses assigned on R&D (per capita, PPS) and when it comes to the tested expenses as % of GDP, it should be talked about the partial divergence and more precisely about the lack of reasons to state that the convergence does not occur in the whole period.

Considering the data presented in figures 1 and 2, it is difficult to indicate clearly for which of the groups presented in them the rate of convergence is higher. However, the unconditional convergence was assessed for both presented groups to specify this rate. The results of the β -convergence analysis show that at the estimation of absolute convergence coefficients β in model (2) are negative and statistically significant in all cases (Table 1).

Table 1.

Estimate of parameters in model (2)

UE members	GERD per capita			GERD as %GDP		
	β	Parameter error	P-value	β	Parameter error	P-value
old EU states	-0.021	0.006	0.003	-0.021	0.008	0,019
new EU states	-0.015	0.006	0.038	-0.003	0.003	0.194

Source: own work based on the GRETL program.

On the basis of the values of coefficients β it is possible to state that the convergence of R&D expenses given in euro per capita, PPS was the same as in the case of these expenses measured as % GDP – about 2.5% in the ‘old’ countries. However, in the new EU states the average annual rate of convergence was different and amounted to 1.1% (per capita) and 4.4% (share in %GDP).

4. Discussion

The convergence of innovativeness may be considered as the ability to create, initiate and absorb the innovations (Bal-Domańska, 2011), regarded as a significant factor affecting the challenges of sustainable growth most often (Azmat et al., 2023). Thus, considering the innovation convergence process is to understand in which scope the new solutions which affect various aspects of social, technological and economic life are introduced. Although each innovation disturbs the current situation in the company, the introduction of a new solution contributes to the increase in competitiveness of small and medium-size enterprises highly (Klimek, 2015), which affects their management and in particular taking strategic decisions.

Considering the convergence from the economic point of view, it can be confirmed that the undoubtedly different level of economic growth can be observed in each country, which makes it more difficult to manage at the mezzo and macro-level. These differences cause that

the research should be focused on the convergence of R&D expenses between countries, i.e. the means playing a significant role at innovativeness (Beizitere, Brence, Sloka, 2020). However, meeting some standards in this scope is difficult despite active support of the Member States by the EU when it comes to stronger economic integration (Kusideł, 2013; Campos, Coricelli, Moretti, 2019; Hecke, Cunj, 2023). In consequence, being by the Union so called 'convergence machine' (Nagy, Šiljak, 2022) may be regarded as complicated but not impossible. In other words, the actions taken by the EU contribute strongly to the GERD convergence measured in % of GDP as this relation is one of the main factors showing the economic condition and innovativeness of the countries (Gürler, 2022).

Taking the above into consideration and according to the opinion of some researchers (Stephan, 2012; Etzkowitz, Leydesdorff, 2000; Petersen, Arroyave, Pavlidis, 2023), it is possible to say that the convergence is really complex, especially in the area of innovativeness. They claim that mutual synergies of the industry, research institutions and the government are incredibly important for all actions oriented on innovations and economic growth (Petersen, Arroyave, Pavlidis, 2023). However, it should be noticed that the companies often finance their research and development activity from their own means (Perez-Alaniz, et al., 2022), which is significant in the process of taking management activities. Despite the range of difficulties the companies meet, they depend on the increase in their ability to innovativeness as it is a necessary condition for the company to develop and obtain the competitive advantage at each level (Crossan, Apaydin, 2010; Raymond, St-Pierre, 2010). Moreover, common activities of the companies may contribute to the creation of new solutions among others technological convergence offered to various subjects (Kim, 2017), but it should be remembered that it is necessary to integrate social sciences with the exact sciences (Ashton, et al., 2024). It results from the fact that the human factor plays the main role in creating any innovativeness which plays in companies striving to be competitive. Moreover, in the process of applying for acquiring customers and increasing their market share, the companies are obliged to take sensible financial decisions and to join them with business strategies both in the short and long perspective (Peprah, Ayaa, 2022). It shows that the company should regard the process of innovation management holistically, especially due to the fact that in the case of innovativeness and in particular while launching innovations, it is possible to talk not only about the existence of convergences but also divergence of the aims of countries or companies. So the convergence does not have to be a continuous process and there may occur the periods of stagnation or inhabitation (Berbeka, 2006; Delhey, 2001).

What is more, innovations are a significant factor of sustainable growth in many countries, which forces the companies to discuss the business strategies so that the company was competitive both in the domestic and foreign market.

5. Conclusions

The comparative analysis of convergence of so called 'new' and 'old' EU states presented by the author showed that the decrease in differentiation in time talks about the equalizing of the level of analyzed expenses among the countries. The existence of greater disperse of data in respect to the expenses per capita confirms the existence of greater inequalities in the case of this value. However, presenting the analyzed expenses as % of GDP, although it is used in international comparisons most often, has some limitations. The value of research and development expenses issued by the citizens of a given country is not visible. So the expenses per capita in euro according to PPS may be a better measurement from the convergence point of view as they show the differences in the levels of these expenses in various countries. Furthermore, on the basis of the presented research results, it is possible to state that big inhomogeneities in the levels of expenses per capita suggest that this variable may play an important role in the convergence processes. Apart from that, the advantage of the greater R&D expenses differentiation converted per capita in particular countries shows both the stronger position of the EU states in which the GDP in respect to the number of people is greater and also the preferences of the persons interested in new solutions.

As it was shown, the values of the share of the standard deviation in the mean decreases with time in each tested group, which confirms the existence of the convergence phenomenon. However, while assessing the convergence power, it was stated that it was very weak and it is possible to even talk about divergence periods, which confirms various level of economic growth in the countries. Thus, it results from the presented research that the convergence is not an uninterrupted process and the conclusion may be taken that such periods exist as: divergence (2007-2011; 2015-2016), falling convergence or the time of sustainable growth. What is more, it is possible to talk about the inverse convergence in 2006 but only when it comes to the R&D expenses in % GDP. Although the change in the positions of the two groups occurred, it may be caused by the changes in the dynamics of this factor growth/fall.

Despite this, it is possible to state after the convergence analysis that the countries strive to the similar state of GERD in the long term in spite of various beginning conditions and do it with various intensification. Thus, it can be stated that the verification of the innovativeness policy is necessary in all the Union states. The author assesses that it will be a long term process and its results will surely depend on the level of economic growth and demographic changes. Especially that functioning of the companies in the scope of innovativeness depends on the condition of the economy and the politics run by the governments. There are some changes in the approach to the innovative actions in all the countries but they are insufficient, especially in the context of leveling inequalities in assigning R&D expenses and in the way of the activity towards human resources.

However, analyzing the innovativeness, the author claims that the human capital without which the creation of innovative solutions is impossible should be undoubtedly included in future analyzes. Thus, the companies should approach both the technological and social convergence in a more responsible way.

In conclusion, the author wants to emphasize that R&D expenses should be considered not only in the economic dimension but also in the environmental and social one. According to the author, the presented analyzes may be a starting point for further research on the sustainable growth factors. Such conclusions are taken from the assessment of funds assigned for innovativeness and with the assumption that new processes and commercial products will have a positive influence on the company management so also the whole economy.

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THE RISK OF MARTIAL LAW FOR A BUSINESS ENTITY

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Purpose: Analysis of the influence of a martial law on a business entity. Indication of ways to manage this kind of legal risk.

Design/methodology/approach: Formal-dogmatic method. Literature studies.

Findings: The introduction of martial law, although unlikely, may impede the functioning of many organizations and even expose them to losses, because there is a significant modification of the principles of functioning of the state and restrictions on the rights and freedoms of citizens. Many of these rights and freedoms are related to running a business. Organizations can manage the risk of martial law by understanding the risks associated with restrictions on rights and freedoms and how to identify and assess these risks.

Practical implications: Raising awareness of the risk of martial law. Specify the list of risks related to the introduction of martial law. Discussion of risk identification methods.

Originality/value: This is the first publication devoted to martial law risk management and one of the few publications regarding legal risk management.

Keywords: martial law, legal risk management, restrictions on the rights and freedoms.

Category of the paper: Research paper.

1. Introduction

The ongoing war in Ukraine and emerging media reports about the risk of an attack on Poland by Russia make it necessary to take into account military operations on the territory of the Republic of Poland as a risk factor in running a business. Military operations pose a threat to business organizations not only in terms of the physical destruction of company assets or the inability to operate, but also from a legal perspective on the part of the Republic of Poland. There are regulations that allow for the restriction of citizens' rights and freedoms, including demanding the provision of a range of benefits to the state. In this way, a business organization can be affected by military operations even if it is not located in a zone of direct military action.

The primary legal act regulating business activity in Poland is the Entrepreneurs' Law (2018). However, this act does not address the impact of war on business activity. Other regulations serve this purpose, namely the Act on Martial Law (2002).

Martial law as a premise for restrictions on running business is one of the extraordinary states listed in the Constitution of the Republic of Poland (1997). An extraordinary state is a period of exceptional threat to the state, requiring the application of special solutions to protect it, primarily increasing the freedom of the executive branch (Kazimierczuk, 2006). Then, there is a deviation from the normal legal order of the state in order to protect some values (Lewandowska, 2022; Eckhardt, 2012). This deviation is reflected both in the sphere of citizens' rights and freedoms and in the functioning of state bodies (Ciapała, 1999; Prokop, 2012; Gebethner, 1982). However, martial law distinguishes from other extraordinary states in entailing the most far-reaching consequences in terms of limiting the rights and freedoms of individuals (Kazimierczuk, 2006).

The premise for imposing martial law may be an external threat to the state or an armed attack on the territory of the Republic of Poland or when an international agreement provides for the obligation to jointly defend against aggression (Masternak-Kubiak, 2022). This state may be introduced in part or all of Poland.

Martial law should not be equated with a state of war. War is a sphere of a state's external relations (Brzeziński, 2007; Eckhardt, 2012; Prokop, 2002a) and does not automatically entail martial law (Majchrowski, Winczorek, 1998). It may be that military operations will take place outside the country's borders and it will not be necessary to modify the rules of the internal functioning of the state (e.g. if the state of war is the result of an obligation to joint defense arising from an international agreement).

Other extraordinary states include a state of emergency and a state of natural disaster. These are introduced in different situations and according to different procedures, but they also pose a risk to business operations. An example is the risk of flooding as a natural disaster, which led to the introduction of a state of natural disaster in September 2024 (Resolution of Council of Ministers on the introduction of a state of natural disaster in the area of parts of the Lower Silesian and Lubusz Voivodeship, 2024) and systemic risk justifying the introduction of a state of emergency. Such a state was introduced in the Podlaskie Voivodeship because of the so-called migration crisis on the Polish-Belarusian border (Resolution of the President of the Republic of Poland on the introduction of a state of emergency in the area of part of the Podlaskie Voivodeship and part of the Lublin Voivodeship, 2021).

Every organization should consider risk in its operations (Jajuga, 2019; Staniec, 2011; Woźniak, 2019). One element of this risk is legal risk (Thompson, Hopkins, 2024; Modras, 2023; Woźniak, 2019). There is no doubt that this concept also encompasses martial law regulations, as the risk of its introduction has recently increased. It may happen that a specific organization will be affected by the consequences of its introduction, which include restrictions on rights and freedoms. So, the analysis of these restrictions on individual rights and freedoms resulting from martial law in the context of business entities that will be the subject of this study, as this topic has not yet been addressed in the literature and is worth to disseminate.

There is only a few publications regarding legal risk management, especially in the Polish literature (Modras, 2022 and Kaczmarek, 2006 can be mentioned) and there is nothing about a martial law risk management.

2. Methods

The issue discussed in this study will be examined based on the literature in the field of legal sciences and management sciences, as well as on the basis of legal acts. Legal acts are usually analysed through legal literature and judicial decisions (of Supreme Court). Such a research method is used in the legal sciences and is called the formal-dogmatic method and this method will also be used in this study. This method does not require to formulate hypotheses, as it shows the content and idea of the law.

This study examines a number of legal acts (shown in references), among them the Act on compensation for property losses resulting from restrictions on human and civil rights and freedoms during a state of emergency (2002) of November 22, Official Journal No 233, item 1955 and the Act of on martial law (2002) of August 29, Official Journal of 2025, item 504 will receive the most attention.

3. Results

3.1. Introduction of martial law

The act on martial law (2002) defines the procedure for declaring martial law, the rules of operation for public authorities, restrictions on rights and freedoms that may be introduced during martial law, and the manner of their implementation. It also specifies the principles of operation of the Supreme Commander of the Armed Forces. This act thus regulates a wide range of modifications to state activities, therefore, issues unrelated to restrictions on rights and freedoms will not be discussed here, as they are less relevant to the subject matter of this study.

Martial law is introduced at the request of the Council of Ministers to the President, if the aforementioned grounds for martial law are met. Upon approval of the request, the President issues a resolution on the introduction of martial law specifying the reasons for the introduction and the area where martial law is being introduced, as well as the types of restrictions on human and civil rights and freedoms, within the scope permitted by the act on martial law (Radajewski, 2018). This regulation is sent to the Sejm within 48 hours of its signing.

Martial law is effective from the date of President's resolution promulgation in the Journal of Laws of the Republic of Poland (i.e., on the website <https://dziennikustaw.gov.pl/DU>), although it is also made public through an announcement by the relevant voivode, by posting notices in public places, and in the manner customarily adopted in a given area. The customarily adopted method is the method traditionally used to inform about the content of the legal regulations in a given municipality, e.g., leaflets, or posting on a notice board at the municipal office or at the village council (Dąbek, 2004, Szewc, A., Szewc, T., 1999; Zadworny, 2014).

Martial law is in force until the date of its abolition by the President in the resolution or until the date of repeal of the Presidential resolution on the introduction of martial law by the Sejm.

3.2. Possible ways of limiting human and civil rights and freedoms

The act on martial law specifies the permissible ways of restricting rights and freedoms after the introduction of martial law (Eckhardt, 2012; Prokop, 2002b), however, from the point of view of the impact on economic organizations, they can be systematized as follows:

- a) prohibitions on running business,
- b) orders to perform additional tasks,
- c) enabling state authorities to censor correspondence and the media,
- d) state interference in the business management,
- e) seizure of assets.

The executive branch, i.e. the Prime Minister, ministers and voivodes is to decide on the introduction of these restrictions. It can take appropriate acts based on the Presidential regulation on the introduction of martial law (Mażewski, 2010). These acts will be resolutions and administrative decisions.

3.2.1. *Prohibition on running business*

During martial law, a ban on conducting a specific type of business activity may be imposed for a certain period of time, or a permit may be required to commence it. In addition to such a direct ban, indirect prohibitions may be introduced, as secondary consequences of prohibitions on specific behaviours or orders to refrain from specific behaviours (depending on how the legislator formulates it), which may be performed within the framework of a business:

- a) a ban on organizing and conducting mass events,
- b) a ban on conducting artistic and entertainment events that are not mass events as part of cultural activities,
- c) periodic suspension of classes in schools, including higher education institutions, with the exception of theological schools and seminaries,
- d) a ban on trading in domestic means of payment and currency exchange,
- e) a ban on operation of communication systems,
- f) switching off communication devices or temporary suspension of the communication services,

- g) depositing radio and television transmitting and receiving devices with the competent government administration authority or establishing another method of securing them against use in a manner that threatens state security or defense,
- h) suspension of postal services for a specified period,
- i) total or partial ban or restriction of the transport of passengers and goods by road, rail, air, sea, and inland waterway,
- j) a total or partial ban on flights of Polish and foreign aircraft over the land territory and territorial sea,
- k) a total or partial ban or restriction on the movement of Polish and foreign vessels in internal sea waters, the territorial sea, and inland waterways,
- l) a total or partial ban or restriction on the movement of all vehicles on public roads.

3.2.2. *Orders to perform additional tasks*

The opposite situation to the one described above is imposing on a business entity the obligation to perform specific tasks, that are necessary for the security or defense of the state, or ensuring supplies to the population. This provision is very generally formulated, as the scope of tasks is essentially unlimited, which results from the use of so-called general clauses, i.e., concepts referring to a system of values beyond legal system (Ziemiński, 1993).

Additionally:

- a) editors-in-chief of newspapers and radio and television broadcasters are obliged, at the request of public administration bodies, to immediately and freely publish or post announcements, decisions and resolutions of these bodies related to state defense and the security of citizens,
- b) natural persons and legal entities running agricultural holdings may be obliged to supply agri-food products to specific entities and to cultivate of specific plant species and animal breeding,
- c) carriers may be obliged to transport goods for the purposes of national defense and security.

3.2.3. *Enabling state authorities to censor correspondence and the media*

One of the crucial aspects of security during martial law is preventive censorship. This censorship involves the complete or partial withholding of publications, postal and courier shipments, and telecommunications correspondence, as well as the interruption of telephone conversations and transmissions of signals transmitted over telecommunications networks. Censorship is based on content that may pose a threat to national security or defense. The role of censorship and control authorities is performed by the relevant voivodes, who may order public administration bodies operating within the voivodeship to perform technical activities necessary to conduct censorship or control. For businesses entities offering postal, courier, telecommunications, and telephone services, this requires enabling censorship authorities to perform these tasks.

3.2.4. *State interference in the business management*

During martial law, the state can influence the business management twofold. The first involves influencing decision-making processes by establishing a receivership in entities producing goods or providing services of particular importance to state security or defense. The receivership aims at ensuring the effectiveness of the production of goods or the provision of services and has the right to:

- a) participate in the work of the business's governing bodies,
- b) obtain from these bodies information necessary to perform their functions,
- c) accept the decisions of the business's governing bodies regarding the production of goods or the provision of services of particular importance to state security or defense,
- d) issue written instructions to the business's governing bodies regarding matters related to the production of goods or the provision of services of particular importance to state security or defense.

The second method of interference involves restricting the freedom of pricing. This deprives the parties to a contract of the principle of freedom of contract in this respect by:

- a) prohibiting periodic price increases for specific goods or services,
- b) mandating the application of established prices for goods or services that are fundamental to consumers' living costs.

3.2.5. *Seizure of assets*

Conducting military operations may also require the use of property belonging to other entities when the armed forces' own resources are insufficient. In such a case, it is possible to:

- a) seize real estate necessary for the Armed Forces or state defense,
- b) seize or requisition road, rail, and air transport, as well as seagoing and inland waterway vessels, for state defense purposes,
- c) introduce the rent of premises and buildings based on an administrative decision for all premises and buildings, and in justified cases, also putting extra individuals in a residential unit or building.

3.2.6. *Compensation of damages*

Although restrictions on rights and freedoms occur in a situation justified by a paramount interest, i.e., state security, the legislature does not deprive of the right to compensation entities affected. The Constitution establishes the principle of granting and paying compensation in accordance with a separate act. This act is the Act of November 22, 2002, on Compensation for Property Losses Resulting from Restrictions on Human and Civil Freedoms and Rights during a State of Emergency, 2022. It grants anyone who has suffered property loss as a result of restrictions on human and civil freedoms and rights during a state of emergency a claim for compensation from the State Treasury, while referring to the Act - Civil Code, 1964) for unregulated matters. This is important because the Code specifies the conditions for liability for damages, which include:

- a) the event,
- b) the damage,
- c) the causal relationship between the event and the damage.

Ad a) An event is a circumstance that caused damage, e.g. a vehicle collision (Czachórski, 1981). In the case of a state of martial law, this event will be the restriction of rights and freedoms following its introduction and during its duration (Kondek, 2021).

Ad b) Damage is defined as loss, or reduction of property or non-property (Szpunar, 2019; Ohanowicz, Górski, 1970), loss of legally protected goods (Wiśniewski, 2013), or a difference between the current property status and the status that would have existed if the event causing the damage had not occurred (Supreme Court Judgment, 1957). Damage thus understood in the light of the Civil Code includes two elements: loss, i.e. reduction in the value of property (Kaliński, 2011) and lost profit, i.e. lack of an increase in assets that would certainly have occurred if the damage had not happened; in other words, it is lost earnings (Kaliński, 2011; Pajor, 1982).

Ad c) A causal relationship is a relationship between an event and damage of such a kind that it is possible to say that the damage results from the event, that the damage is a consequence of the event (Dybowski, 1981).

However, the Act significantly modifies the Code's principles of damage compensation. First, it excludes the possibility of claiming benefits that the business entity could have obtained if the loss had not occurred, thus allows only compensation for pecuniary loss. Second, there is no possibility of restitution. The only way to compensate for the restriction of rights and freedoms during martial law is financial compensation (Kondek, 2021; Rogacka-Łukasik, 2014), i.e., transferring the value of the damage to the injured party in cash (Kondek, 2021), which simultaneously burdens them with activities related to get the damage repaired.

The Act also specifies the procedure for obtaining compensation. The first step is to submit an application to competent authority, which is the voivode with jurisdiction over the location of the property damage, which is imprecise (Kondek, 2021). However the regulations also provide for other circumstances affecting the voivode's jurisdiction, which can be omitted here. In addition to address details, date, and signature, this application must also indicate the type of restriction of rights and freedoms that resulted in the property loss, as well as its amount, time, location, and circumstances. Therefore, such an application must include appropriate justification, although it should not be overly formalized and should not be in the form of an official form.

Importantly, the requirement to provide the applicant's name and surname in an application does not deprive non-natural persons of the right to compensation and is likely an oversight by the legislature. This stems from the fact that the Act grants everyone the right to compensation, and by "everyone" should be understood any legal entity, regardless of their legal status—a natural person, a legal entity, or an organizational unit without legal personality (Rogacka-Łukasik, 2014).

The second stage is for the voivode to review the application and issue an administrative decision. The authority determines the amount of damages and compensation due; therefore, it is not bound by the application in this regard (Kondek, 2021). The decision must be issued within three months of submitting the application and is final, meaning that it cannot be appealed, which is the primary means of challenging administrative decisions, nor can it be requested for a retrial. The third stage of the compensation procedure is the payment of compensation within thirty days of the date the decision is served on the injured party.

A party dissatisfied with the amount of compensation granted in a decision may file a lawsuit with a civil court within thirty days of its delivery. This lawsuit is not a means of appealing the decision, but rather a transfer of the proceedings to the court (Kondek, 2021). Filing a lawsuit does not overturn the decision or suspend the payment of compensation. A significant simplification of court proceedings is the absence of the need to pay a court fee, as these lawsuits are exempt from court fees pursuant to the Act on Court Fees in Civil Cases, 1967.

A claim for compensation is time-barred after one year from the date on which the injured party learned of the financial loss. However, in any case, the claim is time-barred after three years from the date the state of emergency is lifted.

It should be emphasized that the compensation referred to in the discussed act is due in the event of lawful actions by public authorities. If public authorities violate the law by imposing martial law and restricting rights and freedoms, compensation for the resulting damage is based on the general principles set out in the Civil Code, including the right to full compensation covering actual damage and lost profits (Rogacka-Łukasik, 2014; Masternak-Kubiak, 2022; Radajewski, 2018).

4. Discussion

Restrictions on rights and freedoms presented above as a consequence of an introduction of martial law shows that this may be a risky situation for business entities for two reasons. Firstly, due to the scale of their resources or the scope of their business, they could be the recipients of decisions that limit their rights (e.g. by seizing trucks necessary for the Armed Forces to transport ammunition). Secondly, legal protection against the consequences of state actions is significantly weakened. This is primarily due to the limitation of compensation to actual damage. Moreover proving actual damage requires indicating specific property damage. If it were possible to additionally claim lost profits, the organization that owns the example truck could indicate how much it would have earned if it had continued to use the truck and provide services to customers with it. The limitation of compensation entails the possibility of claiming only the possible costs of repairs (if damaged or worn out) or loss of value or fuel

used. Therefore, one can imagine a situation in which the owner of a truck confiscated for the purposes of military operations and then returned in undeteriorated condition and with slightly higher mileage will not be able to claim any compensation because its value has not decreased, even though in fact he will suffer a loss consisting in not generating revenues.

The vision of the potential possibility of introducing martial law in the area where the organization is based, with the resulting consequence in the form of restrictions on rights and freedoms, is undoubtedly included in the concept of risk, consisting in an undesirable effect for the organization caused by legal provisions (Thompson, Hopkins, 2024; Moorhead, Vaughan, 2015; Whittaker, 2003). Although the concept of legal risk is understood in various ways, there is no doubt that it includes the risk posed by the law itself, consisting primarily in the creation of new legal obligations. This risk factor can be referred as to regulatory risk (Modras, 2023).

Legal risk, like any other risk, requires management. Risk management is taking actions and decisions regarding risk, including (Jajuga, 2019; Thompson, Hopkins, 2024):

- a. risk identification (determination of the types of risk for a given entity),
- b. risk measurement (expressing the risk level numerically or qualitatively, e.g. low/medium/high),
- c. risk control (actions adjusting the risk level to a level acceptable by a given entity),
- d. risk monitoring and control (which emphasizes that risk management is a process, not a one-off activity).

Legal risk management is very different from the management of other risk categories, primarily due to the difficulties in its numerical expression and precise determination (Modras, 2023; Stopczyński, 2019). It therefore requires a different approach in relation to individual stages, which will be discussed below.

According to the ISO 31000 standard, risk identification is the search, recognition and description of sources of potential risk, risk events, their causes and consequences. Risk identification is possible using various methods: risk self-assessment, brainstorming, Delphi method, SWOT analysis, SWIFT method, creating risk maps and FEMA (Kokot-Stępień, 2015; Topczak, Patals-Maliszewska, 2019) and in various ways: bottom-up, top-down (Cagan, 2019; Staniec, 2011). Taking into account the characteristics of the legal risk considered here, it seems most appropriate to use the Delphi method, where the expert will be a person with legal skills. The role of such an expert is to search for legal regulations containing provisions with a potentially negative effect on the organization and to interpret them, linking their provisions to the organization's situation. First of all, it requires consideration of whether the organization is located in an area that may potentially be subject to martial law and whether, due to its subject of activity or assets, it may be subject to restrictions on rights and freedoms. This will be done in a bottom-up manner, where the organization's legal unit (or an external law firm) will provide the organization's managers with information about the risk arising from the law. It should also be remembered that such risk will be identified in two stages. First, the situation of the organization must be considered in the light of the provisions of the

act on martial law, 2002, and then in the light of the resolution of the President of the Republic of Poland introducing martial law and regulations and decisions issued on the basis of the President's resolution. At the current stage of risk management (before any martial law was introduced), it is enough to analyze the martial law act and relate its provisions to the organization's situation.

The next stage - risk measurement - involves estimating how severe the risk may be for the organization. This stage in the literature and the ISO 31000 standard is also referred to as risk assessment, analysis or evaluation (Modras, 2023). From the point of view of regulatory risk, at this stage it will be necessary to determine the potential consequences of legal acts regarding martial law. Because law uses language as a tool, it is difficult to use quantitative methods to measure legal risk. Therefore, qualitative methods and verbal assessment should be used to describe the risk as high, medium and low (or on a more extensive scale, if it is used in a given organization). Attempts to calculate the financial dimension of such risk can only provide an approximate result based on estimation (McCormick, 2010; Zawila-Niedzwiedzki, 2013). Assessment (measurement) of legal risk requires, first of all, expert knowledge in the field of law and the use of the Delphi method for risk description, scenario method and risk map taking into account the probability and severity of risk (Staniec, 2011).

Having found the risk factors and measuring them, an organization can start controlling or dealing with this risk, i.e. minimizing its impact and reducing the risk – in the framework of the organization's risk appetite. According to ISO 31000, this may include activities such as:

- risk avoidance (by giving up activities that involve risk),
- taking a risk if there is a chance of making money,
- removing the source of risk,
- reducing the probability of risk,
- change in risk consequences,
- sharing the risk with another entity,
- retention (acceptance) of risk.

Actions against risk can therefore be passive, i.e. stopping and taking risks in the organization) and active, by taking risk-mitigating actions (Modras, 2023). The literature also indicates that the choice of method should depend on the combination of two factors, namely the probability of occurrence of a risk factor and the amount of loss caused by the risk, as shown in Table 1.

Table 1.
Risk profiles and methods of treatment

		Amount of loss	
		low	high
Probability	very often	acceptation, share	avoidance, reducing
	rare	retention, taking	avoidance, share

Source: own work based on Modras, 2023.

In the discussed case of the risk of martial law, its probability can be assessed as rare. However, the amount of potential loss must be estimated individually for each organization, depending on its exposure to restrictions on rights and freedoms. Depending on the result obtained, the organization may take action in accordance with the matrix indicated in Table 1. On this basis, it is possible to develop a plan for dealing with the risk of martial law for the organization. It is worth emphasizing that this plan should be prepared before the introduction of martial law, and on the basis of the act on martial law, 2002. It should include not only the rules for the operation of the enterprise during the restrictions, but also the rules for documenting the damage incurred, which may be very important in the context of a court trial.

Risk monitoring and review is broadly defined in ISO 31000 standards (primarily as verifying the effectiveness of control measures taken, improving risk controls and tracking new risks). Risk monitoring requires establishing key risk indicators, i.e. risk categories important for the functioning of the organization (Kaczmarek, 2006). In monitoring the risk of martial law, such a factor will be the president's regulation on martial law, and then regulations of relevant ministers and administrative decisions of authorized bodies addressed to the organization. Their issuance requires monitoring by the organization and possible modification of the martial law risk management plan.

5. Summary

Martial law is a situation in which important changes occur in the management of the state. Civil liberties (including the freedom to undertake and conduct business activities) may be significantly limited. An interesting example of how a state of emergency may affect business entities may be the well-known historical fact of using Parisian taxis to transport French troops to the Battle of the Marne field. After years of peace and stability, military operations across the Poland eastern border and disturbing statements by politicians indicate an increase in the risk of Russia attacking Poland or other European countries, and therefore an increase in the risk of imposing martial law. For business organizations, this type of risk is a legal risk, and like any other type of risk, it requires management.

Legal risk management differs significantly from the management of other types of risk, in particular in terms of identification and measurement methods. However, among the legal risks, the risk of martial law is distinguished by its level of difficulty due to the extremely difficult possibilities of determining if and to what extent legal risk poses a threat to a specific organization since there is no comparative material. The only one Polish decree on martial law, 1981, was issued in a different political situation and did not apply to economic entities. We can only mention its art. 12 (prohibited tourism and nautical sports in internal and territorial waters), art. 13 (prohibited the organization of artistic, entertainment and sports events)

and art. 17 (prohibited the use of printing devices) that are slightly in common with running a business. In turn, the regulation of the President of the Republic of Poland on the introduction a state of emergency, 2021, prohibits the organization of mass events.

These shortcomings, however, do not eliminate the need to assess the risk the organization is exposed to in the event of martial law being introduced. Pursuant to the act on martial law, 2002, analysed in this study, the following issues can be identified for consideration in the form of a general version of a check-list that can be used by business entities to identify and measure the risk of martial law:

- a) whether the organization conducts a type of activity that may be prohibited,
- b) how to prepare for a period without revenues in the event of a ban on running a business of a given organization,
- c) how to document the amount of employee remuneration and the basis for its calculation as well as other costs incurred at that time in the event of a ban on running a business,
- d) what types of additional tasks (including deliveries of agricultural goods or transport) may be ordered and how to prepare for them in terms of personnel, materials, logistics, etc.,
- e) whether the goods provided by the organization may be subject to pricing,
- f) how to prepare technically to carry out censorship tasks,
- g) how to transfer or secure transmitting and receiving devices,
- h) how to cooperate smoothly with the receivership administrator,
- i) what types of property may be needed during martial law and how to prepare for operation in the event of seizure of property used to run business, including means of transport.

After martial law is introduced by the President, it will be necessary to:

- a) determining whether martial law was introduced legally (it mainly affects the determination of the amount of damage),
- b) determining the beginning of the limitation period and filing for compensation before its expiry,
- c) collecting evidence confirming the amount of damage and costs incurred (they may be particularly useful during court proceedings),
- d) calculation of the amount of damage suffered,
- e) quick receipt of the administrative decision determining the amount of compensation (compensation will be paid within 30 days from the date of its delivery),
- f) comparison of the amount of compensation paid with the amount of damage suffered,
- g) preparing a lawsuit and filing a lawsuit after receiving an unfavorable decision determining the amount of compensation.

Using these lists, an organization can adapt them to its own needs and identify, measure (which will require assigning its own measures), control and monitor the risk, for example following the ISO 31000 standard. However, the *sine qua non* condition is the awareness of the existence of the risk of the martial law.

This study aims at promoting the knowledge about this type of risk among managers and management scientists. They can then examine how to describe and measure different risk factors in different types of business entities, so the next step in scientific research is to find and define risk metrics and martial law risk control techniques. The frames of an article do not let to develop these topics wider. The most important message taken from this study should be the existence and understanding of martial law risk.

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APPLICATION OF THE CHROMATOGRAPHIC DATA SEPARATION METHOD IN INDUSTRIAL IMAGE PROCESSING

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Purpose: The purpose of the paper is to present an innovative image processing method inspired by gas chromatography. The research aims to propose an alternative to classical segmentation and deep learning techniques by introducing a chromatographic data separation algorithm. This method enables efficient, selective analysis of images, particularly for industrial and medical (e.g., microscopic blood analysis) applications, through the transformation of images into chromatograms.

Design/methodology/approach: The research introduces a chromatographic approach to image processing by treating images as mixtures of "substances" (sub-images), each with a retention time determined by its affinity to a simulated stationary phase. The methodology involves dividing the image into sub-regions, calculating the retention time for each sub-image, creating chromatograms that reflect the distribution of these sub-images, and applying various image operations such as filtering, subtraction, removal of dominant peaks, dilation, and erosion. Additionally, algorithms modeled on chromatographic processes are used to analyze and transform images. The method's theoretical foundation is based on analogies with gas chromatography, enabling both qualitative and quantitative analysis of image content.

Finding: The proposed method effectively enables new operations in image processing, including the selective removal of dominant or unwanted elements, background elimination through chromatogram subtraction, skeletonization of objects (contour extraction), and morphological operations such as dilation and erosion within the chromatographic framework. These operations have proven useful in isolating features and enhancing image clarity. The results demonstrate the flexibility and selectivity of the approach, particularly in complex segmentation tasks.

Research limitations/implications: The method's performance is sensitive to parameter choices, especially the number of "shelves" (resolution levels) and the granularity of sub-image division. While the approach shows promise, further research is needed to optimize parameter selection and adapt the method to high-resolution color images and real-time systems. Future work could explore integration with existing deep learning techniques or its extension to 3D imaging.

Practical implications: The chromatographic approach to image analysis provides an alternative tool for industries and laboratories requiring robust image filtering and object recognition. Its ability to isolate and enhance image features may improve quality control processes, diagnostics, and object detection pipelines. Applications include microscopic imaging (e.g., blood analysis), product inspection, and environmental monitoring.

Originality/value: This paper introduces a novel paradigm in image processing that draws from chemical analysis techniques, specifically gas chromatography. Unlike traditional image analysis methods, this chromatographic data separation model provides a unique way to structure and process images. Its originality lies in merging chemical separation concepts with visual computing, offering a new pathway for segmentation, feature extraction, and morphological operations. It is valuable to researchers and practitioners in image analysis, industrial inspection, and medical diagnostics.

Keywords: chromatographic data separation, image processing, retention time, morphological operations, object segmentation.

Category of the paper: Research paper.

1. Introduction

In recent years, dynamic development of image processing methods has been observed, both in industrial and medical applications. Techniques enabling automatic analysis of images in real time, supporting diagnostic processes, quality control and classification of objects, are gaining particular importance. One of the key challenges in this area is the effective extraction of important information from the image and its further interpretation. The article proposes a new approach to image processing, inspired by the principles of gas chromatography.

The main motivation for undertaking the research was to find an alternative approach to image classification and segmentation that could compete with classical techniques and methods based on deep learning. The presented concept assumes treating the image as a mixture of substances, the elements of which can be separated and analyzed based on retention time – analogously to the chromatographic process. Thanks to this, it is possible to create the so-called image chromatogram, which reflects its structure in the form of a retention histogram.

The article presents a detailed description of the chromatographic data separation algorithm and the method of image representation using it. It also describes key image processing operations, such as filtration, selection, removal of dominant objects, skeletonization and morphological operations inspired by erosion and dilation. The authors show how the use of chromatograms allows performing complex analytical operations on images in an efficient and selective way.

The proposed method can be used in industry, biology, and especially in microscopic analysis of blood, where precise segmentation and classification of cells is crucial. The paper also includes examples of algorithms and visualizations of their effects. The aim of the paper is not only to present a new approach, but also to show its potential in practical image processing scenarios. Ultimately, this method can be an alternative or complement to existing techniques, opening new possibilities for visual analysis (Kristensen, Lützen, 2013).

2. Chromatographic data processing method

The chromatographic data separation method, which is inspired by the separation of substances by a gas chromatograph, is based on several assumptions. The first important assumption is that the vectors that are fed to the classification process are treated as a mixture – of substances. In the case of the presented algorithm, it was assumed that all vectors resulting from the division of the output vector are of the same length (Święcicki, 2024).

2.1. Principle of chromatographic image processing

Figure 1 presents the idea of the chromatographic data separation method. As you can see, the method consists of several phases. In the first phase, the processed vector is divided into smaller vectors and the affinity value for the stationary phase is calculated for each subvector. This value affects the speed of the vector migration through the chromatographic column, i.e. the retention time, i.e. the time a given vector spends in the column, will depend on this value. After leaving the "column", the vectors are counted. Where vectors with the same retention time are treated by the presented algorithm as the same vectors. As a result of the above-described process, we obtain a spectrum, i.e. the relationship between the number of vectors with the same retention time and the retention time (Hohrenk et al., 2020; Martens et al., 2017; Mondello et al., 2008; Stilo et al., 2021).

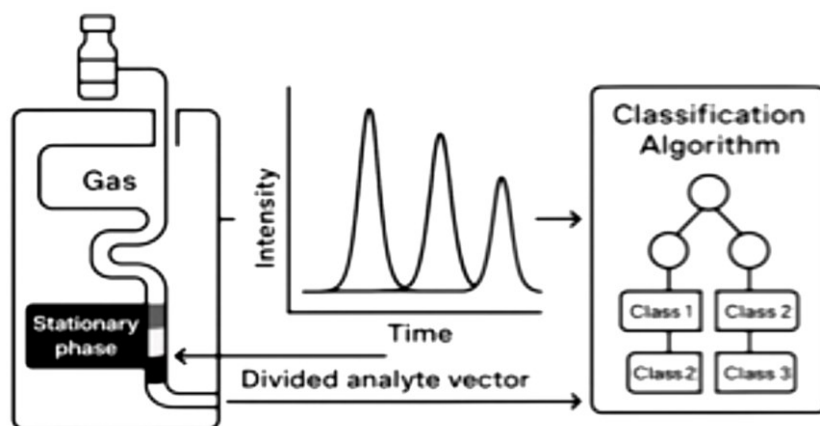


Figure 1. The idea of the chromatographic data separation method.

The chromatographic separation algorithm has been described in detail in the following works, therefore only those elements of the algorithm that are significantly related to the presented image processing methods will be presented in this article (Święcicki, 2024).

2.2. Representation of images

The image is represented as a two-dimensional array, the elements of which take values from 0 to 255 – in the case when the image is processed in grayscale. In accordance with the basic assumption of the chromatographic separation method of data. The array represents

a mixture of compounds that will be subject to the processing process, so the next step will be to divide the array into equal-sized sub-areas – sub-arrays that will be processed by the algorithm – for which the retention time will be calculated (Solomon, Breckon, n.d.).

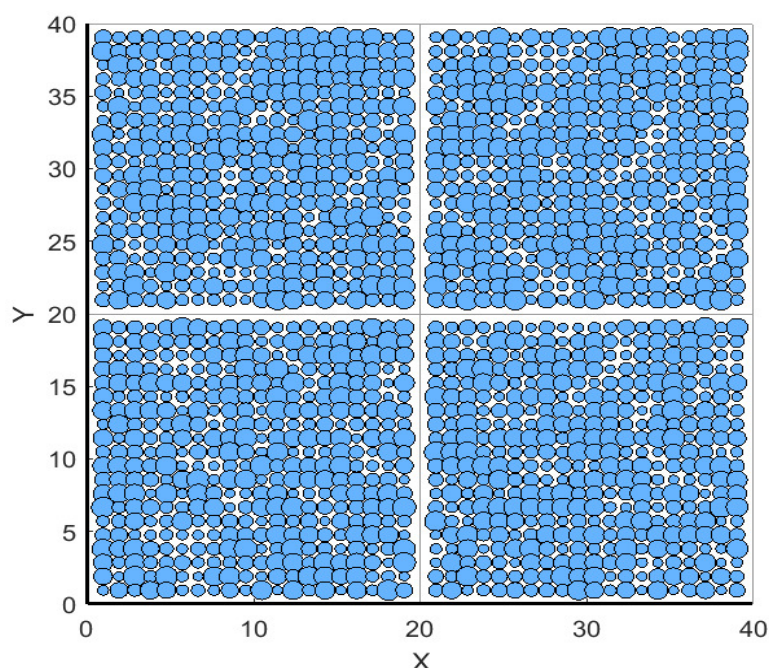


Figure 2. The division of the image, which constitutes a mixture, into four sub-regions, each treated as a separate "substance" for which the retention time will be calculated.

Figure 3 shows the process of converting an image to a chromatogram, which will be the basic structure in the further image processing. As it was shown, in this case the image, which was a mixture, was divided into one hundred sub-areas – substances for the chromatographic data separation algorithm for which the retention time will be calculated. It is obvious that the retention time value depends on the values of the elements that are in a given sub-area (Young et al., 1995).

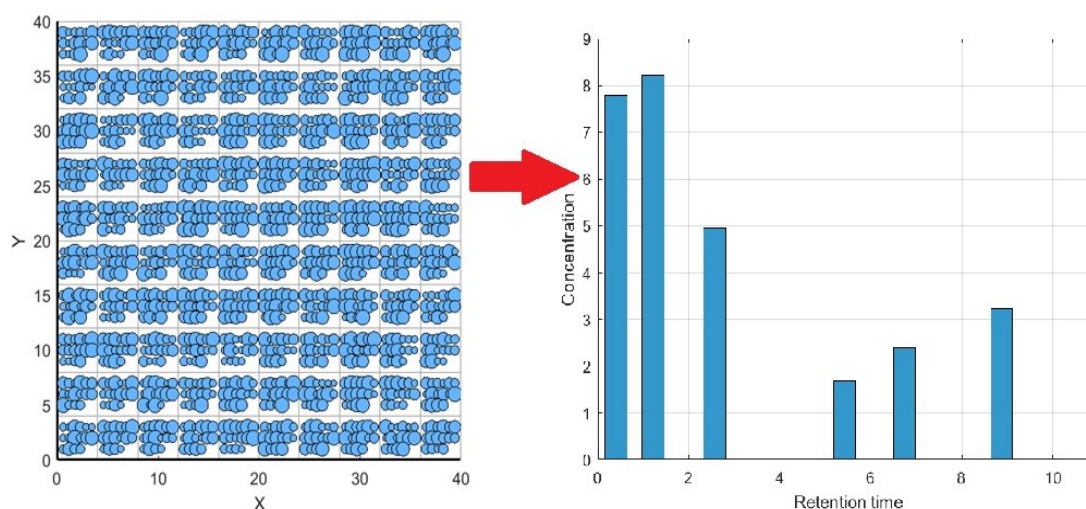


Figure 3. The process of converting an image into a chromatogram.

The result of the calculation for each retention time area and the grouping process is a chromatogram. The height of the individual bars – peaks in the chromatogram is determined by the number of sub-areas with the same retention time (Hohrenk et al., 2020; Pezzatti et al., 2020; Schmidt-Traub et al., 2020; Sparkman, 2005; Stilo et al., 2021).

2.3. Chromatographic data processing algorithm

Algorithm 1 presents an algorithm for chromatographic data separation, which is inspired by the gas chromatography method. As it results from the presented algorithm, the data for this algorithm is the processed image P , which in a special case can be a color image represented as an RGB table. The next parameters are the size N_1 and M , which determine the size of the subimages into which the input image will be divided. The last input parameter for the presented algorithm is the parameter that is responsible for the resolution in the real chromatographic system, i.e. for the so-called number of shelves, which is determined by the length of the chromatographic column. The longer the chromatographic column, the higher the resolution of such a chromatograph. It is similar in the case of the presented algorithm.

Input : $P \in \mathbb{R}^{M \times N}$: input image (mixture), K : number of non-overlapping subimages of size $M_1 \times N_1$, L : number of theoretical plates, $t_{\min}, t_{\max}$

Output: Ch : calculated chromatogram

1 **Assumptions**: Image P is divided into K subimages S_i ($i = 1..K$). Subimages at borders may have smaller size if M_1, N_1 are not divisors of M, N . Retention time t_r is computed as $(t_{\max} - t_{\min})/L$ and rounded to nearest point. Affinity of substance to stationary phase is sum of subimage elements. Chromatogram Ch contains columns: retention time, frequency, subimages, positions. **End Assumptions**

2 Divide image P into subimages $S = \{S_1, \dots, S_K\}$;

3 **foreach** subimage S_i in S **do**

4 $\alpha_i \leftarrow \text{computeAffinity}(S_i)$;

5 $\tau_i \leftarrow f(\alpha_i)$;

6 $t_i \leftarrow \text{round}((\tau_i - t_{\min})/\Delta t) \cdot \Delta t$;

7 $Ch[t_i] \leftarrow Ch[t_i] + 1$;

8 Store S_i and its position in Ch at t_i ;

9 **end**

10 **return** Ch ;

Algorithm 1. The chromatographic data separation algorithm.

The chromatographic separation algorithm is based on concepts known from gas chromatography and is used to analyze an image containing a mixture of different substances. As an input, it takes an image of given dimensions, which is treated as a set of substances to be separated. This image is divided into smaller, non-overlapping sub-images, each of which represents a single substance. For each sub-image, the retention time is calculated, which determines its affinity for the stationary phase. The retention time values are discretized, i.e. rounded to the nearest points in a fixed time grid, the density of which depends on the number of plates and the minimum and maximum retention time.

Subimages with the same retention time are grouped and create common peaks in the chromatogram. The height of each peak corresponds to the number of subimages that belong to it. This process allows the input image to be transformed into a structure describing the composition of the mixture in the form of a chromatogram. The key part of the algorithm is the division of the image and the assignment of retention time based on specified rules. The algorithm allows for quantitative and qualitative analysis of the components contained in the image. The input parameters are the image, dimensions of subimages, the number of trays and the minimum and maximum retention time values. The output parameters are the structure of the chromatogram and a set of data grouped by retention time. This algorithm is the basis for further operations, such as the removal of selected substances or the reconstruction of the image without specific components. Thanks to its flexible structure, it can be used in various image processing applications inspired by chemical analysis.

3. Image operations

In this section, the operations on the image will be presented, which were implemented using the mechanisms and data provided by the chromatographic separation algorithm. The basis of all operations is the chromatogram, which will provide information about the structure of the processed image. It can be said that the central structure in the image processing process, which will be used in all the presented algorithms, is the chromatogram. It is thanks to the connection between a given peak in the chromatogram – and under the image, i.e. the substance that belongs to the mixture, i.e. the image, that it is possible to select individual images. It can be said that all operations on images will be related to the filtration operation – as it is in the case of a real chromatographic system (Babushok, 2015; Chromatography..., n.d.; Hage, 1999; Qi et al., 2018).

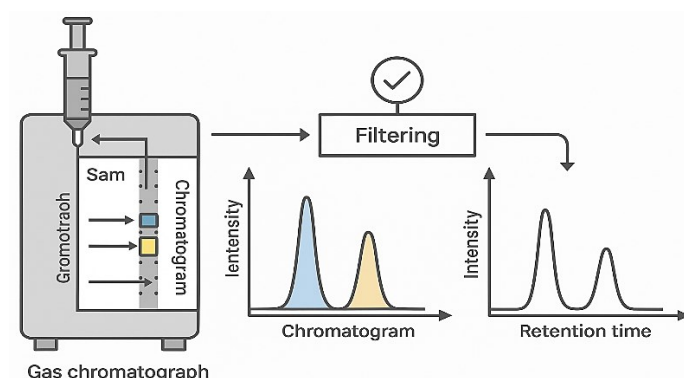


Figure 4. The idea of image processing corresponds to the filtration of individual peaks that belong to the chromatogram.

Figure 4 illustrate in a pictorial way the general concept of operations on images using a chromatographic data separation algorithm.

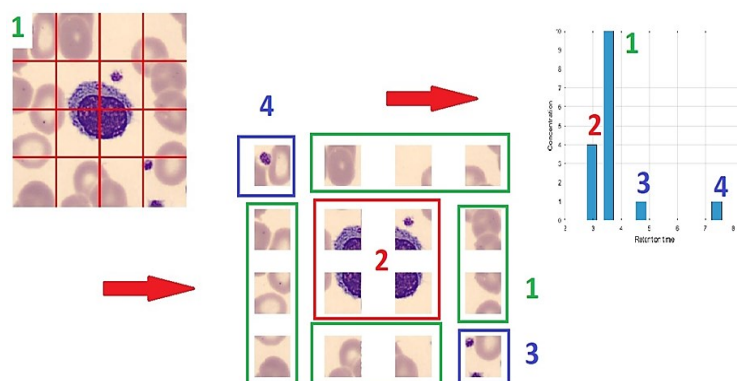


Figure 5. Phases of image processing using the chromatographic data separation algorithm.

Figure 5 shows the individual stages of image processing. As shown in the first phase, the image is divided into sub-images, for which the level of interaction with the stationary phase is calculated, resulting in the retention time value being determined. In the next phase, substances with the same retention time values are grouped. As can be seen from the presented figure, many images with the same retention time value can be assigned to one peak in the histogram. As can be seen from the figure, the peak marked.

3.1. Sub-image selection operation

The first operation that will be presented is the operation of filtering specific sub-images that are part of the processed image.

The algorithm is used to remove substances with a specific retention time from the image, using inspiration from the gas chromatography mechanism. The input image is treated as a mixture of substances, which is divided into sub-images, each of which represents a single substance. For each of these sub-images, the retention time is calculated based on their properties. The retention time determines the ability of a given substance to interact with the stationary phase. All calculated retention times are rounded to the nearest point values determined based on the number of plates and the specified minimum and maximum retention time values.

Then, a chromatogram is created that groups substances by common retention time. The height of each peak in the chromatogram corresponds to the number of substances at a given time. The algorithm analyzes this chromatogram and identifies substances that have a specified retention time to be removed. Sub-images corresponding to these substances are removed from the set. The remaining sub-images that do not meet the retention time criterion are retained.

Input : $P \subset \mathbb{R}^{M \times N}$: input image,
 $S = \{S_1, \dots, S_K\}$: set of subimages,
 $L \in \mathbb{N}$: number of theoretical plates,
 $t_{\min}, t_{\max} \in \mathbb{R}$: min and max retention time,
 $t^* \in \mathbb{R}$: retention time to remove

Output: C : chromatogram,
 $P' \subset P$: reconstructed image

1 **Assumptions:**
2 • $t_{\max} > t_{\min}$
3 • $\Delta t = \frac{t_{\max} - t_{\min}}{L}$
4 • S is a non-overlapping partition of P
5 **End Assumptions**

6 Initialize map $C : \mathbb{R} \rightarrow \mathbb{N}_0$;
7 Initialize set $R = \emptyset$;
8 **foreach** $S_i \in S$ **do**
9 $\alpha_i \leftarrow \text{Affinity}(S_i)$;
10 $\tau_i \leftarrow f(\alpha_i)$;
11 $t_i \leftarrow \text{round}\left(\frac{\tau_i - t_{\min}}{\Delta t}\right) \cdot \Delta t$;
12 $R \leftarrow R \cup \{(S_i, t_i)\}$;
13 $C[t_i] \leftarrow C[t_i] + 1$;
14 **end**

15 Remove all $(S_i, t_i) \in R$ such that $t_i = t^*$;
16 Reconstruct P' from remaining subimages;
17 **return** C, P' ;

Algorithm 2. The algorithm for removing sub-images with a specific retention time from the image.

Based on the remaining sub-regions, the algorithm reconstructs a new output image. The final image no longer contains substances with unwanted retention time. The input parameters of the algorithm are the original image, the number of plates, the retention time range and the retention time to be removed. The algorithm operates on the chromatogram structure, which represents the frequency of occurrence of individual substances. As a result of the algorithm, we obtain a new chromatogram and a modified image from which specific substances have been eliminated. The key stages of the algorithm are: calculation of retention time, creation of the chromatogram, identification and removal of selected substances and reconstruction of the final image.

3.2. The operation of removing the peak, which corresponds to the substance with the highest concentration

Algorithm 3 presents the sequence of operations responsible for removing substances with the highest concentration from the chromatogram. As a result of this operation, sub-images, i.e. substances that occur most frequently, are removed from the mixture of substances – i.e. from the image. As can be seen from the presented algorithm, the input argument is the image that will be processed by the algorithm. The parameters also include parameters that determine the size of sub-images and the degree of generalization by the chromatographic data separation algorithm, i.e. the parameter defining the number of shelves.

Input : $P \in \mathbb{R}^{M \times N}$: input image,
 $\mathcal{S} = \{S_1, \dots, S_K\}$: set of subimages,
 $L \in \mathbb{N}$: number of theoretical plates,
 $t_{\min}, t_{\max} \in \mathbb{R}$: min and max retention time
Output: $\mathcal{C}$: chromatogram,
 $P' \subset P$: reconstructed image

```

1 Assumptions:
2 •  $t_{\max} > t_{\min}$ 
3 •  $\Delta t = \frac{t_{\max} - t_{\min}}{L}$ 
4 • Peak height equals number of subimages
5 End Assumptions

6 Initialize map  $\mathcal{C} : \mathbb{R} \rightarrow \mathbb{N}_0$ ;
7 Initialize set  $R = \emptyset$ ;
8 foreach  $S_i \in \mathcal{S}$  do
9    $\alpha_i \leftarrow \text{Affinity}(S_i)$ ;
10   $\tau_i \leftarrow f(\alpha_i)$ ;
11   $t_i \leftarrow \text{round}\left(\frac{\tau_i - t_{\min}}{\Delta t}\right) \cdot \Delta t$ ;
12   $R \leftarrow R \cup \{(S_i, t_i)\}$ ;
13   $\mathcal{C}[t_i] \leftarrow \mathcal{C}[t_i] + 1$ ;
14 end

15  $t_{\max\text{Peak}} \leftarrow \text{argmax}_{t \in \text{dom}(\mathcal{C})} \mathcal{C}[t]$ ;
16 Remove all  $(S_i, t_i) \in R$  such that  $t_i = t_{\max\text{Peak}}$ ;
17 Reconstruct  $P'$  from remaining subimages;
18 return  $\mathcal{C}, P'$ ;
  
```

Algorithm 3. The algorithm for removing sub-images with the highest concentration from the image.

As Algorithm 3 shows, after removing the sub-images with the longest retention time, the image is reconstructed from the sub-images and the algorithm returns the image from which the fragments that occurred most frequently have been removed.

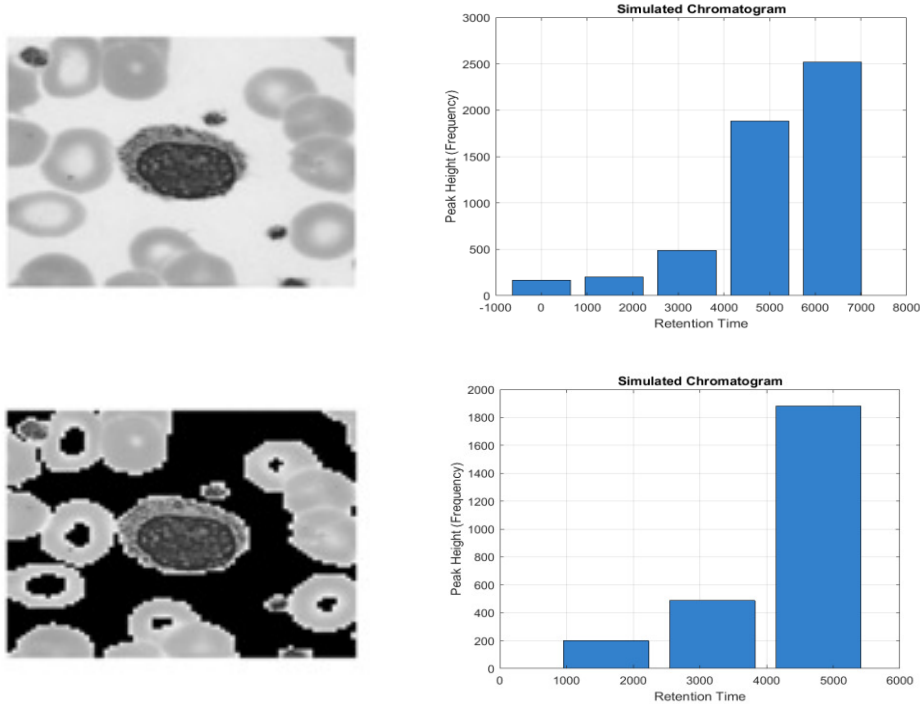


Figure 6. Image and chromatogram before and after removal of the dominant substance (Number of Poles = 4, Image dimensions 5x5).

Figure 6 the effect of the algorithm for removing the substances with the highest concentration was presented. As can be seen from the figure, the area that was the background of the image was removed from the lower part of the image. The second column contains chromatograms of the output image and the image that was created as a result of using the presented algorithm.

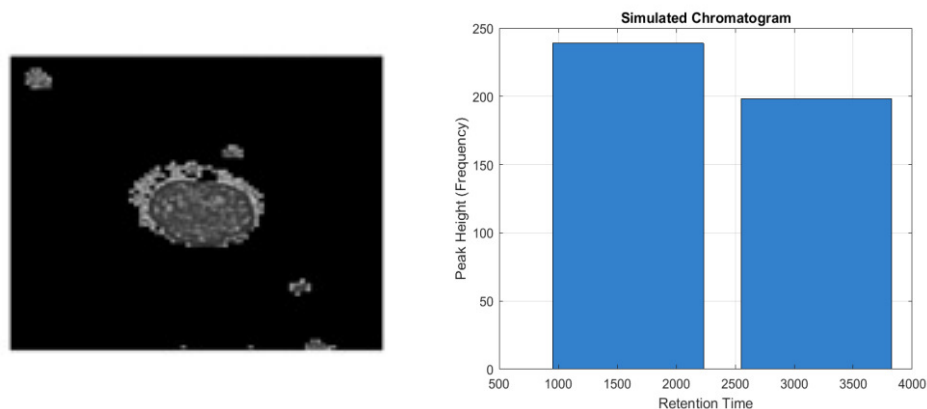


Figure 7. Image and chromatogram after removal of the dominant substance (Number of Poles = 4, Image dimensions 5x5), resulting from three iterations of the dominant peak removal operation on the original image.

Figure 7 shows the result of multiple application of the operation of removing the dominant peak from the image. As you can see, this process involves isolating an object from the image, which in a later stage can be another operation, which are related to recognizing a given object.

As it results from the presented chromatograms, the number of shelves used for the removal operation is 4. If the number of shelves increases, the generalization ability of the chromatographic algorithm will decrease – and the background removal process will require multiple applications of the presented algorithm.

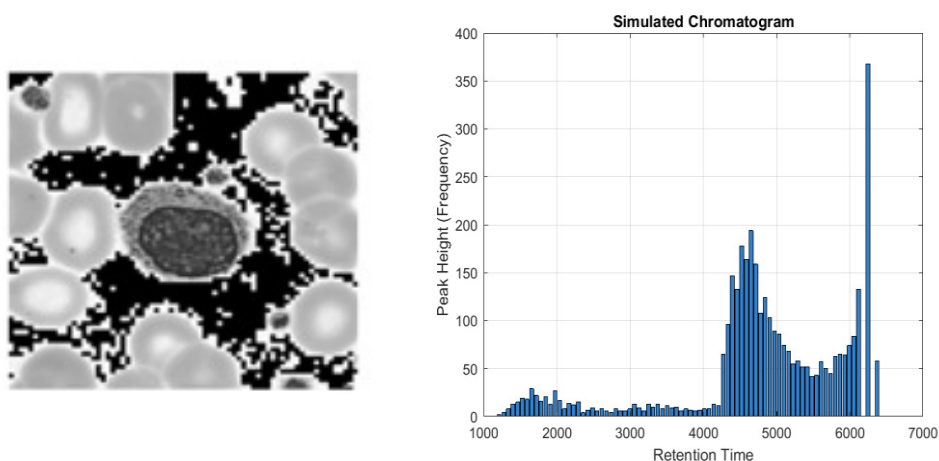


Figure 8. Image and chromatogram after removal of the dominant substance (Number of Poles = 100, Image dimensions 5x5), resulting from three iterations of the dominant peak removal operation on the original image.

Figure 8 the result of using the operation of removing the peak with the highest height to remove the background from the image was presented. As can be seen from the presented image, increasing the number of shelves in the algorithm caused the background removal

process to be longer, compared to the algorithm where the number of shelves was 4. On the other hand, it should be said that increasing the number of shelves in the algorithm causes the extraction process to be more selective (Solomon, Breckon, 2011; Young et al., 1995).

3.3. Algorithm for subtracting two chromatograms

Another operation on chromatograms that can be used in image processing is the operation of subtraction of two chromatograms. . **Algorithm 4** presents the sequence of operations related to the subtraction of two chromatograms. The input arguments of the presented algorithm are, among others, parameters that are responsible for the process of dividing the input image, and for the ability to generalize the chromatographic system, these parameters were discussed earlier. Another argument of the presented algorithm is the chromatogram, which will be subtracted from the chromatogram of the input image. The presented algorithm assumes that the input chromatogram was created by the chromatographic data separation algorithm with the same parameters that will be used to create the chromatogram of the image P, in particular the number of shelves, which is responsible for the resolution.

The algorithm is relatively simple, because the algorithm compares individual chromatogram peaks with each other, where the only criterion for comparison is the retention time. If the retention times of two peaks are the same, or the relative difference between the retention times is smaller than the value of the eps parameter, then such a peak, together with the images that belong to it, is removed from the chromatogram of the P image. Since the algorithm returns an image, as the algorithm states, the image is reconstructed based on the modified chromatogram.

The operation of subtracting chromatograms can be useful in the context of image processing in two categories of problems. The first category is the extraction of an object or objects from an image by removing the background, which often has a complex structure, then the use of **Algorithm 3** may not bring the desired results, especially when the extracted object or objects occupy a larger area than the background. The second category of problems, in which the presented algorithm can be used for skeletonization, i.e. representing an object in the form of a contour, which is an important issue in the image recognition process.

Input : $P \in \mathbb{R}^{M \times N}$: input image (mixture),
 $S = \{S_1, \dots, S_K\}$: set of non-overlapping subimages,
 $ChSub$: subtracting chromatogram,
 $L \in \mathbb{N}$: number of theoretical plates,
 $t_{\min}, t_{\max} \in \mathbb{R}$: min and max retention time,
 $\varepsilon \in [0, 1]$: retention time tolerance

Output: C_{out} : resulting chromatogram,
 $P' \subset P$: modified image after chromatogram subtraction

```

1 Assumptions:
2 •  $t_{\max} > t_{\min}$ 
3 •  $\Delta t = \frac{t_{\max} - t_{\min}}{L}$ 
4 •  $S$  is a non-overlapping partition of  $P$ 
5 •  $ChSub$  computed using same  $L, t_{\min}, t_{\max}$ 
6 •  $|\text{dom}(ChSub)| \neq |\text{dom}(C_P)|$ 
7 End Assumptions

8 Initialize map  $C_P : \mathbb{R} \rightarrow \mathbb{N}_0$ ;
9 Initialize set  $R = \emptyset$ ;
10 foreach  $S_i \in S$  do
11    $\alpha_i \leftarrow \text{Affinity}(S_i)$ ;
12    $\tau_i \leftarrow f(\alpha_i)$ ;
13    $t_i \leftarrow \text{round}\left(\frac{\tau_i - t_{\min}}{\Delta t}\right) \cdot \Delta t$ ;
14    $R \leftarrow R \cup \{(S_i, t_i)\}$ ;
15    $C_P[t_i] \leftarrow C_P[t_i] + 1$ ;
16 end

17 Initialize map  $C_{out} \leftarrow C_P$ ;
18 foreach  $t_p \in \text{dom}(C_P)$  do
19   foreach  $t_s \in \text{dom}(ChSub)$  do
20     if  $|t_p - t_s| \leq \varepsilon$  then
21       Remove peak at  $t_p$  from  $C_{out}$ ;
22       Remove all  $(S_i, t_i) \in R$  such that  $t_i = t_p$ ;
23     end
24   end
25 end

26 Reconstruct  $P'$  from remaining subimages in  $R$ ;
27 return  $C_{out}, P'$ ;

```

Algorithm 4. Algorithm for subtracting two chromatograms.

Another important operation that plays a significant role in image processing is the skeletonization of a given object – that is, the presentation of a given object using contours, which allows in particular the identification of the object using shapes. In the case of using the chromatographic data separation method for image processing, this effect can be obtained with skillful processing of chromatograms.

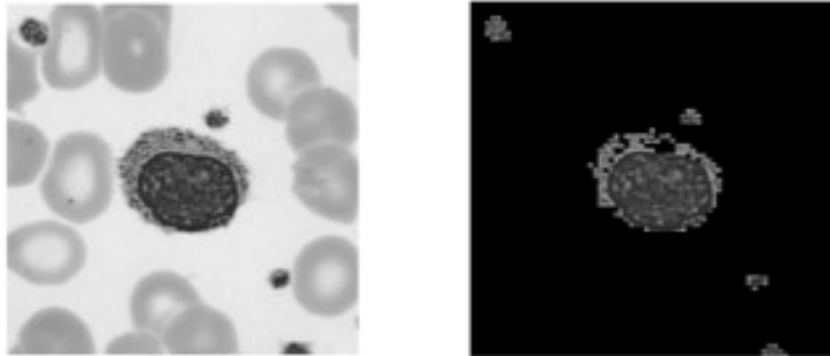


Figure 9. Background removal as a result of chromatogram subtraction operation.

Figure 9 shows the effect of the chromatogram subtraction operation. In this case, the chromatogram that was subtracted was a chromatogram that was created based on an image containing graphic motifs related to the background. As can be seen in the figure on the right, the image has been stripped of its background, and in the center of the image there is an object that can be subjected to the recognition process.

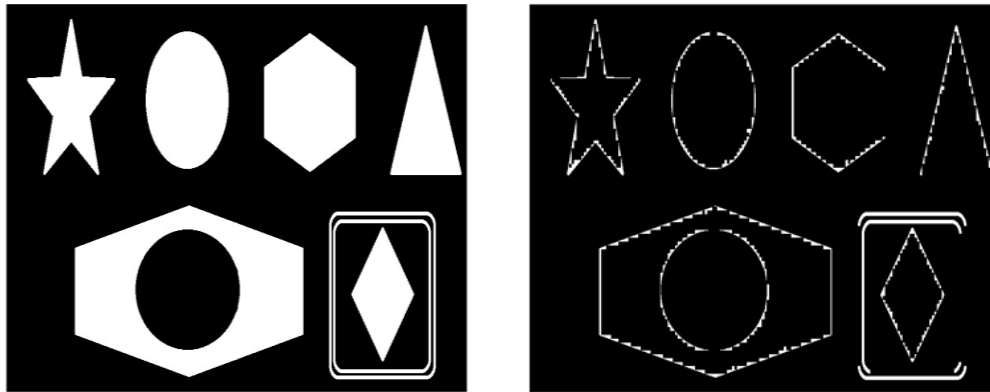


Figure 10. Skeletonization as a result of chromatogram subtraction operation.

Figure 10 shows the result of the chromatogram subtraction operation, in a situation where the subtracted chromatogram was created based on images that constitute the filling of objects that will be subjected to the skeletonization process. As shown in the figure on the left, the contours of objects were created. However, it should be noted that the appropriate selection of parameters also plays an important role, such as the number of shelves used by the chromatographic separation algorithm and the value of the eps parameter, which is responsible for the permissible value of the difference between individual chromatogram peaks (Baxes, 1994; Mondello et al., 2008; Stilo et al., 2021).

3.4. Algorithm for removing common peaks between chromatograms

To obtain the effect of objects in the image being replaced by object contours, it is necessary to remove the common image fragments from the chromatogram containing the objects that we want to be represented by contours, which correspond to the filling of the images. This means that we must have at least two chromatograms, the first chromatogram was generated based on the image that is to contain the elements that we want to be removed from the second image. The remaining chromatograms were created based on the images that will undergo the skeletonization process.

Input : $\{P_i\}_{i=1}^N$: set of images, $\{S_i\}_{i=1}^N$: sets of subimages, $\{Ch_i\}_{i=1}^N$: chromatograms, $L \in \mathbb{N}$, $t_{\min}, t_{\max} \in \mathbb{R}$, $\varepsilon \in [0, 1]$

Output: $\{Ch'_i\}_{i=1}^N$: modified chromatograms, $\{P'_i\}_{i=1}^N$: modified images, $\{S'_i\}_{i=1}^N$: modified subimage sets

```

1 Assumptions:
2 •  $t_{\max} > t_{\min}$ 
3 •  $\Delta t = \frac{t_{\max} - t_{\min}}{L}$ 
4 •  $\forall i, Ch_i$  computed with same  $L, t_{\min}, t_{\max}$ 
5 • Peakheightequalssubimagecount
6 End Assumptions

7  $k \leftarrow \operatorname{argmin}_{i \in \{1, \dots, N\}} |\operatorname{dom}(Ch_i)|$ ;
8 Reference chromatogram  $Ch_{ref} \leftarrow Ch_k$ ;
9 foreach  $i \in \{1, \dots, N\}, i \neq k$  do
10   foreach  $t_r \in \operatorname{dom}(Ch_{ref})$  do
11     foreach  $t_i \in \operatorname{dom}(Ch_i)$  do
12       if  $|t_r - t_i| \leq \varepsilon$  then
13         Remove peak at  $t_i$  from  $Ch_i$ ;
14         Remove all  $(S, t) \in S_i$  such that  $t = t_i$ ;
15       end
16     end
17   end
18 end

19 foreach  $i \in \{1, \dots, N\}$  do
20   Group peaks in  $Ch_i$  by identical retention times;
21   Reconstruct  $P'_i$  from  $S'_i$ ;
22 end
23 return  $\{Ch'_i\}, \{P'_i\}, \{S'_i\}$ ;

```

Algorithm 5. Algorithm for removing common peaks.

Algorithm 5 shows the sequence of operations, which aim to remove common peaks between chromatograms. The input arguments for the presented algorithm are chromatograms, which were created as a result of the chromatographic data separation algorithm, which is presented by **Algorithm 1**. The peaks between individual chromatograms are compared with respect to retention time. Peaks with the same retention time or with retention time where the difference between peaks is less than the value of the eps parameter, are removed from the chromatogram, which has a greater number of peaks. It is obvious that the chromatograms constituting the input arguments must have been created by **Algorithm 1** with the same parameters, and in particular with the same number of fields.

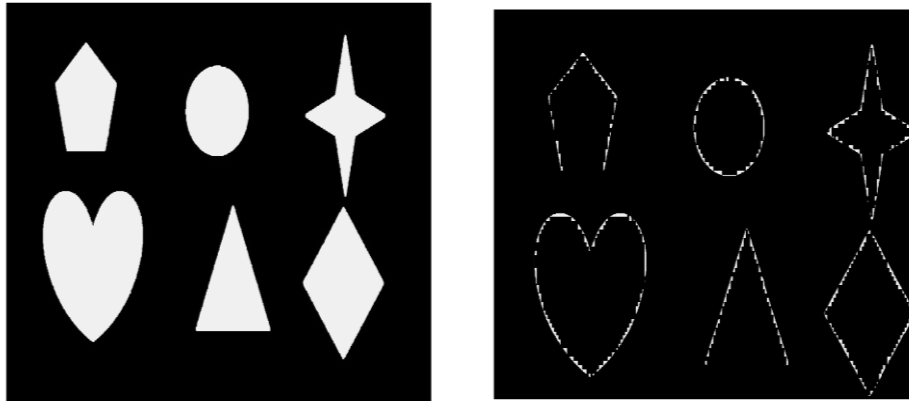


Figure 11. Input image and the image resulting from the application of the common peak removal algorithm (Algorithm 5).

Figure 9 shows the result of the operation, which consists in removing common peaks between chromatograms. As you can see, the result of this operation is the contours of the objects, which are on the left in the figure. Of course, the quality of the creation of the skeletons of individual objects is influenced by several parameters (Parker, 2010; Young et al., 1995).

3.5. Dilation algorithm

Dilation is one of the basic morphological operations in image processing, used mainly on binary images, but can also be extended to grayscale images. It consists in "expanding" objects contained in the image by adding pixels to their boundaries. In practice, dilation makes objects larger, and small gaps, cracks or irregularities in their structure are filled. Dilation is the opposite of erosion, which does the opposite – it reduces objects. Both of these operations are often used together, e.g. in morphological opening or closing, to clean images from interference.

In the case of representing images using chromatograms, it is also possible to define operations on the chromatograms that will ultimately correspond to the dilation operation.

```

Input :  $Ch_{in}$ : input chromatogram,  $L, t_{min}, t_{max}, M_1, N_1, M_2, N_2,$ 
          $L_2, t_{min2}, t_{max2}$ 
Output:  $Ch_{out}$ : dilated chromatogram

1 Assumptions:
2 •  $Ch_{in}$  contains peaks with retention time, frequency, subimages, positions
3 •  $t_{max} > t_{min}$ 
4 •  $\Delta t = \frac{t_{max} - t_{min}}{L}$ 
5 • All images may have different sizes
6 • split_chromatogram and reconstruct_image are available
7 End Assumptions

8 foreach peak  $p_i$  in  $Peaks(Ch_{in})$  do
9   if  $t(p_i) > 0$  then
10     foreach subimage  $S_{ij}$  in  $SubImages(p_i)$  do
11        $Ch_{ij} \leftarrow \text{split\_chromatogram}(S_{ij}, M_2, N_2, L_2, t_{min2}, t_{max2});$ 
12     end
13      $p_{max} \leftarrow \text{argmax}_{p \in Peaks(Ch_{ij})} (t(p), \text{freq}(p));$ 
14     foreach peak  $p_k$  in  $Peaks(Ch_{ij})$  do
15       if  $p_k \neq p_{max}$  then
16         Modify all subimages of  $p_k$  using representative subimage
           of  $p_{max}$ ;
17       end
18     end
19      $S'_i \leftarrow \text{reconstruct\_image}(SubImages(Ch_{ij}));$ 
20     Replace subimages of  $p_i$  in  $Ch_{in}$  by  $S'_i$ ;
21   end
22 end

23  $P' \leftarrow \text{reconstruct\_image}(AllSubImages(Ch_{in}));$ 
24  $Ch_{out} \leftarrow \text{split\_chromatogram}(P', M_1, N_1, L, t_{min}, t_{max});$ 
25 return  $Ch_{out}$ ;

```

Algorithm 6. Gas Chromatography-Inspired Dilation Algorithm.

The algorithm presented in the pseudocode performs the dilation operation inspired by the principles of gas chromatography. For each peak in the input chromatogram that has a non-zero retention time, a split of all its subimages is performed using the *split_chromatogram* function. From the obtained peaks, the one with the longest retention time and the highest frequency of occurrence is selected. Then, this selected subimage is used to modify the remaining subimages (including those belonging to peaks with zero retention time). The reconstructed subimages are inserted back into the original peak. After the operation is completed for all peaks, the entire image is reconstructed and split again – the final result is the reconstructed chromatogram after the dilation operation.

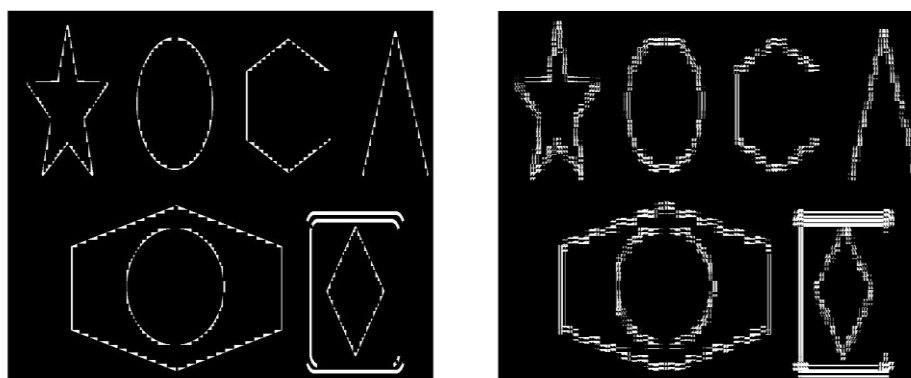


Figure 12. Input image and the image resulting from the application of the dilation algorithm (Algorithm 6).

Figure 12 shows the image before the dilation process – the image on the left. The image on the right was processed by the presented dilation algorithm. As you can see, the contours of individual objects have been thickened. However, the gaps that occurred in the outline of the objects have been filled in. It is obvious that the quality of the dilation process is influenced by the parameters that were described in the presented algorithm.

3.6 Erosion algorithm

Erosion is one of the basic morphological operations used in image processing, especially binary ones. It involves removing pixels from the edges of objects, thereby reducing their size. It works by moving a structural element across the image and leaving only those pixels that are completely within the object. As a result, erosion effectively eliminates small distortions and noise, which is useful in cleaning up the image before further analysis steps. As a result of this operation, fine structures and small details can disappear, allowing for better separation of closely located objects. The type of structural element used, e.g. circular, cross or square, affects the final effect of erosion. In the case of grayscale images, the operation involves assigning each pixel the minimum value of its neighbors defined by the structural element. Erosion is often used together with dilation, creating more complex operations such as morphological opening and closing. Despite its simplicity, it is an important tool in shape analysis, segmentation and recognition of objects in images. Its applications are found in many fields, from medicine to industry and vision systems (Young et al., 1995).

Input : Ch_{in} : input chromatogram, $L, t_{min}, t_{max}, M_1, N_1, M_2, N_2, L_2, t_{min2}, t_{max2}, ErosionThreshold \in [0, 1]$

Output: Ch_{out} : eroded chromatogram, P' : modified input image

1 **Assumptions**: All peaks in Ch_{in} contain retention time, frequency, subimages, positions. $t_{max} > t_{min}$. $\Delta t = \frac{t_{max} - t_{min}}{L}$. All images may have different sizes. Functions `split_chromatogram()` and `reconstruct_image()` are available. $ErosionThreshold \in [0, 1]$ defines activation level of erosion. **End Assumptions**

2 **foreach** peak p_i in $Peaks(Ch_{in})$ **do**

3 **if** $t(p_i) > 0$ **then**

4 **foreach** subimage S_{ij} in $SubImages(p_i)$ **do**

5 $Ch_{ij} \leftarrow \text{split\_chromatogram}(S_{ij}, M_2, N_2, L_2, t_{min2}, t_{max2});$

6 **if** exists peak p_0 in $Peaks(Ch_{ij})$ with $t(p_0) = 0$ and $height(p_0) > ErosionThreshold * M_2 * N_2$ **then**

7 Replace all subimages in Ch_{ij} with subimage corresponding to p_0 ;

8 **end**

9 **end**

10 $S'_i \leftarrow \text{reconstruct\_image}(SubImages(Ch_{ij}));$

11 Replace subimages of p_i in Ch_{in} by S'_i ;

12 **end**

13 **end**

14 $P' \leftarrow \text{reconstruct\_image}(AllSubImages(Ch_{in}));$

15 $Ch_{out} \leftarrow \text{split\_chromatogram}(P', M_1, N_1, L, t_{min}, t_{max});$

16 **return** Ch_{out}, P' ;

Algorithm 7. Gas Chromatography-Inspired Erosion algorithm.

The algorithm performs the erosion operation in the context of processing chromatographic data representing images of chemical substances. The input is a chromatogram containing peaks, each of which consists of sub-images and an assigned retention time. It is assumed that the retention time is rounded to values consistent with the formula based on the number of shelves and the retention range. Additionally, all images can have different sizes, and the erosion threshold ($ErosionThreshold$) is in the range $[0, 1]$. The algorithm uses the `split_chromatogram` function, which separates sub-images based on the given parameters. For each peak with a retention time different from zero, a separation is performed, and in the case of detecting a dominant peak with zero retention time exceeding the threshold, all sub-images are replaced with this one. Then, the sub-images are reconstructed using the `reconstruct_image` function, which leads to their update. After completing all transformations, the algorithm rebuilds the entire chromatogram and performs its final segmentation. The algorithm outputs an updated chromatogram and a reconstructed image containing erosion results. The goal of the algorithm is to eliminate weak signals by applying erosive image reduction, which leads to a simplification of the input data structure.

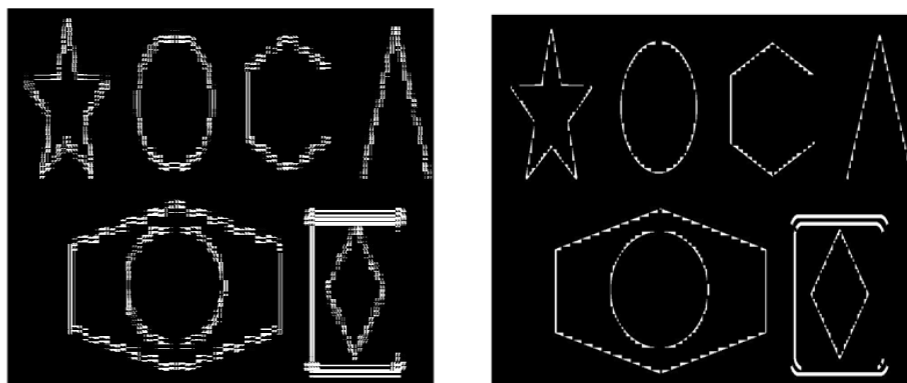


Figure 13. Input image and the image resulting from the application of the erosion algorithm (Algorithm 7).

Figure 12 shows the image before the erosion process – the image on the left. The image on the right was processed by the presented erosion algorithm. As you can see, the contours of individual objects have been eroded – they are thinner.

4. Summary

The text describes an innovative approach to image processing, based on the chromatographic data separation method, inspired by gas chromatography. Image processing is crucial in the automation of quality control and diagnostics, including in industry and hematology. Classical image analysis methods use segmentation, feature extraction and classification using algorithms such as SVM or neural networks. The proposed method treats the image as a mixture of substances, where individual fragments (subimages) correspond to "substances" subjected to the chromatographic process. Subimages are assessed in terms of affinity to the stationary phase, which affects their retention time in the "chromatographic column".

The process produces a chromatogram, i.e. a distribution of sub-image retention times, which reflects the image structure. The algorithm divides the image into sub-areas, calculates the retention time for them, and creates a histogram grouping sub-images with similar times. This approach allows for performing various operations on the image, such as selection, removing dominant fragments (e.g. background) or extracting objects.

An important element is the ability to remove subimages with the highest concentration from the image, which allows for the isolation of important elements and reduction of interference. Additionally, the algorithm allows for the subtraction of chromatograms, which allows for the removal of the background or skeletonization of objects, i.e. the creation of contours useful for shape recognition. As a result, you can obtain an image without a background or extract its contour structures.

This method allows for image filtering in a manner similar to chromatographic filtration, which is a unique approach in the field of image analysis. The advantage of the algorithm is the ability to adjust the resolution (number of shelves), which affects the selectivity and generalization of the process. It was emphasized that the appropriate selection of parameters is crucial for the quality of the results.

The operations of removing common peaks between chromatograms are also presented, which allows further processing and extraction of information from images. The method can be used in various applications, from product quality control to medical diagnostics, especially hematology.

Classical image processing techniques, such as segmentation, feature extraction, and classification, have long been the foundation of many applications in industry and medicine. These methods typically rely on algorithms like edge detection (e.g., Canny or Sobel operators), thresholding, region growing, and machine learning models, including Support Vector Machines (SVM) and neural networks. Although these techniques have proven useful in various tasks, they often encounter issues related to sensitivity to noise, complexity of feature extraction, and difficulty in handling highly variable image data without significant pre-processing.

The chromatographic data separation method, in contrast to traditional approaches, proposes a unique technique by treating the image as a mixture of substances, similar to chemical processes in chromatography. This enables selective analysis of the image's components based on their "affinity" to a simulated stationary phase, offering a new way to segment and manipulate image data. The process of converting an image into a chromatogram allows not only for effective feature isolation but also for performing operations that enable selective enhancement or removal of specific image elements (e.g., background or unwanted disturbances).

The chromatographic method allows for precise adjustment of image processing resolution (through the number of chromatographic shelves), which increases the accuracy of feature extraction. This is particularly beneficial when working with images that are highly complex or noisy, where traditional segmentation may fail. Since this method allows for various operations, such as removing dominant elements, selectively adjusting the background, or extracting contours, it is useful in analyses that require precise object separation, such as in medical applications (e.g., microscopic blood analysis) or industrial quality control.

Another significant advantage is the reduced sensitivity to background noise. By focusing on the retention time of individual sub-images, the method enables more precise removal of the background and irrelevant parts of the image, ultimately increasing the accuracy of object detection and image filtering. This approach also stands out due to its innovative combination of chemical analysis principles with image processing, opening new possibilities in fields such as environmental monitoring and medical diagnostics, where classical methods may have limitations.

One of the main challenges of the chromatographic method is its sensitivity to parameter selection, such as the number of shelves or the granularity of sub-image division. Incorrectly choosing these parameters can lead to inefficient image segmentation or excessive loss of relevant information. Therefore, it is necessary to carefully adjust these settings to achieve the optimal result.

In summary, the chromatographic data separation algorithm is a novel tool for image analysis and processing, offering the possibility of selection, filtering and extraction of objects based on the chromatographic model, which opens new directions in image automation and recognition.

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A MODEL OF THE DYNAMICS OF CORPORATE-STARTUP ENGAGEMENT

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Purpose: The purpose of this paper is to address a critical gap in the literature created by fragmented studies on corporate-startup collaborations. It aims to answer the research question: "What is the causal chain linking organizational asymmetries to specific collaboration outcomes?" by proposing a dynamic model that synthesizes the concepts of asymmetry, complementarity, paradoxes, and tensions into a single, explanatory framework.

Design/methodology/approach: The conceptual framework was developed through an interpretive narrative literature review and a qualitative synthesis of selected research. The approach is theoretical, focusing on the core dynamics of inter-organizational relationships within the specific context of Corporate-Startup Engagement.

Findings: The findings show that challenges in achieving mutual benefits can be interpreted as tensions arising from paradoxes in four key dimensions: performing, learning, belonging, and organizing. The model demonstrates that these tensions can be logically traced back to the interplay of asymmetry and complementarity between the partner firms, which reveals inherent paradoxes that directly affect the relationship's outcomes.

Research limitations/implications: The primary limitation is the subjectivity inherent in the narrative review methodology. The proposed model is conceptual and requires empirical validation to allow for the generalization of its conclusions. It serves as a robust foundation for future empirical research aimed at testing the model's causal links and exploring its application in various contexts.

Practical implications: The model provides managers with a diagnostic tool to better understand and navigate the complexities of corporate-startup collaborations. By explaining how predictable tensions arise, it can inform the strategic design and dynamic management of these partnerships, ultimately enhancing their effectiveness and potential for success.

Originality/value: This study offers a novel synthesis of four key theoretical categories into a cohesive, dynamic model. Its value lies in providing a more integrated and systemic understanding of Corporate-Startup Engagement, offering a valuable framework for both academics researching inter-organizational dynamics and practitioners responsible for managing these critical innovation partnerships.

Keywords: startups, Corporate-Startup Engagement, corporate-startup collaboration, innovation.

Category of the paper: Research paper.

1. Introduction

Contemporary business operates in a turbulent business environment (Zakrzewska-Bielawska, 2017). The challenge of digitalization (Matt et al., 2015; Reis et al., 2020; Warner, Wäger, 2019) and the related threat of market disruptions (Cozzolino et al., 2018; Liao et al., 2020) are of particular importance. Although corporations dominate in the field of incremental innovations, they often exhibit structural and cultural inability to implement breakthrough technologies that could render their core competencies obsolete (Kupp et al., 2017; Steiber, 2020; Steiber, Alänge, 2020; Weiblen, Chesbrough, 2015). These breakthrough innovations are increasingly introduced by agile, fast-growing startups. This dynamic has created a strategic imperative for corporations to seek new ideas, technologies, and talent beyond their organizational boundaries (Sbampato et al., 2025).

From the perspective of large enterprises, relationships with startups are one of the key tools in open innovation strategies (Chesbrough, 2002). Startups, in turn, want to benefit from access to corporate resources such as brand recognition, distribution networks, customer bases, and financial capital (Weiblen, Chesbrough, 2015). These motives are the main reason for establishing relationships between corporations and startups, which include a diverse set of activities, in most cases initiated and led by corporations.

The wide spectrum of engagement models ranging from low-commitment hackathons to high-commitment acquisitions (Sbampato et al., 2025; Weiblen, Chesbrough, 2015)—indicates an ongoing search for optimal solutions in business practice. Among these, corporate venture capital (CVC), accelerators/incubators, and startup competitions are three of the most preferred engagement channels utilized by corporations (Collaboration between Start-Ups and Corporates, 2018). However, the persistent high failure rates across these popular models suggest that the choice of a specific structural form is insufficient for ensuring success (Dizdarevic et al., 2024). The core challenge lies in managing the underlying dynamics, as the tensions this paper explores are particularly acute in these common formats (Chappert et al., 2024). For instance, corporate accelerators inherently amplify the 'creativity vs. control' tension (Dizdarevic et al., 2024; Kohler, 2016), while pilot projects frequently stall due to the clash between startup speed and the "long corporate sales cycles" that exemplify the 'agility vs. embeddedness' problem (Chappert et al., 2024; Collaboration between Start-Ups and Corporates, 2018). It is widely acknowledged, that despite a mutual awareness of potential benefits, a significant gap exists between the promise of these collaborations and their outcomes. This is evidenced by high failure rates, difficulty in replicating successes, and a lack of established management practices to ensure effective collaboration (Bagno et al., 2024; Brigl et al., 2019; Collaboration between Start-Ups and Corporates, 2018; Dizdarevic et al., 2024; Dörner et al., 2020). Therefore, a theoretical model that explains these fundamental

dynamics could provide practitioners with a vital diagnostic tool, enabling them to look beyond the collaboration's structure to anticipate and manage the inevitable points of friction within it.

Let us consider a hypothetical collaboration between 'SyncAI,' a technology startup with a novel AI-driven logistics algorithm, and 'Global Foods Corp.,' an established multinational distributor. The partnership is founded on clear complementarities: SyncAI possesses unique technological capabilities but lacks the capital and data for commercial validation, while Global Foods offers vast market access but struggles with internal innovation. Despite this synergy, the engagement falters. SyncAI's agile development cycle clashes with the corporation's rigid, lengthy IT security, procurement and decision-making processes, creating an operational impasse. Concurrently, to integrate its solution, the startup must risk its core intellectual property, fearing the corporation could absorb the knowledge and become a future competitor. This common scenario reveals how structurally sound partnerships can be undermined by predictable tensions that arise directly from the partners' inherent asymmetries.

A growing body of research identifies key motivators like resource complementarity and significant challenges such as cultural clashes and power imbalances. However, despite these valuable insights, research in this area remains fragmented. Scholars have often examined the constituent elements of these relationships—such as organizational asymmetries, emerging paradoxes, and interorganizational tensions—as separate phenomena. What is critically missing is a cohesive conceptual model that explains the causal pathway connecting these elements. Little is understood about how foundational asymmetries between corporations and startups systematically give rise to predictable paradoxes, which in turn manifest as the managerial tensions that ultimately determine a collaboration's success or failure. Accordingly, this paper addresses this gap by proposing a dynamic model that synthesizes asymmetry, complementarity, paradoxes, and tensions into a single, explanatory framework. The central research question guiding this work is: "What is the causal chain linking organizational asymmetries to specific collaboration outcomes?"

2. Research Method and Conceptual Framework

This article proposes an original approach to the issue of Corporate-Startup Engagement, presenting this phenomenon from the perspectives of **asymmetry**, **complementarity**, **paradoxes**, and **tensions**. The rationale for selecting these four specific categories is grounded in a causal chain that explains the core dynamics of Corporate-Startup Engagement. The model is built on the following logic:

- Asymmetry is the foundational concept. It represents the inherent, defining state of difference in resources, power, and structure between a corporation and a startup, acting as both the primary driver for collaboration and the root source of friction.

- Complementarity is included because it represents the potential value that can be unlocked from asymmetry. It is the source which enables the differences to be leveraged to create superadditive value, making collaboration strategically desirable.
- Paradox is the theoretical lens used to understand the persistent contradictions that arise when partners attempt to manage their asymmetrical relationship. The simultaneous need to cooperate (to achieve complementarity) and compete, or to be flexible and structured, creates inherent structural paradoxes that cannot be eliminated.
- Tensions are selected as the final category because they are the tangible, experiential manifestation of these underlying paradoxes. Tensions represent the felt stress and managerial dilemmas that directly impact collaboration outcomes, making them the critical focal point for practical management.

Together, these four categories form a comprehensive explanatory pathway, moving from the fundamental state of the relationship (asymmetry) to the day-to-day managerial reality (tensions) as illustrated on Figure 1. This approach allows the model to connect the questions of:

- a) why the collaboration exists with,
- b) why it so often becomes difficult to manage, and
- c) why so often outcomes are far from what has been expected and planned.

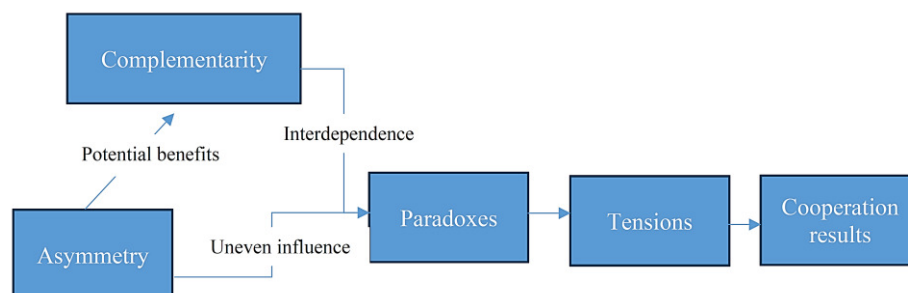


Figure 1. Relationships between the categories of asymmetry, complementarity, paradoxes and tensions in cooperation.

Source: own elaboration.

The proposed model emerges from a narrative analysis of existing literature (Green et al., 2006), guided by an interpretive approach. The aim of this methodology is to construct a coherent theoretical framework by organizing key conceptual categories. The literature review was purposive, targeting texts that explore the core themes of asymmetry, complementarity, paradoxes, and tensions, both within the general context of inter-organizational cooperation and specifically within Corporate-Startup Engagement. The literature review was conducted along three paths:

- selection of highly cited publications on given topics,
- selection of new publications (i.e., published after 2020) on given topics,
- selection using the snowball technique (Wohlin, 2014), i.e., reviewing the sources referenced in the above publications.

The literature selection process was guided by specific inclusion criteria to ensure the relevance and scholarly quality of the synthesized material. The search was primarily limited to peer-reviewed academic publications in English and Polish, accessed through major scholarly databases such as: Scopus, Web of Science and Google Scholar. To ground the model in contemporary business challenges, this academic corpus was supplemented by high-impact practical reports from renowned organizations, including the World Economic Forum, McKinsey, Boston Consulting Group and MassChallenge. This multi-faceted search yielded an initial pool of over 150 sources, from which 85 were ultimately selected for their direct contribution to constructing the framework's core conceptual categories and explanatory logic.

It is important to acknowledge the limitations inherent in the chosen methodology. Unlike a systematic literature review, which follows a rigid and exhaustive search protocol, the narrative and interpretive approach employed here involves a purposive and, therefore, subjective selection of sources. This subjectivity creates a potential risk of selection bias, where the resulting framework may unintentionally omit or underrepresent alternative theoretical perspectives. The goal of this study, however, was not to provide an exhaustive summary but to synthesize key conceptual categories into a coherent theoretical narrative. Consequently, the proposed model should be viewed as a theoretical proposition intended to guide future empirical validation, rather than a definitive statement on the phenomenon.

The narrative core of the review consisted of the concepts of asymmetry, complementarity, paradoxes, and tensions. All of them are subjects of lively scientific debate within the discipline of management sciences, especially in the context of inter-organizational cooperation.

Asymmetry is defined as a discrepancy, imbalance, or lack of equivalence between cooperating entities in one or more dimensions (Oliver, 1990). This state is often the main impetus for forming cooperative ties, such as strategic alliances, joint ventures, and networks. General research on inter-organizational relationships reveals a key duality: asymmetry can be both a primary motivation for cooperation and a fundamental source of friction, instability, and failure in relationships (Doz, Hamel, 1998; Hamel, 1991; Stańczyk-Hugiet, Strychalski, 2013).

Research on asymmetry is deeply rooted in several major streams of organization and management theory and economics. The **Resource-Based View (RBV)** assumes that firms form alliances to access complementary, and thus asymmetric, bundles of resources or to combine them to create a competitive advantage that would be unattainable alone (Barney, 1991; Dyer, Singh, 1998). **Resource Dependence Theory (RDT)** argues that asymmetries in the control over key resources create dependencies, which in turn generate power imbalances that shape the dynamics between firms (Casciaro, Piskorski, 2005; Gulati, 1998; Pfeffer, Salancik, 1978). At the same time, theories focusing on transactional inequalities, such as **Transaction Cost Economics (TCE)** and **Agency Theory**, emphasize how asymmetries, especially informational ones, create risks of opportunism (moral hazard) and adverse selection (Gulati, 1998; Jensen, Meckling, 1976; Williamson, 1987).

Complementarity occurs when organizational practices exhibit supermodularity—meaning that the marginal benefit of implementing one practice increases when other complementary practices are also applied (Milgrom, Roberts, 1995; Whittington et al., 1999). In the strategic management literature, complementarity is a system-forming principle that enables synergy between different types of resources, functions, institutions, and partners (Dyer, Singh, 1998). It describes the fit that exists between organizational elements when their features are well-matched and mutually supportive (Das, Teng, 2000). This concept is fundamental to understanding how organizations create a sustainable competitive advantage through the strategic alignment of multiple organizational components (Ennen, Richter, 2010; Siggelkow, 2002).

In the context of inter-organizational relationships, this means that the resources, capabilities, or strategies of two or more firms are complementary when their combined use generates **superadditive value**—that is, returns greater than the sum of what each firm could generate from its assets in isolation (Ennen, Richter, 2010).

Paradox is conceptualized in management science as a "persistent contradiction between interdependent elements" (DeFillippi, Sydow, 2016; Schad et al., 2016; Vangen, 2017). This perspective is based on the fundamental idea that paradoxes consist of "contradictory yet interrelated elements that exist simultaneously and persist over time" (Smith, Lewis, 2011; Gnyawali et al., 2016; Jay, 2013; Raza-Ullah, 2020; Sharma, Bansal, 2017). The essence of this understanding is that such contradictions are not temporary problems to be solved, but enduring and inherent features of organizational systems (Poole, Van De Ven, 1989). These elements may seem logical in isolation but can appear absurd and irrational when they occur simultaneously (Gao et al., 2010; Wilhelm, Sydow, 2018), which highlights their complex and non-linear relationship.

The literature identifies numerous pairs of paradoxes, including contradictions between cooperation and competition (Das, Teng, 2000; Gnyawali et al., 2016; Munten et al., 2021; Ricciardi et al., 2022) rigidity and flexibility (Fang et al., 2011; Vangen, Winchester, 2014), and autonomy and accountability (Berthod et al., 2016; Vangen, 2017). Other common examples include the paradoxes of exploration versus exploitation (Im, Rai, 2008; Lin et al., 2013; Rozkwitalska-Welenc et al., 2025), knowledge sharing versus knowledge protection (Dushnitsky, Shaver, 2009; Jarvenpaa, Majchrzak, 2016), and value creation versus value appropriation (Niesten, Stefan, 2019; Van Fenema, Loebbecke, 2014; Volschenk et al., 2024). These paradoxes are seen as an inherent element of collaborative systems, constituting fundamental and enduring strategic challenges (Das, Teng, 2000).

Paradoxes can remain latent or unnoticed until they are activated by environmental or strategic changes, at which point they manifest as tensions that leaders must navigate to maintain organizational effectiveness (Ospina, Saz-Carranza, 2010).

Tension is distinct from paradox, although the terms are sometimes used interchangeably (Gnyawali et al., 2016). A paradox is best understood as an underlying, latent, and persistent structural condition (Schad et al., 2016; Smith, Lewis, 2011). In contrast, a **tension** is the manifest, felt experience that emerges from this underlying contradiction, often as a negative consequence (Das, Teng, 2000). Tension represents the "cognitive and emotional stress" (Gnyawali et al., 2016), discomfort (Tóth et al., 2018), that can trigger conflict, which in turn can "paralyze, deteriorate, or even sever business relationships" (Tura et al., 2019). Therefore, a paradox is a dormant structural potential, while tension is its visible, sometimes destructive, expression.

The emergence of tension is a significant factor shaping the dynamics in inter-organizational relationships, with the potential to seriously weaken or destroy joint efforts. Tensions can directly trigger conflicts, undermine value creation, and ultimately lead to the failure or dissolution of the relationship (Casey, Lawless, 2011; Dyer et al., 2018; Van Fenema, Loebbecke, 2014). A key nuance is that tensions rarely exist in isolation; they often interact with each other, creating complex and compounding challenges for managers. The impact of tension on outcomes is a critical issue, as it can worsen the results of a joint venture by creating friction and disagreement between partners (Gnyawali et al., 2016).

3. Narrative Literature Review

3.1. Asymmetries in Corporate-Startup Engagement

Researchers acknowledge that asymmetries are fundamental to Corporate-Startup Engagement (Kohler, 2016), yet a comprehensive scholarly analysis of this dynamic is notably lacking. Existing studies identify various forms of asymmetry that logically complement one another, together painting a more complete picture of the problem.

Resource Asymmetries: This is one of the most visible dimensions. Corporations possess extensive physical and financial capital, established brands, market legitimacy, and extensive distribution channels (Weiblen, Chesbrough, 2015). These assets provide stability and scalability but introduce rigidity in strategic adaptation processes. Startups, on the other hand, operate with limited resources but are characterized by greater risk tolerance, a culture of experimentation, and the ability to pivot quickly in response to feedback (Bortolini et al., 2021).

Power Asymmetries: Unequal access to resources leads to power imbalances. The uneven distribution of control over key and scarce resources often allows the stronger entity to shape the terms, pace, and scope of the collaboration (Pfeffer, Salancik, 1978; Walske et al., 2021). In practice, corporations command many resources, while startups seek them as complementary

assets to commercialize their novel technologies (Kurpjuweit et al., 2021; Weiblen, Chesbrough, 2015).

Knowledge Asymmetries: Asymmetries in a relationship can emerge and change over time. Empirical research shows that the center of power shifts depending on the phase of cooperation. At the stage of searching for and acquiring partners, a startup with a unique solution can gain an advantage in the relationship. Thus, the source of asymmetry is the possession and management of access to key information for innovation that the startup has developed (Kager et al., 2022; Remneland Wikhamn, 2020). However, in later stages, the resources of the large enterprise become more significant, and the bargaining power shifts towards the corporation. The main source of these disparities is knowledge asymmetry—in the initial phases concerning technology, and in later phases, commercialization. Startups often control unique technical know-how but lack established commercialization paths (Ford et al., 2009). Empirical studies confirm that startups face a high risk of knowledge leakage due to having limited control and protection mechanisms, while corporations often set knowledge absorption as a collaboration goal (Chappert et al., 2024).

Structural Asymmetries: A complementary aspect, particularly in advanced stages of collaboration, can be structural asymmetries, which stem from differences in legal, IT, security, and procurement structures. On the corporate side, these units can act as gatekeepers to resources valuable for startups (Denysiuk, 2018; The State of Startup/Corporate Collaboration 2016, 2016). Although collaboration is theoretically mutually beneficial, the control of large enterprises over critical assets allows them to set conditions that may be unfavorable for startups (Walske et al., 2021).

Organizational and Managerial Asymmetries: Also of significant importance are organizational and managerial asymmetries, resulting from differences in the level of hierarchy and decision-making methods in corporations and startups. Corporations consist of hierarchical, multi-level decision-making systems built around formal rules, compliance requirements, and cross-functional coordination channels (Moschner et al., 2019). Startups, by design, minimize hierarchy to accelerate decision-making and the iteration of early versions of their products (Blank, Dorf, 2012). These asymmetries are among the most persistent barriers in corporation-startup collaboration, as they place unequal partners in fundamentally different organizational architectures, decision-making authorities, and control systems. Corporate procedures define the "speed limits" and rules of engagement in joint work (Moschner et al., 2019; Steiber, Alänge, 2021).

Goal Asymmetries: The above challenge is amplified by a fundamental divergence in strategic objectives. For corporations, engaging with startups often represents a peripheral initiative, designed to supplement core strategy by stimulating innovation, monitoring technological and market shifts, or exploring new growth options. In stark contrast, for startups, such collaborations are typically central to their survival and development, directly addressing

critical objectives like product validation, market entry, building credibility, and securing essential financing.

At the same time, research gaps can be noted in the literature on Corporate-Startup Engagement, which include the issues of network power asymmetry (Cook, Emerson, 1978; Gulati, Gargiulo, 1999), informational asymmetry (Bergh et al., 2019; Cimon, 2004), learning asymmetry (Cimon, 2004; Cohen, Levinthal, 1990; Hamel, 1991), and trust asymmetry (Graebner, 2009), which are studied in the broader literature on inter-organizational cooperation.

3.2. Complementarities in Corporate-Startup Engagement

In corporation-startup collaborations, established firms and entrepreneurial ventures combine different assets, organizational routines, and positions to jointly create and scale innovations that neither party could achieve alone (Dizdarevic et al., 2024; Prashantham, Kumar, 2019). In this view, complementarity arises precisely because corporations and startups are not equal: they differ in resources, capabilities, decision-making logic, and institutional context. These asymmetries can be leveraged to create novel combinations—pairing the creativity, speed, and technological novelty of startups with the scale, regulatory prowess, and market access of established firms. At the heart of this collaboration is the pursuit of **synergy**, where the combined output exceeds the sum of individual efforts (Pinnington, 2024). A review of research allows for the distinction of three primary types of complementarity:

- **Capability Complementarities:** This primarily relates to resources, functions, and knowledge. Startups typically bring breakthrough technologies, novel business models, and creativity, while corporations provide manufacturing capabilities, supply chains, regulatory expertise, brand credibility, and global channels for scaling proven concepts (Dizdarevic et al., 2024; Kohler, 2016).
- **Linkage Complementarities:** This is embedded in strategic, architectural, and inter-organizational perspectives. Corporations add value as network orchestrators by lowering search and coordination costs and providing standardized interfaces (e.g., startup programs). Startups, in turn, provide connectivity to emerging niches, user communities, and novel technological domains that established firms cannot easily access (Kager et al., 2022; Prashantham, Kumar, 2019).
- **Contextual Complementarities:** This describes the phenomenon of jointly obtaining benefits arising from geographical location or fitting into specific legal and regulatory conditions. For example, in emerging markets, corporations may fill institutional voids while benefiting from the ingenuity of local startups (Ching, Caetano, 2021; Prashantham, Kumar, 2019).

3.3. Paradoxes and Tensions in Corporate-Startup Engagement

While the study of paradoxes and tensions is well-established within the broader field of inter-organizational cooperation, research focused specifically on Corporate-Startup Engagement remains comparatively scarce. To illustrate this thesis, (Fortes et al., 2023) in a systematic literature review identified 21 types of paradoxes present in research on inter-organizational cooperation. The most comprehensive study of the subject in the context of Corporate-Startup Engagement (Dizdarevic et al., 2024) proposes focusing on four paradoxes, which are discussed below.

The **performing paradox** arises from the pursuit of competing goals and strategies by partners within the collaboration between large enterprises and startups (Dizdarevic et al., 2024). It manifests as a tension between the need to cooperate to create value and the drive to compete to capture it (Chappert et al., 2024; Dizdarevic et al., 2024). Both parties collaborate to innovate and grow, yet their individual motivations can diverge, especially regarding intellectual property (IP) and market share. This is an example of **the value creation vs. value capture paradox**, widely described in the literature on inter-organizational cooperation. It leads to **tensions along the cooperation vs. competition line**. This paradox is most visible in the tension related to the disclosure of key information (Dizdarevic et al., 2024). To enter into a partnership, a startup must disclose its innovative technology and knowledge to the corporation. However, this very act of openness creates a vulnerability to knowledge leakage and imitation, a situation often described as 'swimming with sharks' (Prashantham, Kumar, 2019; Dizdarevic et al., 2024). The corporation that has the most to offer in terms of complementary assets can also pose the greatest threat, creating a constant tension between the need for cooperation and the need to protect one's own interests (Dizdarevic et al., 2024).

The **learning paradox** refers to tensions between the past and the future, which directly relates to the widely discussed **exploitation vs. exploration tension** in management literature (Dizdarevic et al., 2024; Bagno, Salerno, de Souza Junior, O'Connor, 2020). Corporations are designed to exploit existing, proven business models, which provides them with stability and predictable profits. Their processes and resource allocation are optimized for this purpose. On the other hand, startups are exploration-oriented organizations, designed to search for new business models and drive change. This is an inherently uncertain process (Steiber, Alänge, 2020; Chappert et al., 2024). This fundamental difference creates significant tension around resource allocation. Committing corporate resources—financial capital, employee time, and management attention—to a risky, uncertain startup venture directly competes with the needs of the stable and profitable core business (Dizdarevic et al., 2024). A successful collaboration with a startup (measured by project development progress) may require increasing resources, which can be perceived as a threat to other internal business units (Dizdarevic et al., 2024, Chesbrough, 2000). This forces corporations to constantly balance the stability of today with the uncertain changes of tomorrow.

The **belonging paradox** manifests in cultural tensions. These concern the inter-organizational line between the corporation and the startup, but can also occur within large organizations (Dizdarevic et al., 2024). In Corporate-Startup Engagement, both partners have distinctly different identities: the corporate model, focused on scale, efficiency, planning, and control, versus the entrepreneurial model, which champions creativity, speed, and innovation (Dizdarevic et al., 2024; Freeman, Engel, 2007). This leads to the emergence of **tensions on the creativity vs. control lines**. The discipline, coordination, and planning necessary for corporate operations are often contrary to the conditions that foster creativity and innovation (Dizdarevic et al., 2024). The situation is further complicated by the "not invented here" syndrome. Within this phenomenon, corporate employees show a negative attitude towards accepting external knowledge, perceiving it as a threat to their own status or competence (Collaboration between Start-Ups and Corporates, 2018; Dizdarevic et al., 2024). Effectively creating a common, collaborative identity requires managing the inherent tension between the startup's need for creative freedom and the corporation's drive for control and adherence to procedures.

The **organizing paradox** results from the tension between competing organizational processes and structures (Dizdarevic et al., 2024). Corporations require alignment, structure, and predictability to manage complexity and ensure consistency across business units. Their procurement, legal, and IT processes are designed for stability and control. In contrast, startups thrive on flexibility and adaptability, allowing them to quickly change direction in response to market signals (Chappert et al., 2024; Kager et al., 2022). This paradox creates **tensions on the agility vs. embeddedness line** (Chappert et al., 2024). The agile and fast-paced operation of a startup clashes with slow, entrenched, and often cumbersome corporate processes (Kohler, 2016). This is acutely felt during procurement and contracting processes, where corporate legal and procurement departments, unaccustomed to the startup's pace, can cause significant delays that threaten the startup's cash flow and survival (Chappert et al., 2024; Collaboration between Start-Ups and Corporates, 2018). The need to integrate an external, flexible entity with a highly structured internal system is a constant organizational challenge, requiring a delicate balance between alignment and adaptability.

Based on this review, the study argues that four key dimensions could explain the dynamics of the corporate-startup relationship, which allows us to formulate a conceptual model of the dynamics of Corporate-Startup Engagement.

4. A Model Proposal

The preceding review provides the basis for a conceptual model that organizes the dynamics of Corporate-Startup Engagement through the interconnected dimensions of asymmetry, complementarity, paradoxes and tensions (Fig. 2).

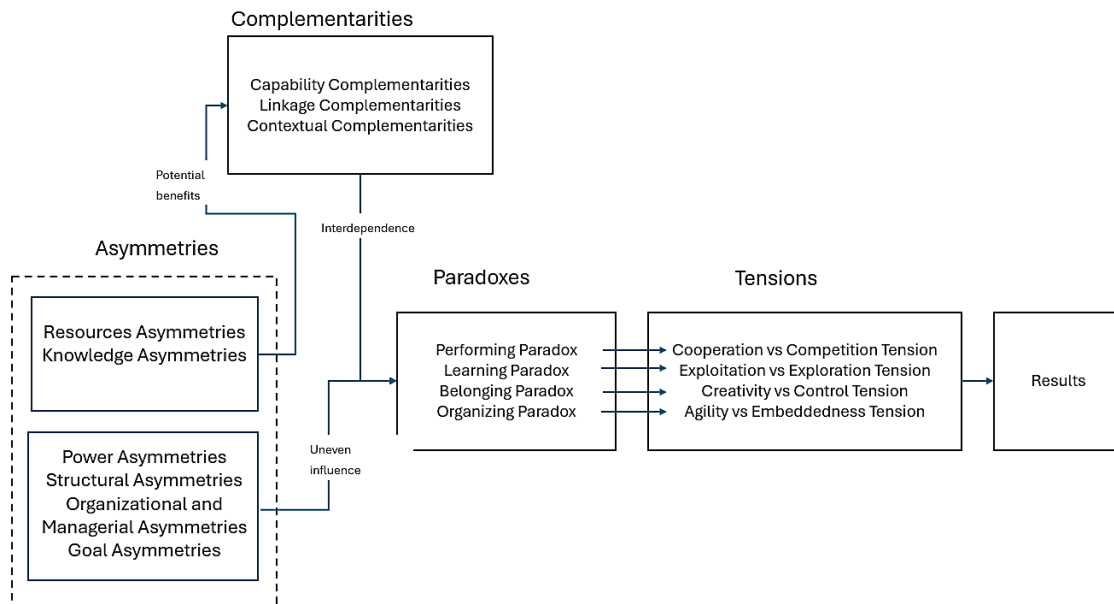


Figure 2. Schematic model of the dynamics of the Corporate-Startup Engagement.

Source: own elaboration.

The asymmetries inherent in Corporate-Startup Engagement are foundational, shaping the collaborative dynamics in two distinct ways. Firstly, asymmetries in resources and knowledge create a potential for mutual benefit, which is realized when organizational efforts harness complementarities in capabilities, linkages, and context to foster interdependence. Second, asymmetries of power, structure and management, and goal create an unequal distribution of influence and bargaining power.

This power imbalance, typically reinforced by the corporation's superior resources, places corporations in a privileged position. However, knowledge asymmetry can act as a significant counterweight, particularly in the early stages of a partnership. When a startup possesses unique, well-protected technology, it can shift the locus of influence in its favor, a dynamic that often diminishes as the focus moves from technological innovation to commercialization, where corporate strengths become more critical.

The convergence of this interdependence and unequal influence gives rise to inherent paradoxes. Under specific conditions, these paradoxes manifest as tangible tensions that directly impact the collaboration's outcomes. The performing paradox ignites the tension between cooperation and competition. The learning paradox creates a conflict between the exploitation of existing knowledge and the exploration of new frontiers. The belonging

paradox pits the corporate need for control against the entrepreneurial drive for creativity. Finally, the organizing paradox highlights the fundamental clash between corporate rigidity and startup agility, resulting in the tension between embeddedness and adaptability.

5. Conclusions and Future Research Directions

This paper, through a narrative literature review, proposes a coherent model for organizing the complexity inherent in Corporate-Startup Engagement. The model posits that asymmetry is the primary driver of this complexity. It reframes the resulting tensions—often characterized in the literature as sources of cognitive and emotional stress that can derail partnerships—as fundamental decision-making dilemmas. The challenge of navigating these dilemmas stems from the interdependence forged between the partners, with the dynamics of resolution being shaped by the prevailing balance of influence.

A key implication of this model is that the effective management of these relationships hinges on a deep understanding of the specific asymmetries at play. The selection of formal tools (i.e. Corporate-Startup Engagement modes) and management practices must be tailored to this understanding. Consequently, decision-making frameworks, particularly those governing resource allocation and value distribution, must be built on clear, transparent principles agreed upon at the outset of the partnership.

The proposed model and its underlying principles offer a robust foundation for future empirical research. Initial inquiries should focus on validating the model, for instance, by examining the relation between partners' awareness of asymmetries and collaboration outcomes. Further research should address the optimal alignment of management practices and formal tools with specific asymmetry profiles. From a theoretical standpoint, ongoing work is needed to refine and expand the model, potentially by incorporating additional variables and further elucidating the causal links between its components.

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APPRECIATIVE INQUIRY AND THE ENGAGEMENT OF LOCAL GOVERNMENT EMPLOYEES: A CASE STUDY

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Purpose: The aim of this article is to identify and evaluate the impact of the Appreciative Inquiry (AI) approach on the level of engagement among local government employees. The study focused on a municipal office in the Silesian Province, which enabled an empirical analysis of AI application in the specific context of the public sector.

Design/methodology/approach: The research was conducted as a case study using a quantitative method – a questionnaire survey addressed to employees of 12 departments of the municipal office. Statistical analyses included non-parametric tests and correlation coefficients.

Findings: The results confirmed the main research hypothesis – the AI approach positively influences employee engagement, particularly through practices based on appreciation and positive feedback. Respondents identified recognition from supervisors, remuneration, and job security as the most important motivational factors. The frequency of receiving positive feedback was significantly correlated with the declared level of engagement.

Research limitations/implications: The main limitation of the study is its cross-sectional nature and the use of a single case study, which hinders the generalisation of results. Future research should include longitudinal studies and methodological triangulation with the use of in-depth interviews.

Practical implications: The findings may provide a basis for incorporating elements of AI into HR procedures in local government administration, thereby contributing to the development of a culture of appreciation and enhancing the attractiveness of the municipal office as a workplace.

Social implications: The application of AI in local government administration may foster the creation of a climate of trust, shared responsibility, and openness, which translates into the quality of public services provided and increased citizen trust in local government institutions.

Originality/value: This article contributes to the literature on public sector management by demonstrating both the potential and the limitations of AI in local government administration. It provides an empirical addition to existing knowledge as well as practical recommendations for local government managers.

Keywords: appreciative inquiry (AI), change management, employee engagement, local government administration, case study.

Category of the paper: Research paper.

1. Introduction

Contemporary local government offices operate in an environment of growing citizen expectations, frequent regulatory and legal changes, and pressure for efficiency and transparency. In such an environment, employee engagement, understood as a lasting and positive connection to work, becomes crucial. At the same time, the public sector faces specific challenges. These include a high level of formalisation of processes, rigid procedures and a multi-level hierarchy. This makes developmental approaches, which strengthen employees' internal motivation and have a positive impact on the quality of team relations without the need for costly systemic changes, increasingly important.

One such approach is the appreciative inquiry (AI), which assumes that organisations develop most effectively by identifying and strengthening what is most valuable in their functioning. AI emphasises dialogue, discovering strengths, positive feedback and co-creating the desired future of the organisation. In the logic of human resource management in the public sector, this translates into building a climate of recognition, deepening cooperation and increasing the sense of agency among employees, which is linked to higher levels of engagement and better quality public services.

However, the application of AI in local government administration faces constraints resulting from the nature of public organisations: strong regulation, accountability to external stakeholders and the need to remain impartial. In this context, it is particularly important to understand which elements of AI (e.g. recognition, positive feedback, partnership dialogue, co-creation of a vision) actually support employee engagement in the reality of a city council, and what role leadership and organisational climate play in this. Despite growing interest in the appreciative inquiry approach in public sector management research, there is still a lack of in-depth empirical analyses of its practical impact on the engagement of local government employees in Poland. Most of the studies to date have focused on commercial organisations or educational institutions, while local government offices remain largely outside the scope of quantitative research. There is also a lack of studies that systematically analyse the relationship between the implementation of AI principles and changes in the attitudes and behaviours of public sector employees. Filling this gap is the main motivation for undertaking this study.

The aim of this article is to identify and assess the impact of the appreciative inquiry (AI) approach on the level of engagement of local government employees, using a single case study of a city council in the Silesian Province. The article makes an empirical contribution to the literature on public sector management by providing data from a quantitative study covering functionally diverse departments of the office. It also has a practical dimension: it identifies areas where AI-inspired implementations can have the greatest impact, both at the individual level (motivation, sense of influence) and at the team level (climate of cooperation, quality of relationships).

Referring to the practical implications of the topic, it can be pointed out that the appreciative inquiry (AI) approach can be a useful tool supporting both department managers and HR staff. In the former case, it can contribute to the development of a leadership style based on trust, recognition and cooperation. In the latter case, it can have an engaging effect on the atmosphere of staff meetings, reinforce regular positive feedback and promote a communication style based on appreciation. The practical potential of the appreciative inquiry (AI) concept can be seen in the increased number of training courses on motivation and interpersonal and team communication. In a broader perspective, the principles of the concept in question can also be applied in participatory processes with city residents. Examples include public consultations or the development of city development strategies. Joint discovery of the strengths of the local community allows for a better understanding of citizens' needs and their involvement in the process of co-creating public policies.

In light of the above assumptions, the research problem of this study can be formulated as follows: What is the impact of the appreciative inquiry approach on the level of engagement of city hall employees? This problem gives rise to the following research questions: (1) what is the relationship between the perception of the appreciative inquiry (AI) approach and the level of professional engagement of city hall employees; (2) Which components of the appreciative inquiry (AI) approach are considered by city hall employees to be the most motivating and supportive of their professional engagement? (3) How do management actions consistent with the appreciative inquiry (AI) approach influence the organisational climate and the quality of team relations? Based on a review of the literature, research hypotheses were also formulated – main and detailed: MH – Appreciative inquiry has a positive and significant impact on the level of commitment of city hall employees; SH1 – There is a statistically significant positive relationship between the perception of the appreciative approach (AI) and the level of professional engagement of city hall employees; SH2 – City hall employees consider positive feedback, recognition of achievements and the opportunity to co-create the organisation's vision to be the most motivating and supportive of professional engagement; SH3 – Management actions in line with the appreciative inquiry (AI) approach have a positive impact on shaping the organisational climate and improving the quality of team relations.

The article has been divided into several parts. The second chapter, following the introduction, presents an overview of the theoretical assumptions covering the basics of the appreciative inquiry (AI) approach and its potential applications in local government administration. The third chapter presents the methodological basis of the study, including the rationale for a single-case study, a description of the sample selection and the socio-demographic profile of the respondents. It is also noted here that the study was quantitative in nature and that a questionnaire was used as the research tool. Chapter 4 presents the results of a study conducted in August 2025 among employees of one of the city offices in the Silesian Province, which was the case study. The fifth and final chapter presents a discussion of the results in the light of the literature and conclusions, including the verification of research hypotheses and implications resulting from the adopted case study perspective.

2. Literature review

The concept of Appreciative Inquiry (AI) was developed in the 1980s in the United States by David Cooperrider and Suresh Srivastva from Case Western Reserve University (Cooperrider, Srivastva, 1987). This approach originated in management sciences, in particular in research on organisational change (Cooperrider, Srivastva, 1987; Bushe, 2011; Cooperrider, Whitney, Stavros, 2008). Epistemologically, it derives from social constructivism (Berger, Luckmann, 1966) and generative theory (Gergen, 1994), and methodologically, it is rooted in participatory action research (Reason, Bradbury, 2008).

Appreciative inquiry (AI), strongly associated with positive organisational scholarship (Cameron, Dutton, Quinn, 2003), is an approach to diagnosing and implementing organisational change that shifts the focus from deficiencies to identifying and developing existing resources, strengths and factors that sustain the well-being and effectiveness of social systems (Cooperrider, Whitney, 2005). Its origins are linked to criticism of the problem-solution paradigm that dominates organisational scholarship, both in research and in organisational development practice, and to the call for the creation of theories that inspire new organisational areas and practices (Cooperrider, Srivastva, 1987).

When attempting to break down the meaning of this concept, it can be pointed out that 'appreciate' is defined as the ability and act of recognising the best qualities in people and the surrounding reality, as well as affirming successes. In turn, 'discourse' ('inquire') is understood as exploration and discovery combined with the art of asking questions and demonstrating an attitude of openness to recognising potential, strengths and opportunities (Cooperrider, Whitney, 2005, p. 7). The appreciative inquiry (AI) approach can therefore be described as a method of researching and reflecting on change in social systems (groups, organisations, communities) that encourages joint discovery of what works best in order to imagine a desirable future on this basis and design it in such a way that the changes are attractive enough that they do not require coercion to implement them (Bushe, 2013).

The appreciative discourse perspective reverses the classic approach: it assumes that the organisation itself is a value and contains resources, strengths and past successes that are worth extracting, appreciating and developing. In this approach, the organisation is primarily a solution that needs to be strengthened, rather than a problem to be fixed (Cooperrider, Whitney, Stavros, 2008). Appreciative discourse sees performance as a 'glass half full,' filled with proven practices, rather than a space to be filled with improvements (Lewis, Van Tiem, 2014, p. 19).

A key element of AI is the organisation's 'positive core' of an organisation, comprising key strengths: achievements and capabilities, innovations, technical and financial resources, collective wisdom and best practices, leadership, values and relationships, social capital, and a vision of the desired future (Cooperrider, Whitney, 2005). The above assumptions form

the foundation of the 4D model, which is at the core of appreciative inquiry (AI) (Cooperrider, Srivastva, 1987). In practice, the process begins with the Discovery phase, which involves the entire system (rank-and-file employees, managers, external stakeholders) being engaged in the process of identifying the best experiences, successes and areas of strength within the organisation. At this stage, participants identify the elements that work most efficiently and search for the 'positive core' of the organisation, i.e. the element that decisively gives it life and energy (Cooperrider, Whitney, Stavros, 2008). The second phase of the cycle is Dream, during which participants jointly build a picture of the desired future. This involves imagining how the identified potential can strengthen the organisation's strengths and guide its further development in the future. The result is inspiring but realistic images of the organisation's near future (Cooperrider, Whitney, 2005). The third phase, Design, is the stage at which the vision from the previous Dream phase is translated into practical action, i.e. specific organisational solutions, processes and roles that will enable the dreams to come true. Participants focus on developing new or improved systems and structures, as well as implementation plans and measures of success (Cooperrider, Whitney, Stavros, 2008). And the fourth and final phase, Destiny, which involves implementing the designed changes in the organisation and includes launching initiatives, gradually consolidating them and learning on an ongoing basis so that the new way of operating becomes a permanent practice. In this phase, it is important to expand responsibility, track progress, and reinforce what works, so that the organisation is, in a sense, rebuilt based on the results achieved (Cooperrider, Whitney, 2005).

The positive core of the organisation is created in stages throughout the 4D cycle: discovered, mobilised, designed and finally implemented (Cooperrider, Whitney, Stavros, 2008).

Classic approaches to AI combine five related principles that organise thinking and practice (Cooperrider, Whitney, Stavros, 2008; Watkins, Mohr, Kelly, 2011). The first, the Constructionist Principle, assumes that organisations are created through conversations. This means that language not only describes but also co-constructs organisational reality. The second principle, the Principle of Simultaneity, states that change begins when a question is asked, i.e. the very act of inquiry is an intervention. The third principle, the Poetic Principle, emphasises that organisations are like 'open books' that can be read and whose reality can be co-created by choosing topics of conversation. The fourth principle, the anticipatory principle, states that images of the future trigger present actions, i.e. they influence actions taken here and now. This means that the process of creating a positive vision by an organisation inspires actions aimed at its actual implementation. The fifth and final principle, the Positive Principle, emphasises that reinforcing emotions and narratives foster the co-creation of energy for action (whereby the aforementioned 'positivity' refers to direction and generativity, not avoidance of difficult topics) (Cooperrider, Whitney, Stavros, 2008; Barret, Fry, 2005).

In their book *The Power of Appreciative Inquiry*, the authors expand the catalogue of AI principles with three rules that facilitate understanding and implementation of the approach in various organisational contexts (Whitney, Trosten-Bloom, 2010). *The Wholeness Principle* emphasises a holistic view of the system and the participation of the entire organisational community in change (Whitney, Trosten-Bloom, 2010, p. 66). *The Enactment Principle* emphasises that change begins 'here and now' when people act in accordance with the desired vision and values (Whitney, Trosten-Bloom, 2010, p. 68; Bushe, 2011). *The Free-Choice Principle* assumes that freedom of participation and choice of action strengthens responsibility and individual commitment (Whitney, Trosten-Bloom, 2010, p. 71; Watkins, Mohr, Kelly, 2011). These principles are applied not only in business, but also in the public sector, healthcare and education, where they support broad stakeholder engagement and the implementation of generative solutions (Bushe, 2011; Watkins, Mohr, Kelly, 2011).

One of the most important advantages of the appreciative approach is its ability to bring out and mobilise positive energy in organisations. It is emphasised that focusing on what works well helps to strengthen the sense of meaning in work, shared responsibility and employee engagement (Cooperrider, Whitney, 2005; Cameron, Dutton, Quinn, 2003). It is worth mentioning here the connection between appreciative inquiry and theories of employee engagement, which define the psychological basis of the bond between the individual and the organisation. The point of reference in this regard is W. Kahn's (1990) concept of engagement, which he defines as full involvement in one's professional role in cognitive, emotional and physical terms. Commitment is treated here as the result of a sense of security, significance and accessibility, i.e. components that can be successfully reinforced by appreciative practices. It is also pointed out that professional commitment is shaped as a result of social exchange between the employee and the organisation (Saks, 2006). In this respect, appreciation can play a significant role in strengthening this relationship. Furthermore, Schaufeli and Bakker's (2004) Job Demands-Resources (JD-R) model indicates that access to organisational resources promotes higher levels of engagement, while appreciation practices can be interpreted as tools for strengthening key employee resources, leading to the development of engagement. The integration of the AI approach with classical engagement theories thus allows for the construction of a coherent theoretical framework that combines positive organisational transformation with psychological mechanisms that promote sustainable employee engagement.

The concept of appreciative inquiry (AI) creates a basis for breaking out of routine thinking and opening up to dialogue, which in turn increases trust and builds an organisational climate conducive to innovation and change implementation (Bushe, 2013). This is particularly important in times of dynamic and unpredictable socio-economic change, when organisations and public institutions need flexible tools to support adaptability, creativity and shared responsibility for the transformation process (Bushe, 2013; Cameron, Spreitzer, 2012).

Another advantage of appreciative inquiry (AI) is its participatory and inclusive nature. Unlike traditional models of organisational diagnosis, which are often based on deficit analysis and hierarchical decision-making, AI involves a wide range of stakeholders in the process of co-creating a vision and designing change (Whitney, Trosten-Bloom, 2010). As a result, organisations not only strengthen their resources, but also develop a culture of cooperation and shared responsibility, which translates into lasting effects. In public and local government administration, this means greater involvement of both civil servants and local communities in decision-making processes, which supports the democratisation of management and increases the legitimacy of actions (Mahroof et al., 2025). This approach also has beneficial effects in other sectors. Examples include military training (Wójcik-Chodorowska, 2025), social assistance (Młyński et al., 2024) and nursing homes (Dal Corso, 2021), healthcare (May et al., 2011) and parental coaching (DeGaetano, 2011). These examples show that AI can be an effective tool not only in managing commercial organisations, but also in a broader social context, where it promotes the development of shared visions of the future. From the perspective of this article, the most interesting area of application for appreciative inquiry (AI) is local government administration, where this approach focuses on involving not only civil servants but also residents of a given city in the processes of co-creating public services and strategic planning at the municipal level. It is pointed out here that AI can increase public trust and the quality of civic dialogue, especially at the local level, where the proximity of problems facilitates the identification of the positive core of the community and its translation into action (Schooley, 2012; Whitney, Trosten-Bloom, 2010). Institutional guidelines for the public sector recommend AI as a participatory procedure for visualising the desired future and designing solutions with residents, rather than ‘for’ residents (U.S. EPA, 2025). At the level of urban practice, a classic example is the ‘Focus on Longmont’ process, in which the city of Longmont (USA) used appreciative inquiry (AI) to work on a strategic plan and engage stakeholders—civil servants, non-governmental organisations, and residents. City documents and studies on this process point to the development of a shared vision and the translation of conclusions from the dialogue into specific public policy priorities (City of Longmont, 2024a, 2024b).

The prospects for further development of AI are linked to its adaptation to contemporary organisational challenges, such as globalisation, digitalisation and sustainable development. Increasing attention is being paid to the possibility of integrating AI with other approaches to change management, such as complexity theory or dialogic practices in organisations (Bushe, Marshak, 2015). Such combinations can foster the creation of more sustainable and inclusive forms of organisational development that respond to dynamic and uncertain environmental conditions.

The appreciative inquiry (AI) approach, although highly regarded and widely applicable, is not without its limitations. One of these is the risk of overemphasising positive elements while overlooking key problems such as inequalities or conflicts, which can lead to overly superficial diagnoses or misguided decisions (Grant, Humphries, 2006). For this reason, there

is a growing emphasis on the need to combine appreciation with a constructive approach to problems in order to ensure a balance between optimism and realism (Cockell, McArthur-Blair, 2012). Applying this approach in practice also requires sufficient time and a high level of competence on the part of those responsible for transformation processes (Bushe, 2013). In the case of local government administration, the implementation of an appreciative inquiry (AI) approach may also be threatened by the neglect of dialogue practices and implementation mechanisms embedded in the public policy cycle (Schooley, 2012; Bushe, Marshak, 2015). Nevertheless, in light of the perspectives presented, the concept of appreciative discourse seems to have more strengths than weaknesses, especially when treated as an integrated perspective of positive organisational communication. It offers more than just a tool for motivation or strengthening commitment – it proposes an innovative shift in the cognitive paradigm, thus constituting a significant novelty in thinking about change.

3. Methodology

The results presented in this article refer to research conducted in August 2025 among employees of one of the municipal offices in the Silesian Province. The main objective (MO) of the research was to identify and assess the impact of Appreciative Inquiry on the level of engagement of municipal office employees. In order to achieve this objective, several specific objectives were set:

- SO1: To examine the relationship between the perception of Appreciative Inquiry (AI) and the level of work engagement among municipal office employees.
- SO2: To identify the components of the Appreciative Inquiry (AI) approach that municipal office employees consider most motivating and supportive of their professional engagement.
- SO3: To assess the impact of management actions consistent with the Appreciative Inquiry (AI) approach on shaping the organisational climate and the quality of team relationships.

In order to achieve the indicated objectives, the main research question (MRQ) was formulated as follows: *What is the impact of Appreciative Inquiry on the level of engagement of municipal office employees?* Specific research questions were also presented:

- SQ1: What is the relationship between the perception of Appreciative Inquiry (AI) and the level of professional engagement of municipal office employees?
- SQ2: Which components of the Appreciative Inquiry (AI) approach are considered by municipal office employees to be the most motivating and supportive of their professional engagement?
- SQ3: How do management actions consistent with the Appreciative Inquiry (AI) approach influence the organisational climate and the quality of team relations?

Research hypotheses were formulated for the research questions: a main hypothesis and detailed hypotheses. MH: The Appreciative Inquiry (AI) approach has a positive and significant impact on the level of commitment of municipal office employees. The detailed hypotheses were as follows:

- SH1: There is a statistically significant positive correlation between the perception of the Appreciative Inquiry (AI) approach and the level of professional commitment of municipal office employees.
- SH2: Municipal office employees consider positive feedback, recognition of achievements and the opportunity to co-create the organisation's vision to be the most motivating and supportive of professional engagement (statistically more often than other components).
- SH3: Management actions consistent with the Appreciative Inquiry (AI) approach have a positive impact on shaping the organisational climate and improving the quality of team relations.

The study was a single-case study conducted at a municipal office in the Silesian Province. The case was selected as typical for a medium-sized local government administration characterised by a high degree of functional heterogeneity, which allowed for capturing diverse organisational practices and working conditions. The study used a quantitative method, employing a survey technique. The research tool was an original questionnaire, which was made available to the respondents in paper form. Respondents were informed that participation in the study was voluntary. The questionnaire was anonymous and consisted of 12 closed questions – single and multiple choice – and a personal data form.

The choice of a local government unit located in the Silesian Province was justified. It should be noted that this region is characterised by significant social and economic diversity and developmental transformation. Local government administration in such areas faces challenges in terms of economic restructuring, demographic changes and the ever-growing expectations of public service beneficiaries. In this context, it seems interesting to analyse appreciation practices that can support employee engagement and the effectiveness of public institutions operating in conditions of high dynamic change.

The sample selection in the conducted research was non-probabilistic and was carried out in two stages. In the first stage, purposive sampling was used, covering 12 selected departments of the municipal office. The criteria for their selection were the size of the department (the units with the largest number of employees were selected) and the diversity of the employees' competences (departments with different task profiles were taken into account). In the second stage, questionnaires were distributed to all persons working in the selected departments. Participation in the survey was entirely voluntary – all employees were informed that participation in the survey was voluntary. The final sample was therefore shaped by the decisions of those who expressed a willingness to participate, which methodologically means the use of self-selection sampling.

The sampling method used has both strengths and methodological limitations. Purposeful sampling in the first stage enabled the selection of departments relevant to the research topic, which allowed us to capture the internal diversity of the organisation. However, it should be noted that the researcher's determination of selection criteria is subjective and may limit the possibility of fully generalising the results to all departments of the surveyed municipal office. On the other hand, the voluntary selection used in the second stage ensured that the respondents' participation was completely voluntary and anonymous, which is a significant advantage from the point of view of research ethics. At the same time, such selection reduces the representativeness of the sample and creates the risk that the results obtained may reflect the attitudes of people who are more open, motivated and willing to cooperate than the entire population of the departments surveyed.

When analysing the profile of the people who took part in the study, it should be noted that the largest percentage of the research sample were women (60.1%), people aged 36-45 (44.8%), with 6 to 10 years of service in the municipal office under study (54.6%), and those holding middle-level civil service positions (89.6%). Detailed breakdowns are presented in Table 1.

Table 1.

Sociodemographic profile of respondents (data in numbers and %) (N = 163)

Sociodemographic information		N	%
Gender	Female	98	60.1
	Male	65	39.9
	Other	0	0.0
Age	Up to 25 years old	4	2.5
	26-35 years old	21	12.9
	36-45 years old	89	54.6
	46-55 years old	31	19.0
	Over 55 years old	18	11.0
Length of service in the current office	Less than 1 year	5	3.1
	1-5 years	23	14.1
	6-10 years	73	44.8
	11-20 years	45	27.6
	Over 20 years	17	10.4
Position held	Support position	2	1.2
	Mid-level administrative position	146	89.6
	Senior administrative position (managerial)	15	9.2
	Other – what?	0	0.0
Overall		163	100.0

Source: own study.

The calculations were performed using SPSS Statistics 26 software, while the statistical tests used were Pearson's chi-square independence test and other non-parametric tests: Mann-Whitney U, Kruskal-Wallis H, post-hoc test: Dunn with Holm correction, and Spearman's rank correlation coefficient (rhoSpearman). Relationships with a significance level of less than 0.05 were considered statistically significant.

4. Results

This chapter presents the results of research on the functioning of employees of a selected local government unit and the relationship between socio-demographic characteristics and the perception of the analysed phenomena.

The first question of the survey included four statements about working in the city hall, rated by respondents on a five-point Likert scale.

The first statement referred to the respondents' opinions on their superiors' perception of their strengths. The results show that, regardless of gender, the respondents rated this statement highly (70.4% of women and 87.7% of men).

The second statement examined the phenomenon of the so-called positive feedback culture in the institution. In this case, there are also no differences in the choices between women and men. High ratings dominate in both groups (86.5% on average). However, the situation is different with regard to age. The Kruskal-Wallis ANOVA statistical test showed that there is a significant correlation between the age of the respondents and the degree to which they believe a culture of positive feedback exists in their workplace ($H(6) = 13.706$, $df = 4$, $p = 0.008$). The value of the coefficient $\epsilon^2 = 0.061$ indicates that approximately 6.1% of the variability in the results can be attributed to differences between groups, which means a moderate effect size. The value of the coefficient $\epsilon^2 = 0.061$ indicates that approximately 6.1% of the variability in the results can be attributed to differences between groups, which means a moderate effect size. The detailed results are presented in Figure 1.

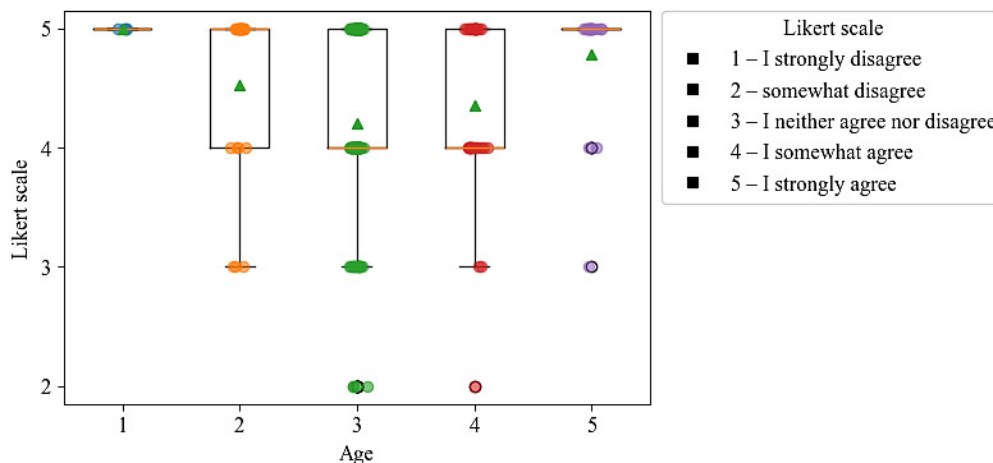


Figure 1. Assessment of the culture of positive feedback depending on the respondents' age.

Source: own study.

To determine which groups differed from one another, additional post-hoc tests were conducted: Dunn's test with Holm correction, which indicated significantly higher scores among individuals aged over 55 compared with those in the 36-45 age group ($p_{adj} = 0.029$, $\delta = -0.398$). The value of Cliff's delta coefficient ($\delta = -0.398$) indicates the moderate strength

of this effect. At the same time, no significant differences were identified between the other age groups. Detailed results are presented in Figure 2.

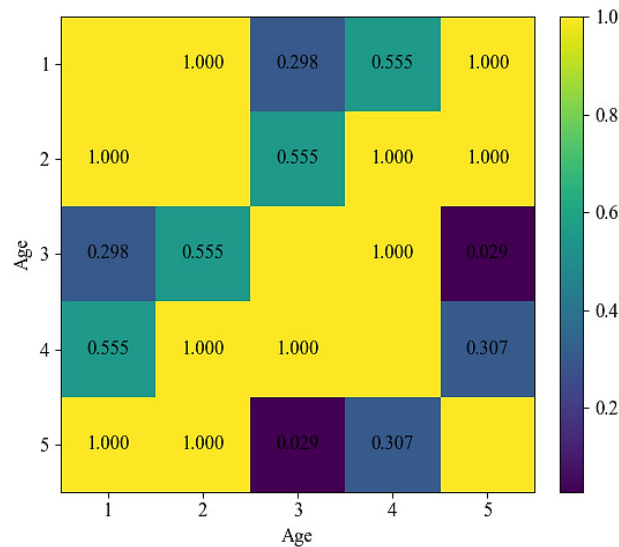


Figure 2. Assessment of the culture of positive feedback depending on respondents' age with consideration of intergroup differences.

Source: own study.

With regard to length of service, ratings at the upper end of the scale (4 or 5) accounted for an average of 87.3% in each group.

The third statement concerned the consideration of employees' opinions in the process of implementing changes. In this case as well, no differences were identified in relation to gender or job position, but a statistically significant association was found with respect to the age of respondents ($H = 18.66$, $df = 4$, $p = 0.0001$). The ϵ^2 coefficient was 0.093, which means that approximately 9.3% of the variability in results can be attributed to differences between groups, indicating a moderate effect size. Detailed results are presented in Figure 3.

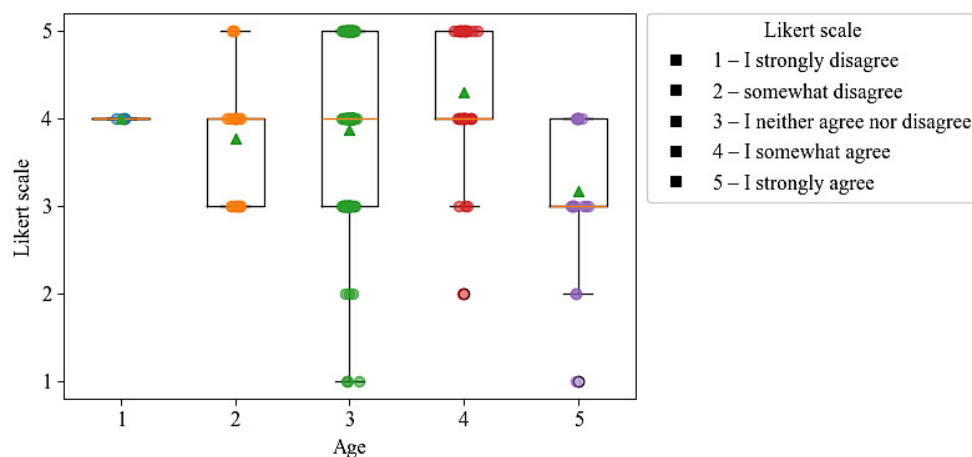


Figure 3. Assessment of the consideration of employees' opinions in the change implementation process depending on respondents' age.

Source: own study.

Based on post-hoc tests (Dunn's test with Holm correction), significantly higher scores were observed among respondents aged 36-45 compared with those aged over 55 ($p_{adj} = 0.023$, $\delta = 0.415$). A significant result was also recorded in relation to length of employment ($H = 27.48$, $df = 4$, $p = 0.000$). Employees with 11-20 years of service rated the consideration of their opinions in the process of implementing changes more highly (84.4%) than those with 6-10 years of service (63.0%) ($p_{adj} = 0.000$; $\delta = -0.25$) and those with more than 20 years of service (41.2%) ($p_{adj} = 0.000$; $\delta = 0.661$).

The final statement from the first question concerned the assessment of the work environment in terms of opportunities for personal development. Here as well, age proved to be a significant factor ($H = 10.81$, $df = 4$, $p = 0.03$). Approximately 3.0% of the variance in results can be explained by differences between the groups studied, indicating a weak effect size. It was shown that respondents in the 46-55 age group rated developmental opportunities in the workplace more highly than those aged over 55 ($p_{adj} = 0.021$, $\delta = 0.437$). The value of Cliff's delta ($\delta = 0.437$) indicates a correlation strength close to strong. Detailed results are presented in Figure 4.

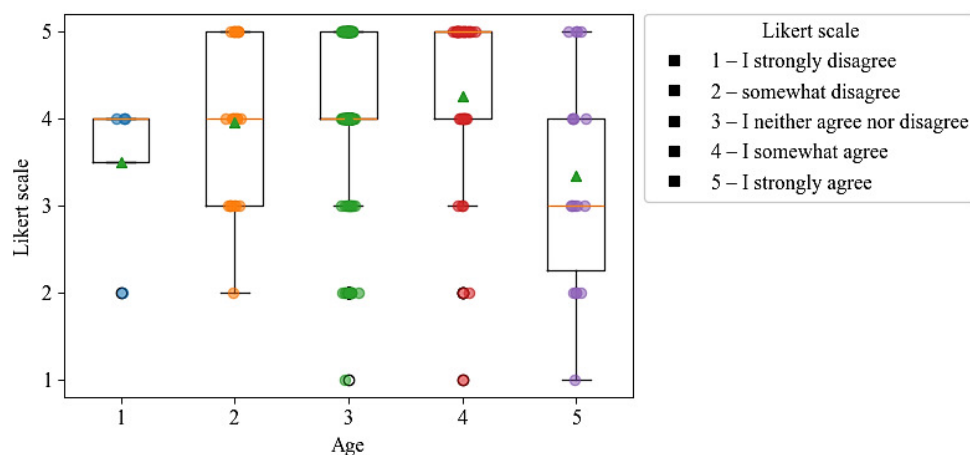


Figure 4. Assessment of the work environment in terms of supporting personal development depending on respondents' age.

Source: own study.

Interesting conclusions are also provided by the analysis in terms of length of service, where, similar to the previous issue ($H = 24.41$, $df = 4$, $p = 0.00$), employees with 11-20 years of service recorded significantly higher scores than those with 6-10 years of service ($p_{adj} = 0.000$ $\delta = -0.200$) and those with more than 20 years of service ($p_{adj} = 0.004$ $\delta = 0.437$).

In the analysis of the first question, the highest ratings were observed among men in middle-level clerical positions aged 36-45 with 6-10 years of professional experience (24 respondents; 14.4%) and women with analogous demographic characteristics (22 respondents; 13.5%). Attention should also be drawn to the group of respondents who did not award any of the highest scores – these were most often women and men in middle-level positions, aged over 55 and with more than 20 years of service, as well as women with less than one year of experience.

The second question of the questionnaire concerned the declared level of employee engagement in the performance of current duties. Ratings were given on a 10-point scale, where 0 indicated no engagement and 10 indicated full engagement. Analysis using the Mann-Whitney U test showed that women significantly more often than men reported a higher level of engagement ($U = 3943$, $p = 0.0071$). The value of the effect size coefficient ($r = 0.238$) indicates a moderate strength of association, which means that the differences between the groups are significant but of low practical importance. Detailed results are presented in Figure 5.

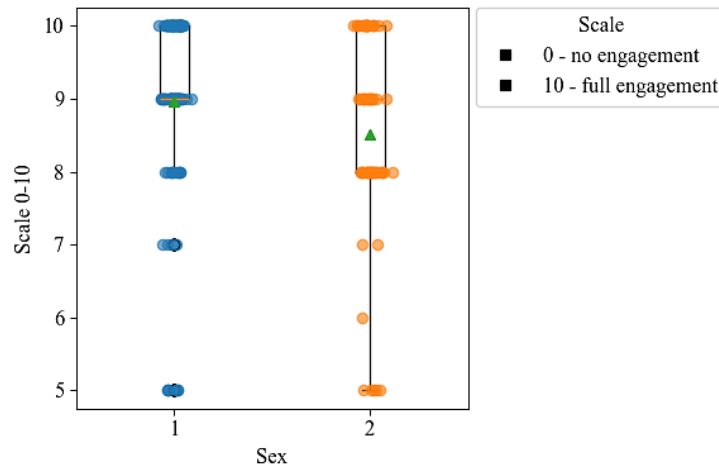


Figure 5. Level of employee engagement in performing current duties depending on the sex of respondents.

Source: own study.

Taking into account the age of employees, the results were also statistically significant ($H = 12.51$, $df = 4$, $p = 0.014$, $\epsilon^2 = 0.054$). Approximately 5.4% of the variance in results can be explained by differences between the groups studied, indicating a moderate effect size. The highest values concerned individuals in the 36-45 and 46-55 age groups. Detailed results are presented in Figure 6.

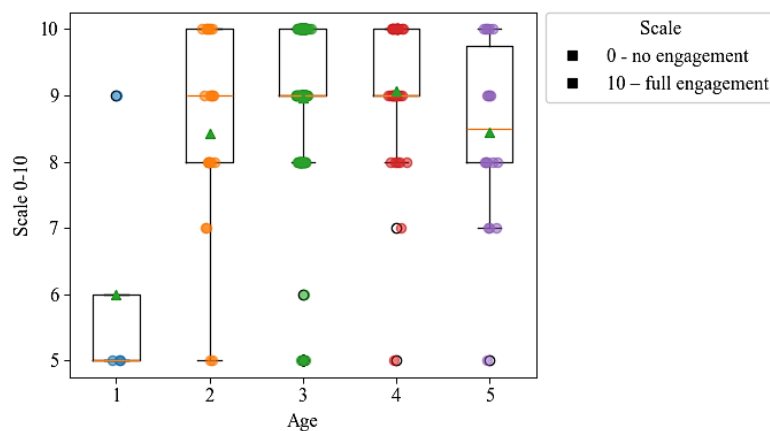


Figure 6. Level of employee engagement in performing their current duties depending on the age of respondents.

Source: own study.

In summary, it can be observed that the highest level of work engagement was declared by women in middle-level clerical positions, aged between 36 and 45, with 6-10 years of professional experience (20.9%), as well as by men with the same sociodemographic profile (16.0%).

The next issue addressed in the study concerned employees' sense of appreciation by their supervisors. Regardless of sex, respondents most frequently selected the response "I do not know" (68.4% of women; 61.5% of men). Detailed results are presented in Figure 7.

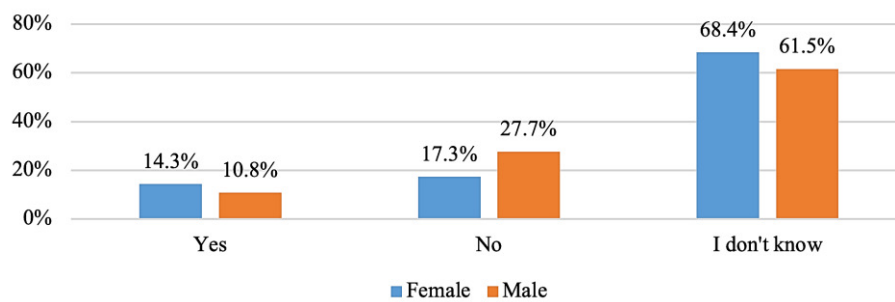


Figure 7. Perceived appreciation from the supervisor by respondents' sex.

Source: own study.

Taking into account the distribution of responses by age, it can be observed that lower ratings were declared by individuals aged between 26 and 55 (on average 12.1%).

In the subsequent part of the questionnaire, respondents were asked to determine the frequency of three types of workplace behaviours: receiving positive feedback from a supervisor, engaging in conversations about the team's strengths, and participating in meetings concerning good practices and successes. Ratings were provided on a five-point scale. Analysis of the first statement showed that in both sex groups a high proportion of respondents indicated the options *Often* or *Very often* (83.4% of women; 81.6% of men). The second item revealed that 85.1% of women and 87.8% of men considered that conversations about the team's strengths occur *Often* or *Very often* within the institution. Interesting observations also emerged from the statement concerning participation in meetings where good practices and successes are discussed. In this case, more than half of women (55.8%) and nearly half of men (44.2%) selected the response *Sometimes*.

At the stage of the fifth question, respondents assessed the impact of appreciation and positive feedback on their motivation to work, using a five-point response scale. The results indicate that positive options (*Definitely yes* and *Rather yes*) were chosen by as many as 90.8% of women and 95.4% of men. The strongest increase in motivation was declared by individuals aged 36-45, with 6-10 years of service, employed in middle-level clerical positions (20.1% of women, 18.2% of men). The lowest indications concerned women over 55 years of age with more than 20 years of professional experience (5.5%).

In the sixth question, respondents evaluated the frequency with which their supervisor focused on their achievements, using a 0-10 scale (0 = never, 10 = very often). Responses in the 7-10 range, treated as the highest level of assessment, accounted for an average of 66.5%,

with no significant differences between sex or age groups. Variation appeared only in relation to length of service in the municipal office under study ($H = 13.30$; $df = 4$; $p = 0.01$). The ε^2 coefficient was 0.059, which means that approximately 5.9% of the variability in the results can be attributed to differences between groups, indicating a moderate effect size. It was further shown that respondents with the shortest and longest periods of employment indicated the most frequent recognition of their professional achievements by their supervisor. Detailed results are presented in Figure 8.

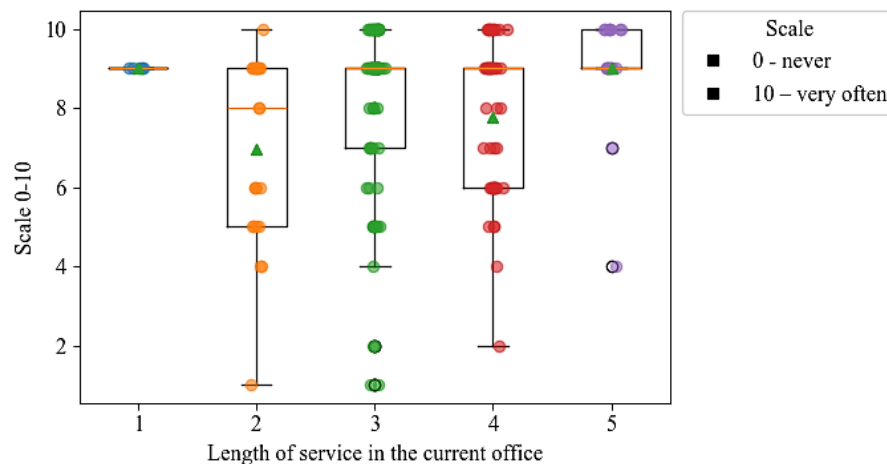


Figure 8. Frequency of employees' achievements being recognized by the supervisor depending on length of service.

Source: own study.

The next issue examined concerned the elements that most strongly motivate respondents to work. According to 92.0% of those surveyed, the most important factor increasing their engagement at work is appreciation from their supervisor. A total of 66.3% indicated remuneration, while for every second respondent job security and recognition from colleagues were also important (55.8% and 48.5%, respectively). One in five respondents pointed to opportunities for professional development (20.9%), and for one in eight the workplace atmosphere was significant (12.9%). The least important factor proved to be autonomy in action (only 3.7%). Detailed results are presented in Table 2.

Table 2.

Factors motivating respondents to work (data in numbers and %)(N = 163)

Answer to choose from	N	%
Appreciation from superiors	150	92,0
Remuneration	108	66,3
Workstability	91	55,8
Recognition from colleagues	79	48,5
Opportunities for personal development	34	20,9
Team atmosphere	21	12,9
Autonomy in work	6	3,7
Other...what?	0	0

Source: own study.

Looking at the detailed results obtained in this section, it can be observed that respondents, regardless of sex, answered at a similar level across all statements. The only exception was the last item, where intergroup analysis showed that there were statistically significant differences between sexes ($\chi^2 = 7.397$, $p = 0.006$, $\phi = 0.213$). It was found that men (62.2%) valued recognition from colleagues considerably more than women (38.8%). Taking age into account, respondents most frequently selected appreciation from a supervisor, team atmosphere, and remuneration within their respective age categories, while differing in the remaining sub-items. In relation to opportunities for professional development ($\chi^2 = 13.270$, $p = 0.01$, $V = 0.285$), job security ($\chi^2 = 14.904$, $p = 0.005$, $V = 0.302$), autonomy in action ($\chi^2 = 16.833$, $p = 0.002$, $V = 0.321$), and recognition from colleagues ($\chi^2 = 10.743$, $p = 0.03$, $V = 0.257$), respondents aged 46-55 stood out most clearly. For this group, job security was considerably less important (38.2%) compared with the average result of the remaining age groups (60.0%). Autonomy in action, on the other hand, proved to be significant for this group (15.8%) compared with the average of the remaining groups (1.1%). An exception was also observed among employees aged 26-35, for whom job security was the most important factor (81.2%).

Another issue examined was respondents' perceived influence on matters concerning the team or the entire municipal office. In this context, interesting results emerged with respect to the distribution by age and length of service. Respondents in the age group up to 25 years (25.0%) and with less than one year of service (40.0%) rated their contribution to the functioning of the workplace the lowest.

The study also addressed the assessment of the level of communicative openness within teams, measured on a scale from 1 (very low) to 5 (very high). The average level of responses amounted to 64.9%, with higher ratings more frequently declared by men (70.8%) than by women (62.2%).

Another aspect concerned respondents' participation in meetings in the form of workshops, dialogue sessions, or team gatherings aimed at jointly creating visions and solutions during the past 12 months. An affirmative response was indicated by 66.3% of women and 55.4% of men. Variation was also observed with respect to age – only 41.9% of employees aged 46-55 reported participation in such meetings, while in the remaining groups the percentage ranged between 61.8% and 81.0%.

A further issue was the evaluation of three statements relating to respondents' work, assessed on a five-point scale (1 = strongly disagree, 5 = strongly agree). The first statement concerned the subjective assessment of the importance of one's work for the functioning of the municipal office. Higher ratings were more often declared by women (75.5%) than by men (55.4%). The lowest results were recorded among the youngest respondents (under 25 years of age, with less than one year of service) – 50.2% compared with 61.1-90.2% in the other groups. A similar distribution was obtained for the statement concerning job satisfaction, where the youngest group again indicated the lowest values (50.9-60.2%) compared with a range of 72.1-100.0% in the other age groups.

When analysing the assessments concerning the statement related to the level and quality of open and supportive cooperation within the municipal office, the highest ratings on the scale were declared by 77.6% of women and 70.8% of men. Statistically significant differences were, however, noted in relation to length of service ($H = 9.82$; $p = 0.04$). The value of the coefficient $\epsilon^2 = 0.037$ indicates that approximately 3.7% of the variability in the results can be attributed to differences between groups, which means that the effect size is low. Employees with 6-10 years of professional experience, compared with those with 11-20 years, rated the quality of cooperation within teams more highly ($p = 0.06$, $\delta = -0.069$). Detailed results are presented in Figure 9.

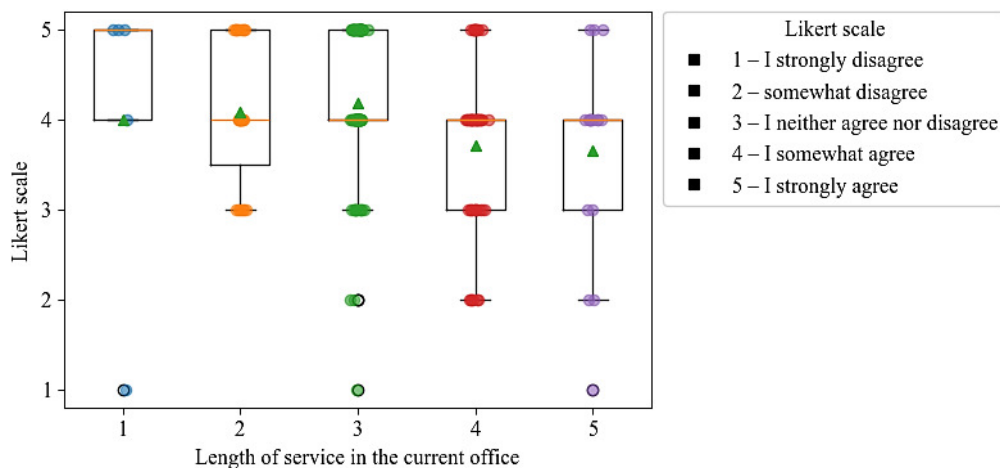


Figure 9. Assessment of the openness and supportive nature of team cooperation depending on length of service.

Source: own study.

The final issue examined was the perception of the desirability of introducing a greater number of initiatives in the municipal office based on everyday employee appreciation. Respondents assessed this matter on a five-point scale (1 = definitely yes, 5 = definitely no). The results indicate that such a solution is highly desirable – 88.5% of respondents gave affirmative responses, regardless of sex. In the age groups up to 25 years and over 55 years, all respondents (100.0%) selected *Definitely yes* or *Rather yes*, whereas in the remaining age and service categories the percentage averaged 85.5%.

5. Discussion

The main hypothesis (MH) in the conducted research assumed that an appreciative inquiry (AI) has a positive and significant impact on the level of engagement of local government employees. The empirical results confirmed the validity of this assumption, pointing to the strong importance of practices based on appreciation and positive feedback for strengthening motivation and maintaining a high level of commitment to work.

The confirmation of the main hypothesis is consistent with a broad body of research indicating that appreciation, recognition and positive feedback are among the most important factors shaping employee engagement. In terms of the JD-R (Job Demands-Resources) model, such practices serve as key work resources that support the motivational process and protect against burnout (Bakker, Demerouti, 2017; Mazzetti et al., 2021). Field research consistently shows that recognition from superiors enhances employee satisfaction and effectiveness, while a lack of recognition is associated with decreased motivation and withdrawal from organisational activity (Brun, Dugas, 2008; Saks, 2006). Appreciation practices are particularly important in public organisations, where financial motivation is often not the main factor determining attitudes towards work. In this context, recognition and constructive feedback become essential tools for strengthening loyalty and commitment, which is also reflected in the literature on public administration (Vigoda-Gadot, Beerli, 2012). At the same time, research shows that the effects of AI are not only the result of individual interventions, but require systemic implementation and a supportive leadership style (Bushe, Kassam, 2005). The importance of appreciation is also highlighted by recent analyses, which indicate that recognition programmes in organisations – both private and public – lead to a marked increase in engagement, quality of cooperation and innovation (Yang, Jiang, Cheng, 2022). What is more, regular feedback strengthens employees' sense of influence on the functioning of the organisation and builds a climate of psychological safety that promotes openness and knowledge sharing (Edmondson, Bransby, 2023; Frazier et al., 2016). The collected results therefore indicate that an appreciative approach can be an effective mechanism for supporting engagement in public administration, as long as it is linked to an organisational culture based on recognition, transparent communication and an inclusive leadership style.

The first specific hypothesis assumed the existence of a positive and statistically significant relationship between the perception of appreciative inquiry (AI) and the level of professional engagement of local government employees. Correlation analysis showed only partial confirmation of this relationship. The relationship proved to be significant, although at a weak level in relation to the frequency of positive feedback ($\rho = 0.258$, $p < 0.000$), but no confirmation was obtained for other indicators related to appreciation, such as discussions about strengths or participation in meetings focused on the exchange of good practices. The partial confirmation of the hypothesis indicates that positive feedback plays a key role in building professional engagement, which is consistent with the results of previous studies. The literature consistently emphasises that regular and constructive feedback is one of the main resources at work that influences motivation and willingness to make additional efforts (Bakker, Demerouti, 2017; Mazzetti et al., 2021). At the same time, the lack of significant correlations with other elements of the appreciative approach may indicate the limited effectiveness of selected practices in the context of public administration. Bushe and Kassam (2005) noted that AI-based interventions are transformative only when accompanied by deep dialogue and genuine employee involvement in the co-creation process. Otherwise, their impact may be weak

or difficult to grasp. Similar observations are contained in critical analyses of Appreciative Inquiry, pointing to the risk of reducing this approach to superficial rituals that do not always translate into actual attitudes and behaviours of employees (Grant, Humphries, 2006).

The second specific hypothesis assumed that the most important factors motivating and supporting the professional commitment of public administration employees are positive feedback, recognition of achievements, and the opportunity to co-create the organisation's vision. Statistical analysis partially confirmed this assumption, indicating a significant although at a weak level relationship between receiving positive feedback and the declared level of commitment ($\rho = 0.258$, $p < 0.000$). However, no analogous relationships were found with regard to recognition of achievements and participation in the process of co-creating the organisational vision. The partial confirmation of the hypothesis suggests that, among the factors analysed, it is positive feedback that has the most direct impact on the level of commitment. The literature emphasises that providing systematic, constructive and positive feedback increases the sense of competence, strengthens internal motivation and promotes pro-organisational behaviour (Bakker, Demerouti, 2017; Yang, Jiang, Cheng, 2022). The lack of significant correlations in terms of recognition of achievements may indicate that in organisational practice it is not always communicated in a clear and consistent manner. Brun and Dugas (2008) point out that the discrepancy between the actual contribution of employees and the perceived level of recognition is a common barrier to the effectiveness of incentive programmes. Similarly, co-creating the organisation's vision did not show a correlation with engagement, which may result from the limited influence of local government employees on decision-making processes and the hierarchical nature of local government structures (Vigoda-Gadot, Beeri, 2012; Ingrams, 2018). Research indicates that participation and co-creation are only effective when accompanied by genuine employee involvement and appropriate leadership styles, such as inclusive leadership (Ashikali, Groeneveld, Kuipers, 2021).

The third specific hypothesis assumed that management actions based on the Appreciative Inquiry (AI) approach contribute to the creation of a positive organisational climate and improve the quality of relationships within employee teams. Statistical analysis provided partial confirmation of this thesis, indicating a significant correlation, although at a weak level between discussions about the team's strengths and the assessment of cooperation as open and supportive ($\rho = 0.165$, $p = 0.04$). The results obtained indicate that practices related to the appreciative approach can foster the development of an organisational climate based on openness and mutual support. Research confirms that conversations focusing on team strengths not only increase trust and cohesion, but also support the creation of a work environment conducive to learning and cooperation (Cooperrider, Whitney, Stavros, 2008; Bushe, Kassam, 2005). At the same time, the literature emphasises that the effectiveness of AI practices depends on their embedding in a broader organisational context and on leadership style. In the public sector, inclusive leadership is crucial, as it strengthens a climate of openness and participation, thereby

increasing the likelihood that appreciation-based actions will have a lasting impact on inter-employee relations (Ashikali, Groeneveld, Kuipers, 2021). The results of empirical research suggest that although the mere presence of conversations about strengths does not guarantee profound transformation, their consistent implementation, combined with an inclusive management style and a culture of openness, can significantly contribute to improving the organisational climate and the quality of cooperation.

The study provided important insights into the role of the appreciative approach in public administration. The results confirm that elements such as positive feedback and discussions about the strengths of the team promote engagement and the quality of cooperation, although their effectiveness is not uniform. At the same time, there are still areas that require further improvement, especially in terms of the clarity of recognition from superiors and the systematic implementation of measures based on daily appreciation of employees.

6. Conclusions

The study confirms that the implementation of the Appreciative Inquiry (AI) approach in the field of local government administration yields positive results. This primarily concerns interpersonal relationships, the quality of cooperation, and employee engagement. Particularly significant was the role of supervisors, whose recognition was identified by respondents as an important motivational factor- often rated higher than material incentives such as salary or job security. The findings also indicate that the frequency of receiving positive feedback translates into an increase in declared employee engagement.

According to respondents, elements of the appreciative approach were present in the daily functioning of the municipal office, which positively influenced job satisfaction and the sense of meaning at work. Conversations about team strengths and employee involvement in change processes were rated especially highly. However, their impact on engagement was found to be less straightforward than that of systematic positive feedback. The results therefore suggest that, while elements of an appreciative culture play an important role in shaping a climate of trust and shared responsibility, their effectiveness is diverse and depends on organisational context and leadership style.

In human resource management practice within local government administration, it is advisable to consider integrating elements of the appreciative approach into HR procedures to strengthen their motivational dimension. Municipal office leadership should treat AI not only as a tool for supporting relationships but also as a component of organisational strategy that can increase the attractiveness of the office as a workplace.

It must be emphasised, however, that this research was designed as a case study. Therefore, the findings cannot be generalised to all local government administration units in Poland. Moreover, the study was conducted within one local organisational culture and at a specific point in the institution's development, which may have influenced respondents' evaluations.

In conclusion, it is worth pointing out the prospects for further research on this issue. It seems particularly interesting to conduct longitudinal studies that would capture the long-term effects of appreciative practices. Such studies would allow for the observation of changes over time at the level of individual units and entire teams, which seems to be a particularly interesting direction of analysis in the case of the discussed topic. Such research would make it possible to distinguish between short-term effects and permanent behaviour patterns. One source of inspiration here is the use of several measurement waves, which would allow for modelling the trajectory of engagement and the impact of the frequency of appreciation practices on its dynamics.

It is also worth considering the use of triangulation of research methods and supplementing surveys with in-depth interviews, which allow for a deeper insight into the subject under study and would make it possible to extract a broader dimension of employees' experiences related to appreciation. In subsequent studies, it is worth adopting specific indicators, e.g. the level of engagement in daily professional duties, organisational climate, psychological safety, leadership style. In this regard, it is recommended to use repeated questionnaire measurements and quantitative analyses based on structural equation modelling, growth curve models and multilevel models. This perspective would allow for a better understanding of the sustainability of the effects and identify factors that promote or limit the implementation of the appreciative approach in local government administration.

Another interesting approach would be to include additional groups of respondents in the research and take into account the perspective of external stakeholders (e.g. citizens, local organisations, cooperating institutions) and to conduct inter-organisational comparisons based on analyses in various local government offices and institutions.

Consequently, future analyses may contribute to the development of effective practical recommendations that will support the growth of a culture of appreciation in the local government sector, thereby strengthening the foundations of efficient and citizen-friendly administration.

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