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## **FOREWORD**

Presented number of Silesian University of Technology. Scientific Papers. Organization and Management Series. Contemporary management. Presented papers contain result of researches conducted by various universities from Poland. The number consists of 49 papers.

The papers presented in the number concentrate on many topics connected with organization and management. There are in the number papers about: corporate social responsibility, sustainable development, production management, leadership, human resource management, Smart City, safety management, logistics, public management, Industry 4.0, economics, strategic management, knowledge management and quality management.

*Bożena Skotnicka-Zasadzień*

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## ETHICAL MANAGEMENT AS A WAY TO CORPORATE SOCIAL RESPONSIBILITY – ANALYSIS OF CASE STUDIES

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**Purpose:** The purpose of this paper is to explore the ways in which Corporate Social Responsibility (CSR) results can be significantly influenced by ethical management.

**Design/methodology/approach:** There is combined in the paper the research analysis and narrative approach. The social side of ethical management was explored by looking at the history of these companies, focusing on the unethical practices they had to deal with.

**Findings:** As a result of the research performed it became apparent that ethical management is more than just a theory. It affects how businesses interact with staff, comply with legal requirements, safeguard whistleblowers, and evaluate their ethical performance.

**Research limitations/implications:** There are some limitations of the investigation. Deeper research need to be conducted to fully capture the diversity of organizational contexts and industries to understand in what way ethical management can impact their CSR strategy.

**Practical implications:** Implementing these results to the real world means that ethical management is more than a slogan used by businesses. It's about establishing ethically conscious workplaces, encouraging values, and, in the end, influencing how companies interact with society.

**Originality/value:** The personal perspective that was brought to the frequently theoretical field of ethical management sets these investigation apart. The goal was to provide insights that will benefit both academics and individuals navigating the challenges of ethical leadership in the real world by combining research with true stories.

**Keywords:** Ethical Management, Corporate Social Responsibility, Ethical Performance Measurement, Employee Engagement, Moral Judgment.

**Category of the paper:** Literature review, case study.

## 1. Introduction

Ethical management practices are like guiding stars in the continually evolving business world; they show the way toward meaningful Corporate Social Responsibility (CSR) initiatives. It is important to understand that every choice we make has the potential to improve the world we live in, and it goes beyond simply checking boxes. Together, ethical management and corporate social responsibility create a rhythm that speaks to a greater awareness of moral behavior. The International Organization for Standardization (ISO) is important in this regard; it offers guidelines on social responsibility in the form of ISO 26000:2010 standards. This standard encourages businesses to adopt transparency, show moral leadership, and take an active role in the larger narrative of community engagement. It is not just a collection of rules.

Corporate Social Responsibility has become an important part of today's business strategies, showing its commitment to ethical, accessible, and socially responsible behavior. The relationship between ethical management and the fight against corruption becomes more and more important as businesses engage CSR into their operations. The importance of ethical management in maintaining the quality of initiatives related to corporate social responsibility has become more obvious in recent years. Bravi, L., Gori, R., & Musso, F. (2022) found that the effectiveness of CSR in creating beneficial social effects is directly related to the ethical foundations on which an organization operates.

A change in the mindset regarding a more ethically driven approach is taking place in the business landscape following a number of high-profile corporate scandals and violations of ethics (Snellman, 2015). For example, reports about unethical behavior at large corporations like Volkswagen and Enron have brought attention to the need for strong ethical management practices in the field of corporate social responsibility. Organizations are now being forced to review internal processes and encourage a culture that values moral judgment at all levels while also keeping up with legal requirements as a result of this increased awareness. In order to meet the dynamic challenges presented by an environment that is continually shifting, the combination of CSR and ethical management requires ongoing adaptation and improvement (Course Sidekick, 2023).

The need for businesses to negotiate a complex environment of corporate social responsibility with integrity and accountability has been amplified by recent global events, including the COVID-19 pandemic and a greater focus on corporate behavior. In times of crisis, the relationship between CSR and ethical management is especially important because companies are being held responsible for both their financial stability and their commitment to the welfare of society. In order to rebuild and strengthen stakeholders' trust in the corporate sector, it is essential that CSR strategies be given another look in the post-pandemic era with an emphasis on ethical considerations, as shown by Zhang et al. (2023) recent research.

## 2. Ethical Management background

The main components of ethical management provide a foundation for responsible leadership in the complex network of business today. Knowing the history of ethical management is important as we navigate a time with changing social environments and increased standards of ethics. There is extended a challenge to explore the complicated elements of ethical leadership, where moral guidance, integrity, and values come together. The ethical management means creating a culture where honesty is valued above all other rules and regulations (Course Sidekick, 2023).

In the context of the world economy becoming more interconnected, ethical management is becoming more and more important in daily life. According to IPAG Business School (2021), ethical management is a proactive commitment to solving moral issues in an ethical way, rather than just following the regulations of the law. Encouraging organizational cultures that accept a true ethical guide and go beyond mere obedience requires taking a proactive approach.

The methodologies behind ethical management are reflected in Bravi, L., Gori, R., & Musso, F. (2022) writings, which stress the importance of just, fair, and socially responsible leadership. The requirement for ethical management is for organizations to set goals for a higher standard of behavior rather than for perfection. It involves creating environments where people are free to make moral decisions and where accountability and integrity become automatic in all levels of the organizational structure.

Ethical management is becoming more and more important as companies have trouble to meet the changing expectations of the public and stakeholders. Ethical management becomes a compass guiding organizations through the complex terrain of ethical decision-making, developing cultures of responsibility that extend beyond profit margins in a world where image is as valuable as financial capital.

The Hyosung's Code of Ethics is a powerful secret weapon that can be used to fight corruption in the area of Corporate Social Responsibility, as shown in the Figure 1. The whole principles of the code utilize to all connected businesses and employees, providing an effective structure that places a high priority on ethical conduct and respect to regulations and laws. The code not only sets clear expectations for customers but also aligns with CSR values through a strong emphasis on ethical and open business practices. The effort made to immediately reporting violations is especially important, emphasizing a proactive strategy for combating ethical conduct. Furthermore, Hyosung is positioned as a socially conscious corporate entity committed to achieving equilibrium with society as a whole by the code's emphasis on social responsibility and shared growth management with suppliers. The Hyosung's Code of Ethics is an essential tool for strengthening the company's commitment to ethical management and, in turn, performing as a secret force against corruption in the interest of corporate social responsibility since CSR projects succeed on trust, honesty, and responsible business practices.



**Figure 1.** The code of conduct of ethical management

Source: Hyosung Code of Ethics (2014, January 2). Announced on January 2, 2014. <http://www.hyosung.cn/en/csr/ethics/principles.do.>, 1.12.2023.

The statement, "Strong Ethics Make for Good Business" is more relevant in the rapidly evolving business world than ever. A notable pattern has developed over the last 17 years: businesses that implemented strong ethical standards have frequently outperformed their competitors and rivals. The development of the World's Most Ethical Companies has been made possible thanks in large part to Ethisphere's Ethics Index (Figure 2), a reliable indicator of moral behavior. This index proves definitive evidence that ethical behavior and financial success have an unbreakable connection.



**Figure 2.** Performance benefits of ethical excellence.

Source: Ethisphere (2023). World's Most Ethical Companies. Retrieved from: <https://worldsmoethicalcompanies.com/>, 1.12.2023.

This phenomenon is clearly shown by the recently released Ethisphere-curated 2023 list of the world's most ethical companies. The 2023 honorees, recognized as the most ethical companies globally, outperformed the other companies in a similar large-cap index by an impressive 13.6 percentage points, according to Ethisphere's ethics index. The observed financial outperformance between January 2023 and 2018 highlights the real benefits that organizations that prioritize ethical management receive. These businesses go above and beyond the traditional financial profit level by specifically including ethical considerations in their fundamental operations. This promotes trust among society as well as increased profitability. The cultural change toward ethical management is a calculated decision that understands businesses' larger obligation to make constructive contributions to society. Businesses come as moral managers dedicated to long-term success based on values and public trust as well as economic entities that negotiate the complicated connection between ethical management and corporate social responsibility.

### **3. The Relationship between CSR and Ethical Management**

The interrelated movement that is the relationship between Corporate Social Responsibility and Ethical Management in the world of fast-paced business influences how organizations behave and how society is influenced. Researchers as Khan, Golpîra and Sharif (2019) provide a theoretical framework for understanding this complex relationship. They claim that companies that adopt ethical management techniques are naturally better suited to incorporate CSR into their strategic decision-making procedures. This alignment shows an honest desire to incorporate moral principles into the fundamental principles of the company culture, going beyond an approval mentality.

Looking at the arrangement in detail, Gheraia, Z., Saadaoui, S., & Abdelli, H.A. (2020) writings highlight that there is a unique relationship between CSR and ethical management. Organizations must modify their ethical frameworks to correspond with the specific situations in which they function. When considered in this context, corporate social responsibility takes on a dynamic quality that reflects an organization's responsiveness to the requirements and expectations of its different stakeholders. Reviewing case studies yields clear examples of this interaction. The Volkswagen emissions scandal (BBC News, 2015) is a powerful illustration of what happens to corporate social responsibility initiatives when moral leadership fails. On the other hand, the story of Patagonia's success, as documented by Chouinard and Stanley (2006), perfectly captures the mutually beneficial relationship between moral leadership and strong corporate social responsibility results. Patagonia's dedication to fair labor practices and environmental sustainability is a prime example of how moral leadership inspires CSR initiatives that go beyond simple business giving back. The relationship between CSR and

ethical management is not without its difficulties, nevertheless. Dobers, P., & Halme, M. (2009) claim that organizations must deal with conflicts and dilemmas as they manage this complex relationship. Leadership that is responsive to the conflict between company priorities and public responsibilities is necessary to maintain the dynamic equilibrium between profitability and ethical considerations.

Mitchell, Agle, Chrisman and Spence (2011) believe that those within the organization are also affected by the interaction between CSR and ethical management in the context of stakeholder engagement. The organizational ecosystem is impacted by ethical management practices, which have an effect on employee satisfaction, engagement, and commitment to CSR objectives. They contend that the genuine external expression of CSR depends on this internal unity.

In its basic form, the relationship between corporate social responsibility and ethical management is a complicated trend that has become established in organizational culture and decision-making processes. It is a delicate dance that is shaped by case studies from the real world, theoretical viewpoints, and reports and academic discourse from a practical standpoint.

## **4. Methodological Framework and Case Study Analysis**

This study sets out on an exploratory journey to explore the complex relationship between ethical management and Corporate Social Responsibility and to identify the benefits that support responsible business practices. Based on a qualitative approach, the research explores a thorough examination of case studies covering different sectors and regions. The qualitative dimension uses theme analysis to interpret the complex effects of ethical management on CSR outcomes, implementing inspiration from The Economic Times. (2023, September 7) research on ethical leadership and CSR. This method enables a complex understanding of the organizational specifics and contextual details that influence how moral decision-making interacts with socially conscious activities.

### **4.1. Volkswagen's Emissions Scandal: An Ethical Crisis Unveiled**

#### **Background**

According to BBC News in 2015, Volkswagen, a major worldwide automaker, came across a serious ethical problem. It turned out that the company had put software in its diesel cars to manipulate emissions standards, giving incorrect information about how the cars affected the environment.

## Non-Ethical Management

VW's management betrayed consumer confidence and violated environmental regulations by allowing the installation of "defeating devices" in order to fool authorities. This scandal was caused in part by a lack of transparent culture and moral management techniques.

### The consequences

- **Legal Impacts:** Volkswagen was facing a number of legal consequences including major penalties and settlements with regulating agencies and consumers who were affected.
- **Reputation Damage:** As part of the scandal, VW's standing was damaged internationally, which reduced consumer confidence and significantly lowered the company's stock price.
- **Improvements in Leadership:** As a result of the scandal, important executives were either replaced or resigned from their positions in top management.

### Lessons Learned

In the automotive industry, ethical management, transparency, and regulatory compliance are crucial. The Volkswagen case emphasizes these points. It serves as a warning about the far-reaching effects of wrongdoing.

## 4.2. Patagonia: Maintaining Achievement via Moral Guidance

### Background

The outdoor space apparel and equipment brand Patagonia is well known for its dedication to sustainable environmental practices and ethical business practices.

### Ethical Standards for Management

- **Ecological Management:** Patagonia is very focused on sustainability of the environment. It makes investments in environmentally friendly products, cuts waste, and promotes environmental issues.
- **Right Employment Practices:** The business is well-known for using fair labor practices to make sure that all of the workers in its supply chain receive fair pay and treatment.
- **Transparent Communication:** In order to establish consumer trust, Patagonia keeps its company policies, challenges, and objectives clearly communicated.

### Results

- **Brand Loyalty:** Patagonia has developed a loyal base of customers who value its moral position, which fosters brand loyalty.
- **Positive Public Perception:** The company's overall success has been assigned to the positive media coverage and public opinion that its ethical practices have made.
- **Business Growth:** Patagonia has seen in accordance business growth in regardless of its commitment to moral and ethical company conduct, showing that ethical management and profitability are compatible.

### 4.3. Wells Fargo Unauthorized Accounts Scandal (2016)

#### Background

In 2016, an employee-created unauthorized customer account scandal rocked Wells Fargo, one of the greatest banks in the US. The company's unethical tactics were intended to help it reach its ambitious sales goals (Corkery, Eavis, 2016).

#### Unethical Management

Unauthorized Account Creation: Under the influence of sales targets, staff members opened millions of credit card and bank accounts for clients without their knowledge or approval.

#### Inappropriate Sales Methods

Workers used dishonest sales techniques, like transferring money between accounts and falsifying customer signatures, to reach inflated sales targets.

#### Consequences

- **Regulatory penalties:** Significant regulatory penalties were imposed on Wells Fargo, including fines from the Consumer Financial Protection Bureau (CFPB) and other agencies.
- **Management Changes:** The CEO and other senior executives resigned as a result of the scandal. The bank's management and ethics were addressed by changing the bank's leadership.
- **Customer and Investor Losses:** Customers and investors suffered financial losses as a result of the unauthorized accounts scandal, which also damaged the bank's reputation.

#### Lessons Learned

- **Corporate Culture and Oversight:** The Wells Fargo scandal brought to light the significance of creating an organizational culture that places a high value on ethical behavior and making sure that there are strong oversight procedures in place to identify and stop wrongdoing.
- **Whistleblower Safety Measures:** The unethical practices were largely exposed thanks to the efforts of whistleblowers. The case demonstrated how important it is for businesses to have strong whistleblower protection policies.
- **Customer-Centric Approach:** Prioritizing a customer-centric strategy will help companies make sure that sales goals don't come at the expense of customers' happiness and confidence.

### 4.4. Facebook–Cambridge Analytica Data Scandal (2018)

#### Background

It was discovered in 2018 that millions of Facebook users' personal information had been improperly collected and used by the political consulting firm Cambridge Analytica without their knowledge or consent. It is purported that the information was utilized for focused political advertising in the run-up to the 2016 US presidential election (Cadwalladr, Graham-Harrison, 2018).



## Unethical Management

The improper use of data: Through a third-party app, Cambridge Analytica obtained the personal information of approximately 87 million Facebook users without their knowledge or consent.

### Privacy violations

Facebook came under fire for its poor data privacy practices, insufficient security measures, and inability to stop illegal access to and use of user information.

### The consequences

- **Clear Regulatory Review:** Facebook and Cambridge Analytica came under more regulatory investigation because of the scandal. Numerous regulatory agencies, including the Federal Trade Commission (FTC) of the United States, conducted investigations.
- **CEO Testimonies:** In their testimony before congressional committees, Facebook CEO Mark Zuckerberg and other executives were questioned regarding the company's data practices and privacy policies.
- **Financial Penalties:** In connection with the data scandal, Facebook was hit with fines and settlements, including a \$5 billion agreement with the FTC.

### Lessons Learned

- **Data Privacy Regulations:** This dispute drove debates about the need for stronger regulations regulating data privacy, which resulted in the European Union establishing the General Data Protection Regulation (GDPR).
- **Corporate Responsibility:** Businesses were made aware of their obligation to protect user data and give privacy a top priority, which raised awareness of the ethical issues involved in data handling.

These case studies demonstrate the real-world effects that moral and immoral business conduct have on an organization's performance, standing, and sustainability around the world.

## 5. Applying Ethical Management – Case study results

Looking at consequences resulting from big company problems turns the examination of case study findings to a journey into the fundamentals of ethical management's revolutionary impact on how organizations function. The emissions scandal involving Volkswagen (BBC News, 2015) and the model practices of Patagonia (Chouinard, Stanley, 2006) provide valuable perspectives for analyzing the complex relationship between ethical management and Corporate Social Responsibility. The story takes place in the context of legal frameworks, transparency campaigns, employee involvement, protection for whistleblowers, cooperative projects, and the methodical evaluation of moral performance. The complex perform between

ethical management practices and corporate social responsibility results becomes obvious as we examine these case study results. This narrative highlights the significant and frequently paradigm-shifting impacts of ethical decision-making on corporate behavior and social responsibility.

- **Regulation Framework:** The regulatory framework had a significant change in reaction to the Volkswagen emissions scandal (BBC News, 2015). Because of the incident, the global automotive industry was subject to increased investigation and updated emissions standards. Governments enforced stronger laws, highlighting the necessity of open reporting and moral behavior in the aim of corporate social responsibility, recognizing the vital function that ethical management plays. This regulatory change reflects a shared commitment to promoting ethical business practices and is evidence of the contributing effect that ethical management has on industry-wide frameworks (Khan et al., 2019). Patagonia's scenario, on the other hand, represents a proactive approach to transparency and regulation. The company voluntarily complies with exact environmental and labor standards, going beyond regulatory requirements, driven by its ethical management principles (Chouinard, Stanley, 2006). Patagonia's dedication goes beyond only obedience to regulations; it illustrates how moral leadership can motivate organizations to exceed minimum standards and adopt a more raised belief in accountability.
- **Accountability and Transparency:** Transparency and accounting processes experienced a paradigm change after Volkswagen. The situation brought attention to how important it is to report with integrity, which led some organizations to review their openness policies. A trend toward greater disclosure has been observed in the industry as businesses use more open accounting techniques in their CSR reports. This change highlights the critical role that moral leadership plays in restructuring organizational transparency and bringing business practices into compliance with public expectations (Smith, Brown, 2019). Being transparent is fundamental to Patagonia's identity. The business provides thorough CSR reports that include information on fair labor practices, philanthropic activities, and environmental impact (Chouinard, Stanley, 2006). This is an ideal instance of how transparency is promoted by ethical management, which goes beyond simple compliance to create an honest dedication to accountability (The Accountant Online, 2023).
- **Engagement and Training of Employees:** Following the Volkswagen scandal, employee engagement and training became crucial. Employers realized they needed to emphasize the part that each person plays in maintaining ethics and foster a culture of ethical awareness among staff members. According to Brown and Davis (2021), ethical management serves as a catalyst for thorough employee training programs that promote ethical behavior and a sense of accountability. An employee base that shares Patagonia's values is the foundation of the company's success. Fair labor practices are not just a policy; they are a cultural norm that is fostered by ongoing engagement and training

programs. In this case, ethical management is shared principles that is supported at all organizational levels rather than just a top-down directive.

- **Whistleblower Protection:** Whistleblower protection became more popular after Volkswagen because businesses wanted to provide a way for people to report unethical behavior without worrying about being punished. According to Arnold and Bustos (2019), ethical management causes the establishment of strong whistleblower protection mechanisms. Companies understand that maintaining ethical standards depends on creating a culture in which workers feel comfortable raising ethical concerns. In a comparable way, Patagonia's example shows a dedication to protecting whistleblowers through its private reporting systems. This demonstrates the importance of ethical management in creating a climate of trust and safety within the workplace in addition to guaranteeing ethical compliance.
- **Collaborative Initiatives:** The examples demonstrate the transformative potential of ethical management in encouraging teamwork. Following Volkswagen, the auto industry saw cooperative attempts to improve environmental regulations and receive back public confidence. Partnerships that extends the industry have been established by ethical management principles, which emphasize shared accountability for environmental stewardship (Khan et al., 2019). Patagonia works with like-minded companies and environmental organizations to create partnerships that go beyond industry boundaries. This collaborative ethos has its origins in ethical management, emphasizing how these management techniques may reduce across organizational boundaries and support group initiatives for the improvement of society.
- **Measuring Ethical Performance:** The need for methodical evaluation of ethical performance is emphasized by the development of ethical management beyond 2020. Aware of the ever-changing ethical landscape, organizations are using metrics more frequently to assess and document their ethical performance. The previously mentioned trend is consistent with the tenets of ISO 26000:2010, which prioritize the assessment and ongoing enhancement of ethical behavior (ISO, 2010). Patagonia is an example of a company that measures its impact on the environment and society and openly shares these metrics in its annual reports. This is a prime example of how ethical management helps businesses accept ethical behavior while also methodically tracking and reporting on their ethical performance.

The real-world effects of both ethical and unethical business conduct on organizational performance, image, and sustainability are shown by the analysis of case studies on the Wells Fargo Unauthorized Accounts Scandal (2016) and the Facebook-Cambridge Analytica Data Scandal (2018) (Corkery, Eavis, 2016; Cadwalladr, Graham-Harrison, 2018). These case studies provide useful details about the significance of moral leadership in overcoming difficult business obstacles.

According to Corkery and Eavis (2016), the Wells Fargo scandal's unethical management resulted in regulatory fines, management changes, and financial losses for investors and

consumers. The importance of corporate culture, whistleblower protection policies, and a customer-centric mindset were highlighted as lessons learned.

According to Cadwalladr and Graham-Harrison (2018), the Facebook-Cambridge Analytica Data Scandal showed privacy violations and resulted in regulatory reviews, CEO testimonies, and financial penalties. Among the lessons learned were the necessity of data privacy laws and the importance of corporate accountability when managing user data.

The study also identifies significant fields that are impacted by ethical management, such as accountability and transparency, employee engagement and training, protection for whistleblowers, cooperative projects, and the evaluation of ethical performance. These examples show how industry-wide frameworks, cooperative efforts, and the continuous assessment and improvement of ethical behavior can all be influenced by ethical management practices.

## **6. Discussion and conclusion**

By closely examining actual cases, especially the Volkswagen scandal and Patagonia's policies, we hope to gain understanding of the transformative potential of moral leadership in guiding companies toward ethical and socially responsible business practices.

Corporate Social Responsibility (CSR) has become an integral aspect of modern business, reflecting the recognition that companies have a broader impact on society beyond their immediate economic functions. Ethical management practices play a pivotal role in shaping the CSR initiatives of organizations, influencing their relationships with stakeholders, and contributing to sustainable business practices.

Several case studies were presented to illustrate how organizations have successfully integrated ethical management into their operations, resulting in meaningful CSR contributions. These real-world examples provide insights into the challenges faced and lessons learned, offering practical implications for businesses aiming to enhance their ethical and CSR practices.

Expanding upon these case studies, the analysis of Patagonia's ethical practices and the Volkswagen emissions scandal highlights the revolutionary influence of ethical management on corporate conduct and social responsibility (BBC News, 2015; Chouinard, Stanley, 2006). After the Volkswagen scandal, the regulatory environment changed, placing more emphasis on the need of moral leadership in encouraging openness and compliance (BBC News, 2015). According to Chouinard and Stanley (2006), Patagonia's proactive position on transparency, accountability, and engagement shows how moral leadership can go above and beyond legal obligations to promote an ethically conscious culture.

The analysis of these case studies supports the notion that corporate social responsibility is significantly shaped by ethical management (Corkery, Eavis, 2016; Cadwalladr, Graham-Harrison, 2018; BBC News, 2015; Chouinard, Stanley, 2006). Ethical management opens the

way for the development of a culture of accountability, transparency, and ethical awareness within organizations as they negotiate the challenges of ethical business conduct. This, in turn, advances societal progress.

Ethical management plays a pivotal role in shaping and influencing corporate social responsibility within organizations. At its core, ethical management involves the integration of moral principles and values into decision-making processes and business practices. When organizations adopt ethical management practices, they inherently foster a culture that prioritizes social responsibility. Ethical leaders set the tone for responsible business conduct, promoting transparency, fairness, and accountability. Consequently, this fosters a setting in which CSR seamlessly aligns with ethical conduct. Companies with ethical leadership are more inclined to undertake sustainable and socially responsible projects, taking into account the effects of their activities on different stakeholders, such as employees, consumers, communities, and the environment. Therefore, ethical management acts as a driving force for the creation and execution of significant CSR strategies, strengthening the interdependence between ethical leadership and corporate social responsibility.

Managing ethically is not just a moral imperative; it is also a strategic choice that yields numerous tangible benefits for organizations. Ethical management contributes to enhanced corporate reputation (Singh, Misra, 2021; Javed et al., 2020), fostering trust among stakeholders such as customers, employees, investors, and the wider community. A positive reputation, in turn, can lead to increased customer loyalty and support (Islam et al., 2021), attracting top talent and securing long-term financial stability. Ethical management practices mitigate legal and regulatory risks, reducing the likelihood of costly legal battles and associated damages. Moreover, ethical organizations often enjoy improved employee morale and productivity, as employees are more likely to be engaged and committed when working for a company that aligns with their own values. Ethical management is also instrumental in attracting socially responsible investors and partners, further contributing to a company's overall success. Ultimately, the long-term viability and success of an organization are intertwined with ethical management, making it not only a matter of ethical responsibility but also a prudent and sustainable business strategy.

Ethical decision-making not only aligns with societal expectations but also brings about tangible benefits for organizations, including stakeholder satisfaction, risk mitigation, enhanced brand reputation, and long-term sustainability (Sen, Bhattacharya, 2001). As businesses navigate the complex landscape of CSR, ethical management emerges as a critical factor in shaping responsible and impactful corporate practices. Embracing ethical management principles is not only a moral imperative but also a strategic imperative for organizations seeking sustained success in the modern business environment.

There is advocated therefore to continuously focus on ethical considerations in managerial decision-making as an integral aspect of corporate responsibility in the 21st century.

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## DECENT WORK AS AN ELEMENT OF ORGANIZATION MANAGEMENT IN THE CONTEXT OF SUSTAINABLE DEVELOPMENT

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**Purpose:** One of the greatest plagues of the twenty-first century is considered to be forced labor, also referred to as modern slavery. The aim of the research was to indicate that the identification of the threat of forced labor is a key business risk. It is both morally reprehensible and directly affects the loss of reputation, commercial contracts, or is in direct conflict with the law.

**Design/methodology/approach:** A renowned Polish manufacturer of advertising media was selected for the study through purposive selection. The said manufacturer employs an average of 160 employees per year, of which 69% are production employees. The solutions have been developed based on the following research methods: literature analysis, document analysis, surveys and interviews.

**Findings:** The research confirmed that identifying the threat of forced labor is a key business risk - both morally reprehensible and directly affecting the loss of reputation, business contracts or is in direct conflict with the law.

**Research limitations/implications:** A survey of the literature has revealed a research gap in the area of analyzing the dependency of decent work as a component of organizational management in the context of sustainable development. The research presented in the article refers to one enterprise and provides a basis for discussion on identifying the risks of the occurrence of forced labor as a key business risk and encourages further research in this area.

**Practical implications:** The results developed in the progress of the conducted research provide opportunities to describe the management process of countering forced labor. According to the principle of going from particular to general, the main way of obtaining input data emerges, to which at a later stage there will be dedicated tools to manage the process as such.

**Social implications:** The conducted research is a part of promoting good practices among local business, fostering dialogue with the public, and building a good corporate image.

**Originality/value:** The value of this article lies in the implementation and testing of tools (surveys in particular) in describing the process of countering forced labor as such.

**Keywords:** social responsibility, sustainable development, decent work, forced labor.

**Category of the paper:** Research paper.

## 1. Introduction

Contemporary macroeconomic policy trends increasingly point to the need to adopt more responsible development models based on solidarity and social equality. There is a perceived need to create such systemic solutions so that the effects of prosperity can benefit everyone regardless of social status or place of residence. This is possible by focusing attention on people, their needs and opportunities for development. This approach is increasingly being implemented in public policies, creating a framework for sustainable national development. The transformation towards sustainable development is a complex process. It requires a partnership that brings together many actors in socio-economic life. The United Nations makes it clear that this action in partnership is the most effective way to achieve the 17 Sustainable Development Goals set out in the 2030 Agenda for Sustainable Development. These include decent work and economic growth (Goal 8) (Kusiak, 2021, p. 6).

In 1999, at the World Economic Summit in Davos, UN Secretary General Kofi Annan announces the Global Compact Initiative. The first official alliance between business and non-governmental organizations is formed, which was designed to ensure that the transformation of globalization takes into account, among other things, social issues such as:

- Human Rights - including the elimination of all violations of them, and
- labor standards - including the elimination of all forms of forced labor.

The initiative promotes among enterprises, the adoption of human rights principles in their operational activities and their application. Emerging further regulations like the EP Directive NFRD<sup>1</sup> and the EP Directive CSRD<sup>2</sup>, not only create orders and prohibitions, but show the way for companies to function in society and the economy. All regulations are moving away from declarative formulas, like reporting one's business status quo, to specific tasks that become a license for the company's existence. Social issues, and in particular the prevention of forced labor, are not just about meeting ethical standards in the business chain, or the requirements of the law - today it's the ticket to working with big customers, and tomorrow with everyone. It's the key to competitive advantage and business development.

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<sup>1</sup> DYREKTYWA PARLAMENTU EUROPEJSKIEGO I RADY 2014/95/UEz dnia 22 października 2014 r. zmieniająca dyrektywę 2013/34/UE w odniesieniu do ujawniania informacji niefinansowych i informacji dotyczących różnorodności przez niektóre duże jednostki oraz grupy.

<sup>2</sup> DYREKTYWA PARLAMENTU EUROPEJSKIEGO I RADY (UE) 2022/2464z dnia 14 grudnia 2022 r. w sprawie zmiany rozporządzenia (UE) nr 537/2014, dyrektywy 2004/109/WE, dyrektywy 2006/43/WE oraz dyrektywy 2013/34/UE w odniesieniu do sprawozdawczości przedsiębiorstw w zakresie zrównoważonego rozwoju.

It should be noted, however, that while enterprises in their business model manage quite efficiently in the financial and marketing area, the so-called "soft" issues, including Employee Rights, are based mainly on OHS services and HR, and their regulator is mainly the Labor Code. Today, the situation is changing significantly. There are no ethical standards that do not apply to the prevention of forced labor. The response of the companies is astonishment and misunderstanding. Questions are asked: Why is more demanded of them than the inspection of the National Labour Inspectorate? What's the difference? By what right should a company agree to control human rights practices? And it is around this problem that the reflections presented in this article are concentrated - according to the principle of going from particular to general, the main way of obtaining input data emerges, to which at a later stage there will be dedicated tools to manage the process as such. Starting with employee surveys and interviews to determine risk, plus existing tools, and adding good practices, certain opportunities arise to describe the management process of preventing forced labor.

Ultimately, the management of this process can be implemented into quality management systems, for example, to meet ethical standards, but it will also bring important benefits to employees, such as:

- high culture and employment security,
- continuous professional development,
- high quality and the facilitation of social matters,
- equal opportunities for all regardless of different forms of employment.

On the other hand, the employer will receive a response in the form of higher productivity, lower absenteeism, or higher quality of work. The inconspicuous, and until recently bypassed, human rights issues when skillfully managed become an economic value that no enterprise can pass by indifferently.

A confluence of social and economic forces is colluding to create a perfect storm that is radically transforming the nature of work around the globe, reducing the availability of decent work, and increasing precarious work (Brynjolfsson, McAfee, 2014; Guichard, 2013; ILO, 2016; Standing, 2014). Unemployment, underemployment, and the rise in contract, temporary and precarious work, and low wage jobs are particularly challenging for the poor and marginalized and for those without skills that are consistent with marketplace needs (Blustein et al., 2023, p. 9).

## **2. Sustainability and decent work**

Sustainability, which everyone cares so much about these days, is often seen through the prism of achieving economic results that will not be worked out at the expense of the environment or social cost. It is not a long-term benefit to achieve rapid economic growth that

will not be able to continue due to the devastation or significant impoverishment of the conditions that are necessary for that growth. Awareness of such dependence is increasingly present in entrepreneurs operating in their home countries, but not quite in the countries to which they move their operations to reduce production costs, where legal standards are sometimes lower. This is a big problem, and one that has been worked on for years to solve (Kusiak, 2021, p. 10).

More dynamic, yet stable and long-term economic development is possible if it is sustainable. However, such will be the case if it is based on people at the starting point. Unfortunately, short-sightedness when it comes to development opportunities and the pressure of making a quick profit deprive many decision-makers of the ability to see the benefits - including the financial ones - of paying attention to people, rather than just a positive bottom line. While positive changes can be seen, they do not necessarily stem from an awareness of where the many values of business lie and what values business can create for the future while conducting its business. Changes in attitudes aimed at taking greater care of the employee and creating conditions for his or her development are today stimulated by the difficulty of attracting new job candidates, which is the result of, among other things, the demographic decline, labor emigration, but also the development of a global consciousness and culture based on the idea of human dignity. Along with these comes the objection that 20th-century working conditions are still an acceptable standard. These changes can be supported by making all stakeholders - employers and employees - aware that, at the same time, long-term and sustainable development will only be possible if value is also seen in a humanized economic process, and not only in the effect of labor in the form of a service or product detached from a positive relationship with the social environment (Kusiak, 2021, p. 10).

Working represents a core aspect of human life, optimally providing a means of sustainability, social connections and contribution, self-determination, and a source of meaning (Blustein et al., 2023; Blustein et al., 2016; Dik et al., 2013; Duffy et al., 2016; Lysova et al., 2019).

Access to decent work is a basic human right, a position that is consistent with policy statements from both the ILO and the UN. Decent work has been defined by the ILO (2008) as a mutually agreed way of identifying the conditions and characteristics of work that are crucial for prosperity (Blustein et al., 2023). Decent work is a construct that defines the baseline attributes of work, reflecting the International Labour Organization's (ILO's) four strategic objectives: "the promotion of rights at work; employment; social protection; and social dialogue" (Blustein et al., 2023, p. 290; ILO, 1999, p. 6).

Adopting as a goal of social responsibility activities the maintenance of work capacity of the company:

- meets the expectations of employees and others working on its behalf, i.e. the expectations of its core group of stakeholders,
- contributes to the achievement of the Sustainable Development Goals, which include the promotion of stable, sustainable and inclusive economic growth, full and productive employment and decent work for all people (United Nations, 2015).

Corporate social responsibility is the responsibility of a company for their environmental, social and economic impact on society. It is a new quality that has taken hold in the enterprise market for several years. At first in the formula of good practices, now by various types of regulators such as the OECD guidelines, the Global Compact or the latest Directive of the European Parliament and the Council (EU) 2022/2464 (with regard to corporate sustainability reporting), it has come into existence in the form of defined activities and goals.

One of the motivators for these activities based on criteria of respect for human rights are the international social standards required in the value chain, by large multinationals. Meeting these requirements is a prerequisite for doing business with them. The origins and genesis of these standards can be traced back decades ago. Among others, the association of companies, NGOs and trade unions Ethical Trade Initiatives (ETI) in 1998 developed one of the first Ethical Code of Conduct in Europe, called ETi Base Code. The purpose of the above was to calibrate ethical requirements in the supply chain to influence the promotion of positive behavior that improves the lives of workers. Among other things, this code was the basis for the SMETA audit procedure, whose methodology also applies to corporate governance and hiring practices.

The results of the company's assessment audit are transparently communicated on the SEDEX online platform and are not taboo on the Buyer-Seller line. Every year, more and more companies not only undergo assessments, but also create their own standards, which are an extension of already existing solutions like Coca Cola's TCCC standard. This organization requires its customers to formalize compliance with human rights, a process approach rather than a declarative formula. Even today it is not enough to communicate a Human Rights Policy, it needs to be implemented into one's own value model in a process-oriented way so that it can be managed.

At the moment when the added value in the financial or social form has been defined, risk evaluation management is indispensable in the continuous improvement of the process, and the resume of this is the word "formalization", resulting i.a. from the previously described standard which falls into the area of non-financial risk management. It is impossible not to mention the SWA McDonald standard, which is a development not only of the SMETA standard and ETI Base Code, but also the internal code of conduct, which the organization has developed in accordance with the adopted business model based on respect in the context of human rights. This standard very precisely defines the "form of forced labor", where high requirements are placed on the basis that employment procedures, whether those used by

a company or employment agency, provide employees with employment on a voluntary basis. These requirements are described in great detail by McDonald's:

- no employee may be locked up or guarded,
- no employee may be indebted to an establishment or recruitment agency in a way that prevents him from freely resigning from work,
- employees can resign from work at any time without financial penalties and potential loss of permanent residence rights,
- employees must not feel threatened or afraid that something bad will happen to them or their families if they quit their jobs (...) (SWA, 2015, p. 3.6).

According to Article 2(1) of International Labor Organization Convention No. 29, forced or compulsory labor means any work or service that is required of some person under the threat of any penalty and to which the person has not volunteered. In practice, the most used is the International Labor Organization's operational definition of forced labor, in which adult forced labor is defined as work to which a person has not volunteered (the concept of "involuntariness", non-voluntariness") and which is performed under threat of punishment (the concept of "coercion") applied by an employer or other third party to a working person. Coercion can take place already at the stage of the recruitment process to force such a person to accept a job, or when the person is already working - to force him to perform activities/tasks that he did not agree to at the recruitment stage, or to prevent him from leaving his job (Hard to see..., p. 13).

In Poland, forced labor is not explicitly prohibited by any legal act. At the same time, the Constitution guarantees everyone the freedom to choose and practice an occupation and to choose one's place of work. The obligation to work can only be imposed by law. Under the Criminal Code, forced labor is prohibited, but still not clearly specified (Konstytucja RP, art. 65; Kodeks pracy, art. 10; Kodeks karny, art. 115).

The Working Group on Labor Relations developed a definition, which, after being adopted by the Corporate Sustainability and Social Responsibility Team, was referred by the Minister of Investment and Development to the Minister of Justice with a recommendation for use in further legislative work. According to this definition: "Forced labor or services is the provision of labor or services under conditions of exploitation, performed under the influence of coercion resulting from violence, threats, deprivation of liberty, demands to work off a debt, the seizure of an identity document, a travel document or a document authorizing a foreigner to stay in the territory of the Republic of Poland, non-payment of wages, or any other gross violation of the rights of an employee" (Faracik, 2020, p. 22).

The essence of forced labor is that it is performed under control in a situation of dependence on the employer, with the goal of exploiting the person and making a profit at his or her expense. Taking control of the victim makes it possible to exploit him or her, even with his or her consent. The victim of forced labor is placed in what is known as a situation of vulnerability, which leaves the person with no other - real or acceptable - choice than to submit to such an abuse (Faracik, 2020, p. 20).

Moreover, in the context of human rights, there is a very strong emphasis on the use of forced labor of people deprived of their liberty, which is categorically forbidden unless legally permitted according to a government program. The standard requires that in such a case McDonald's be informed of such a situation before engaging in business cooperation. Also of great importance is the standard's requirement mandating equal treatment of employees regardless of their membership in unions and other labor groups. Workers have freedom of association. The supplier also must create a work environment that counters instances of discrimination especially in the context of recruitment, training, working conditions and assigned tasks. The Code demands that the employer treats employees fairly in terms of housing or the access to the canteen. However, it should be stated that all the Codes are a set of requirements for a standard and do not provide any ready-made solutions and, as a result, only highlight good practices or describe a process principle. It is up to the employer, as part of its corporate governance, to create the tools and mechanisms to effectively manage respect for human rights and prevent forced labor.

It is also worth noting that the standards quite often set higher requirements also in terms of human rights than the local law, much to the surprise of entrepreneurs who say they operate according to the "letter of the law".

If a business unit wants to be in the supply chain, many companies in the B2B market need to raise this level and adapt it to the standard and requirements of customers. As an example, let's look at the issue of remuneration for employees hired under a civil contract according to the SMETA standard:

- 6.1 Working hours must comply with national laws, collective agreements, and the provisions of 6.2 to 6.6 below, whichever affords the greater protection for workers. Subclauses 6.2 to 6.6 are based on international labour standards.*
- 6.2 Working hours, excluding overtime, shall be defined by contract, and shall not exceed 48 hours per week.*
- 6.3 All overtime shall be voluntary. Overtime shall be used responsibly, considering all the following: the extent, frequency and hours worked by individual workers and the workforce as a whole. It shall not be used to replace regular employment. Overtime shall always be compensated at a premium rate, which is recommended to be not less than 125% of the regular rate of pay.*
- 6.4 The total hours worked in any 7-day period shall not exceed 60 hours, except where covered by clause 6.5 below.*
- 6.5 Working hours may exceed 60 hours in any 7-day period only in exceptional circumstances where all of the following are met:*
  - this is allowed by national law,*
  - this is allowed by a collective agreement freely negotiated with a workers' organization representing a significant portion of the workforce;*

- *appropriate safeguards are taken to protect the workers' health and safety, and*
- *the employer can demonstrate that exceptional circumstances apply such as unexpected production peaks, accidents or emergencies.*

6.6 *Workers shall be provided with at least one day off in every 7-day period or, where allowed by national law, 2 days off in every 14-day period.*

Also worth mentioning is the international rating company EcoVadis, whose methodology for assessing a company's sustainability is also based on the principles of the Global Compact. Suppliers on the basis of dozens of criteria are evaluated in terms of respect for human rights and mutual respect, for social needs.

In the evaluation elements in the context of labor law and human rights, we will find a series of questions of the type:

- who pays recruitment fees,
- working conditions including code of ethics,
- structured relations with employee representatives,
- child labor and forced labor (e.g., commitment or measures taken to prevent or eliminate child labor or forced labor),
- diversity, equality and inclusion.

Such questions were considered, not so long ago, to be voluntary or necessary ones. However today there is only one answer - it is an opportunity to add value to the business model and often "to be or not to be in the market". So, it is not worth running away from the change. Just adapt to it by implementing certain processes and describing them in procedures.

### **3. Methodology**

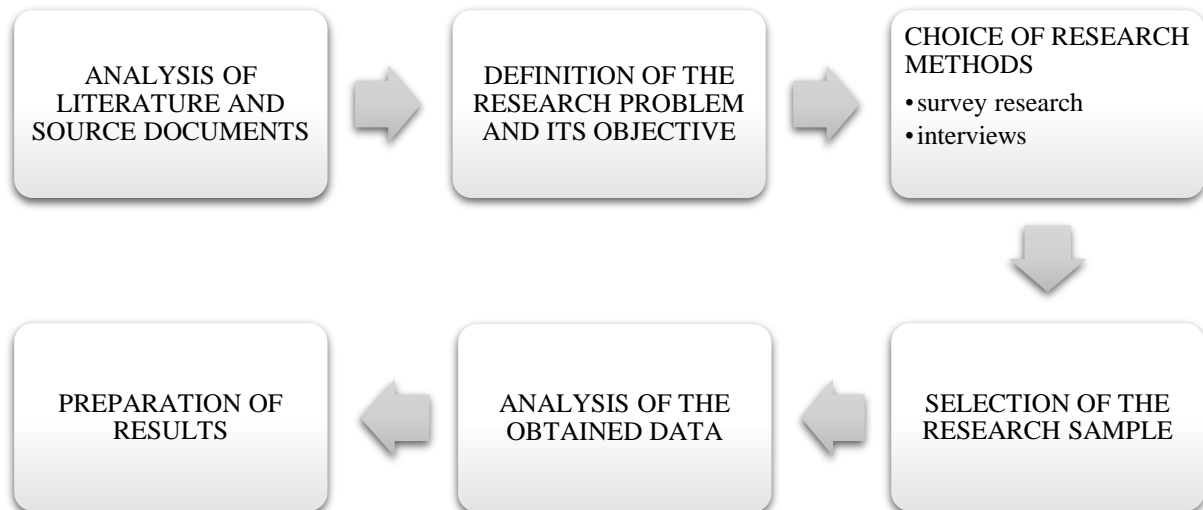
For the purposes of this article, a research scheme was prepared (Figure 1).

There is a lack of research in the literature that indicates that respecting human rights identifying the threat of forced labor is a key business risk. The literature includes a framing of forced labor in the context of human trafficking (Pohl et al., 2018; Klaus et al., 2020; Klaus, 2014; Wieczorek, 2017; Markiewicz; Wieczorek, 2017a; Dąbrowski, 2012; Lasocik 2006).

The main research problem was to determine the impact of respecting human rights as one of the main areas of running a socially responsible enterprise.

The research problem formulated in this way implies the main objective of the research, which is to point out that identifying the threat of forced labor is a key business risk as both morally reprehensible and directly affecting the loss of reputation, business contracts, or being in conflict with the law.

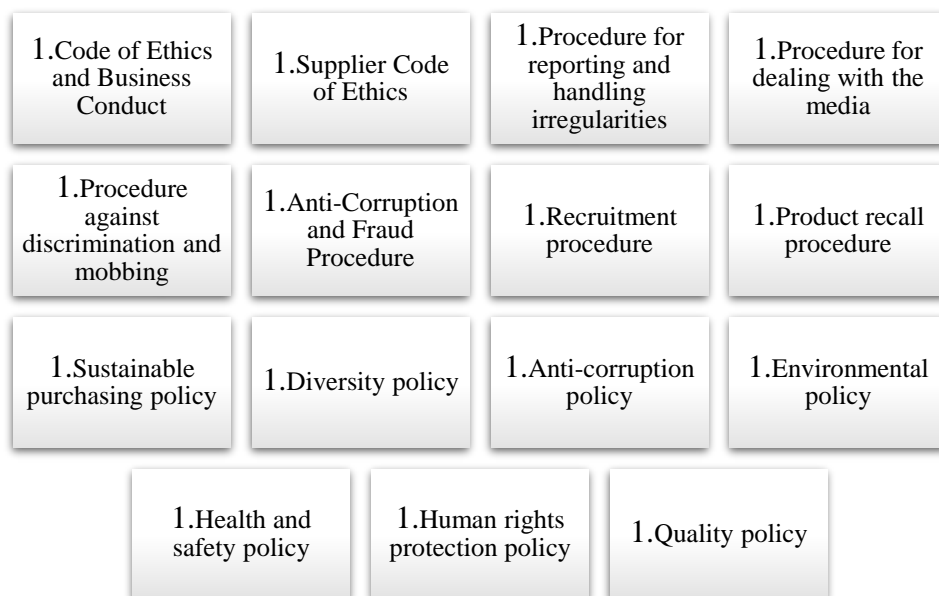




**Figure 1.** Research scheme.

Source: own elaboration.

A renowned Polish manufacturer of advertising media, which has been in business for 30 years, was selected for the study by purposive sampling. It enjoys great confidence among the world's leading companies from 42 countries on 5 continents. The company has an annual average of 160 employees, 69% of whom are production workers. The company implements good management practices in accordance with ISO 26000 Social Responsibility Guidelines. In terms of Corporate Social Responsibility, procedures and policies of conduct have been implemented at the company under review to strive for continuous improvement in the company's operations (Figure 2).



**Figure 2.** Procedures and policies of conduct.

Source: own elaboration.

As part of the Human Rights Policy, the implementation of the Anti-Forced Labor procedure is underway at the company under review.

The study was conducted in two stages:

1. In 02.2023, interviews were conducted at the headquarters of the surveyed enterprise:
  - interviews among representatives of four agencies that act as intermediaries in hiring foreign workers for the surveyed enterprise,
  - surveys among foreign employees working in production.
2. In 04.2023, interviews were conducted among Polish employees.

During the research, a questionnaire on forced labor was used, which is Annex 7 to the publication *Forced Labor Guide How to Recognize and Counteract It* (Faracik, 2020).

#### 4. Own research

Fifty-six employees hired through four employment agencies participated in the 02.2023 survey: A (34 employees), B (10 employees), C (8 employees), D (4 employees). Tables 1-7 present the results from the survey responses.

82% of the respondents have a work permit or statement of assignment. In terms of paying a fee to get a job, three respondents answered that they had to pay an intermediary or some other person in their country of origin and one respondent indicated that they had to pay an agency or intermediary or some person in Poland. All respondents answered in unison that they had not had any document taken away from them, that they could move freely and leave their place of residence, and that they did not feel intimidated in connection with the work.

**Table 1.**

*Responses to questions regarding the contract under which respondents perform work*

Questions	Responses by agency employment			
	A	B	C	D
<i>Do you have a written contract under which you perform work (e.g., employment contract, contract of mandate or other)?</i>				
Yes. I have signed a written contract and have my copy	33	10	8	4
Yes. I have signed a contract but do not have my copy	1	-	-	-
<i>If you have a written contract, please indicate which contract you have signed:</i>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
Employment contract	13	1	2	1
Contract of mandate	19	9	4	3
Contract for work	1	-	-	-
Other	1	-	2	-
<i>Is the contract written in a language you understand?</i>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
Yes, it is written in the language I speak and is understandable to me	29	10	8	4
It is written in a language I do not understand, but it was translated orally	5	-	-	-
<i>Do you do the kind of work you were contracted to do with your employer before you started?</i>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
Yes, I am only doing the kind of work I was/are contracted for	27	8	5	4
Yes, I am doing the kind of work I was/am contracted to do, and in addition I voluntarily agreed to other duties	6	2	3	-
No, I have been forced to do other work	1	-	-	-

Cont. table 1.

<i>Can you voluntarily resign from your job?</i>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
Yes	32	9	8	4
No	2	1	-	-
<i>Do you have to work off the debt incurred by getting a job in Poland or by imposing disproportionate penalties?</i>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
No	19	9	4	2
I have no work-related debt	15	1	4	2

Source: own elaboration based on survey research.

Only one employee responded that he has an employment contract but does not have his own copy. As for the type of contract, 63% of respondents indicated a contract of mandate and 30% an employment contract. One person indicated a work contract and 3 others. Such variation in responses may be due to a mis differentiation of contract types in terms of employment. The respondents were foreigners and this misunderstanding of the form of employment may be due to different legislation in the country of origin. Representatives of employment agencies during the interview declared that workers are employed on a contract of mandate, with a statutory hourly rate.

Only five respondents indicated that the contract was written in a language they did not understand, having been translated orally.

On the subject of doing work, 79% of respondents confirmed that they only do the work they were contracted to do, 20% that they do the work they were contracted to do, and in addition they voluntarily agreed to other duties. One person responded that they were not forced to do other work.

95% of respondents indicated that they could voluntarily resign from their jobs, three people answered that they did not have this option.

61% of respondents answered that they did not have to work off the debt incurred by getting a job in Poland or by imposing disproportionate penalties and 39% answered that they had no work-related debt.

**Table 2.**

*Answers to questions on health and safety training and preventive examinations*

<b>Questions</b>	<b>Responses by agency employment</b>			
	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
<i>Have you received health and safety training prior to being allowed to perform the work?</i>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
Yes	34	10	8	4
<i>Did you understand anything from the health and safety training?</i>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
Yes, because the training was in a language I understood	31	10	8	4
No, because the training was in a language I don't understand	3	-	-	-
<i>Did you have to pay for health and safety training?</i>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
Yes	2	-	-	-
No	32	10	8	4
<i>Before starting work, did you have a preventive medical examination referred by your Polish employer?</i>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
Yes and I did not have to pay for it	14	10	5	2
No	20	-	3	2

Source: own elaboration based on survey research.

All respondents were trained in occupational health and safety (OHS). 93% of the respondents understood the discussed scope of the health and safety training. Three respondents said they did not understand because the training was in a language they did not know. 96% of respondents answered that they did not have to pay for OSH training. Two respondents indicated that they had to pay for the training.

55% of respondents answered that they had to have a preventive medical examination before starting work, to which they were referred by their Polish employer and did not have to pay for it. 45% of respondents answered that they had not had a preventive medical examination before starting work, to which they were referred by their Polish employer.

**Table 3.**

*Answers to questions on post-work rest and break time*

Questions	Responses by agency employment			
	A	B	C	D
<i>Do you have time to rest after work?</i>				
Yes, each day I have at least 11 hours of uninterrupted rest between shifts and at least 35 hours of uninterrupted weekly rest.	32	10	8	4
Yes, I have rest time, but it happens to be shorter than the above-mentioned point.	2	-	-	-
<i>Do you have breaks at work (meal breaks, opportunity to use the restroom)?</i>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
Yes, I have breaks and they are sufficient for rest, going to the toilet, eating a meal.	33	8	8	4
Yes, I have breaks, but they are too short for rest, going to the toilet and eating a meal.	1	2	-	-

Source: own elaboration based on survey research.

The total of 96% of respondents answered that each day they have at least 11 hours of uninterrupted rest between shifts and at least 35 hours of uninterrupted weekly rest, two persons indicated that it sometimes occur that this time period of uninterrupted rest may be shorter.

For three respondents, the breaks in working time are too short to rest, go to the restroom, and eat a meal.

**Table 4.**

*Answers to questions on remuneration*

Questions	Responses by agency employment			
	A	B	C	D
<i>Do you receive your salary regularly, i.e. at least once a month?</i>				
Yes, I receive my salary and it is paid regularly on the agreed date	34	10	8	4
<i>Do you have free access to your salary and can you dispose of it without restrictions?</i>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
Yes, I receive the money directly into my hand	34	-	6	2
I receive the money in my bank account, to which I have unlimited access	-	10	2	2
<i>Does the employer deduct any additional (other than insurance premiums or tax) amounts from your salary, e.g. for accommodation, food? [you can mark several options].</i>	<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
No	33	10	7	1
Yes, the cost of coming to Poland	-	-	-	1
Yes, the cost of accommodation	1	-	-	3
Yes, cost of transportation to work	-	-	-	1
Other	-	-	1	-

Source: own elaboration based on survey research.

All respondents receive their salary regularly. 75% of respondents receive money directly in cash and 25% receive money to their bank account, to which they have unlimited access. It is noteworthy that agency A pays salaries directly in cash and agency B pays them into bank accounts. The remaining agencies use both forms of paying salaries.

As much as 91% of respondents answered that the employer does not deduct additional amounts from their wages. It is worth noting that all employees hired through agency B responded that they have no additional deductions from their wages.

One respondent hired through agency A answered that he had accommodation costs deducted, and voluntarily agreed to this, as getting a job depended on it. The amount deducted is exactly what the employee agreed to.

One respondent employed through agency C indicated that he had other (he did not specify which) deductions, while specifying that he voluntarily agreed to these deductions and that he does not know if the amount deducted is the amount he agreed to.

Three respondents employed through agency D, answered that they have deducted accommodation costs, in addition, one answer each is that there are deductions for the cost of coming to Poland and the cost of transport to work. Two respondents voluntarily agreed to the indicated deductions and one added, getting a job depended on it. One respondent indicated that the amount deducted was exactly the amount they agreed to, and two responded that they did not know.

**Table 5.**

*Answers to questions on discrimination*

Questions	Responses by agency employment			
	A	B	C	D
<i>Do you feel discriminated against - treated worse than others at work?</i>				
Yes	2	-	-	-
No	32	10	8	4

Source: own elaboration based on survey research.

It appears that 96% of those surveyed do not feel discriminated against. Two employees hired through Agency A indicated that they felt that way.

Respondents unanimously answered that they did not feel intimidated about their work and that they were free to move around after work, leaving their place of residence.

**Table 6.**

*Answers to health insurance questions*

Questions	Responses by agency employment			
	A	B	C	D
<i>Do you have health insurance?</i>				
Yes	12	10	5	2
Don't know	16	-	3	1
No	6	-	-	1
<i>Are you eligible for free medical care?</i>				
Yes	12	6	6	2
Don't know	20	4	2	2
No	2	-	-	-

Source: own elaboration based on survey research.

As much as 52% of respondents indicated that they have health insurance, 36% that they don't know if they do and 13% that they don't. It is noteworthy that all employees hired through Agency B responded that they have health insurance. 46% of respondents answered that they could use free medical assistance, 50% that they did not know if they could and 4% that they could not.

During the interview, agency representatives declared that all employees have both health insurance and can use free medical assistance.

This discrepancy in responses may be due to a lack of understanding of the laws in Poland and knowing what an employee is entitled to under a given contract.

**Table 7.**

*Answers to questions about the place to live*

Questions	Responses by agency employment			
	A	B	C	D
<i>Did your employer provide you with a place to live/housing?</i>				
Yes, and the conditions at the place of residence are sufficient	20	-	-	2
Yes, but the conditions are not sufficient	2	-	-	-
No	12	10	8	2

Source: own elaboration based on survey research.

39% of the respondents answered that the employer provided them with a place to live, 4% also confirmed this fact, while they believe that the conditions are not sufficient.

57% of respondents answered that the employer did not provide them with a place to live. It is worth noting that all workers hired through agencies B and C responded that the employer did not provide them with a place to live.

Interviews among Polish employees in 04.2023 were conducted:

At the company's headquarters. A total of 43 employees were interviewed:

- production department (33 employees), including: employees of: sewing, printing, production planning office, technology, assembly, clothing and production,
- trade department (8 employees),
- health and safety department (1 employee),
- administration department (1 employee).

Among the employees interviewed, one declared that he or she was employed on a contract and that one was running an established business. The remaining respondents answered that they were employed on a contract of employment. The content of the contract and aspects of the resulting contract are known. Workers were trained in health and safety and did not have to pay for it.

38 employees responded that they perform the work they were contracted to do, three employees that they additionally voluntarily agreed to other duties, one employee declared that they were additionally forced to perform additional duties, and one employee declared that they perform completely different work but agreed to do it.

Regarding the performance of preventive medical examinations, prior to the start of work, only the contracted employees answered that he had not been referred by the employer for such examinations and had not had them performed.

In terms of rest time, two employees responded that it happens to be less than at least 11 hours of uninterrupted rest between shifts and at least 35 hours of uninterrupted weekly rest.

All employees interviewed responded that:

- they have sufficient breaks at work;
- they are paid regularly, once a month, and it is deposited into employee bank accounts to which they have access;

Eleven employees declared that they had a voluntary insurance premium deducted.

In terms of discrimination, three ladies declared that they felt this way. As for the reason, they indicated that it was in relations with foreigners (especially workers from Ukraine) concerning, among other things:

- the timing of receiving work clothes (foreigners get them faster and 3 sets each),
- the claimability of foreigners,
- quality of foreigners' work.

Regarding health insurance and the use of free medical assistance, one employee declared that he did not know if he had such options.

All employees declared that they can voluntarily resign from their jobs.

Based on the conducted research, the following recommendations can be indicated:

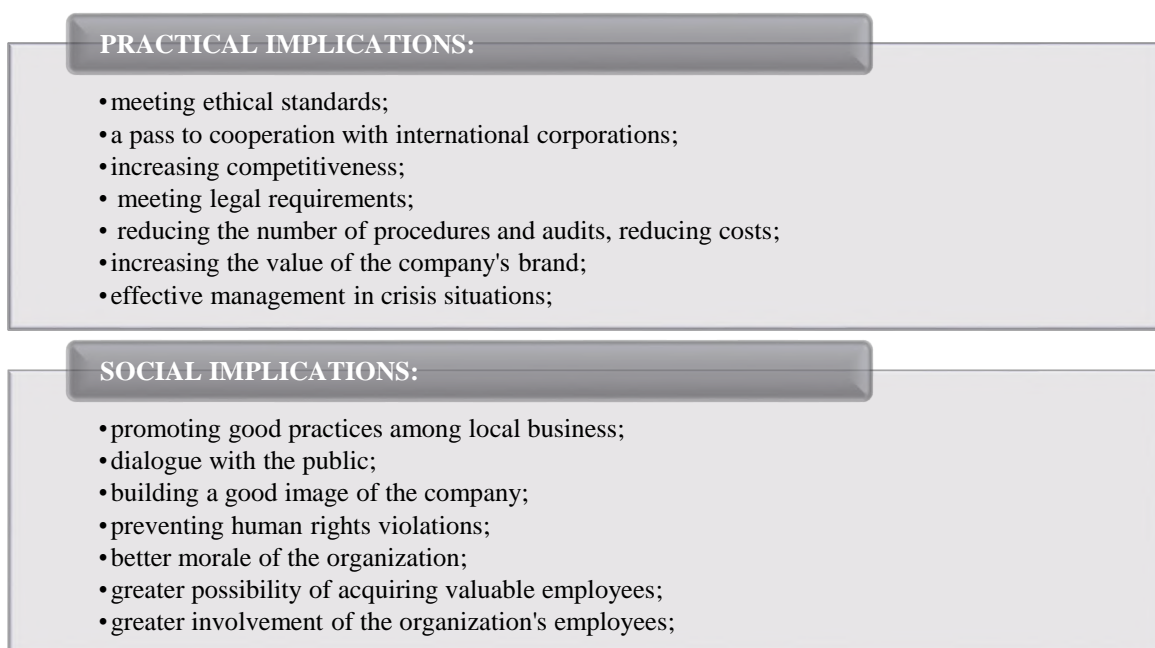
- 1) conducting training in the field of:
  - cultural differences,
  - differences resulting from the form of employment,
- 2) conducting periodic audits of contracts concluded by employment agencies with employees,
- 3) control over the deadlines in the delivery of work clothes and the dates of washing clothes that employees have provided under an employment contract,
- 4) discretionary bonuses for those employees who train newly hired employees, in particular foreigners,
- 5) in the information leaflet for employees it is worth including:
  - brief information about the form of employment, in particular about the type of contract and what results from it, in particular pay attention to issues related to medical care and taxation,
  - dictionary of basic phrases/words used on a daily basis, in particular at work.

## 5. Summary and conclusions

The company's management is increasingly convinced that it is worth being a socially responsible employer who, through the right policy in the area of employee relations, gains over the competition.

Changing environment, among others: pandemic, demographic trends, changes in the labor market, inequalities and social disproportions, technological development, globalization, pose new challenges to enterprises. Companies are increasingly recognizing the need for a broader openness to groups of employees, including the goals and life priorities of society.

From the material collected in the course of research and the analyses carried out, practical and social implications can be indicated (Figure 3).



**Figure 3.** Practical and social implications.

Source: own elaboration.

On the basis of the interviews, the following conclusions can be drawn: there is a visible cultural difference both in everyday behavior and work between Poles and foreigners, which affects human relations and the sense of exclusion, and this has a direct impact on the quality of work.



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## ORGANISATIONAL MANAGEMENT METHODS AS KNOW-HOW

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**Purpose:** The purpose of this article is to answer the question of whether a method of managing an organisation can be protected by the organisation using it against use by another entity, in particular as know-how.

**Design/methodology/approach:** The considerations of the present article are based on the literature on the subject and the case law of common and administrative courts. These materials were subjected to critical analysis.

**Findings:** The analysis leads to the conclusion that a method of managing an organisation cannot be the subject of exclusive rights, and its protection under certain conditions is only possible as a business secret under the provisions on combating unfair competition.

**Practical implications:** The use by organisations of certain management methods gives rise to the need to protect them from use by other organisations, in particular competing entrepreneurs. The article identifies the legal bases that can be the basis for such protection, creating a framework for their practical use.

**Originality/value:** The problem of qualification of organization management methods from the point of view of intellectual property law has not been researched so far, especially in Polish literature. The addressees of this research are, in particular, entrepreneurs who use diverse methods of business management in their activity.

**Keywords:** method, organisational management, intellectual property, know-how, intellectual property courts.

**Category of the paper:** research paper.

### 1. Introduction

The use of management methods in an organisation is important for the realisation of the goals set for that organisation, as well as for its competitiveness in relation to other entities, and therefore raises the question of the possibility of protecting that method, especially in a situation where the method used in the organisation is original in nature, against its use by another organisation, in particular a competing entrepreneur. Consequently, the analysis of this issue becomes important not only from the point of view of an organisation wishing to protect

the management method it uses, but also from the point of view of management and quality sciences. The purpose of this article is to answer the question of whether, and if so on the basis of which regulations and in what proceedings, an organisation may seek legal protection against this type of action, and in particular whether a management method may be protected as know-how?

## 2. Qualification of a management method as an object of exclusive rights

The literature points to the interchangeability of concepts such as method, technique, tool, concept, approach or management system, emphasising that they are instruments in the hand of the manager, facilitating the solution of management problems (Hopej, Kral, 2011), serving to give a specific image (shape) to the management system in the enterprise (Jagoda, Lichtarski, 2003). The terminological diversity occurring in management sciences is a consequence of the relative youth of this discipline of sciences, which results in the fact that not all conceptual categories have been clarified, which leads to ambiguity in their understanding and application. At the same time, the multiplicity of closely related terms found in this area of science often fosters the misapplication of particular terms, as well as difficulties in defining the relationship of such concepts as management method and technique (Matwiejczuk, 2009; Sobaczak, 2017).

Leaving aside the analysis of existing views as to the meaning of these concepts and their interrelationship, which has already been done in the literature (Sobaczak, 2017), it should be pointed out that in the management sciences, method is defined as a way of providing an internal, temporal and logical regulation of the course of the management process. Thus, a management method is defined as a way of proceeding and implementing undertakings aimed at solving management problems arising in a given organisation. (Matwiejczuk, 2009) For the purposes of further consideration, it should be assumed that an organisation's management method can be defined as a series of guidelines on how to effectively and efficiently manage the organisation in order to achieve strategic and operational goals, taking into account the market situation prevailing in a given industry. Management methods and techniques are subject to classification on the basis of differentiated methods (e.g. Blumenthal, Jannink, 2000; Brilman, 2002; Clayton, 2011; Csath, Trzcieliński, 2009; Efere, 2003; Goodwin, Wright, 2007; Hopej, Kral, 2011; Kapferer, 2012; McNeil et al., 2015), which, however, remains irrelevant for the further considerations contained in this article.

Before proceeding to the analysis of the possible qualification of an organisational management method as one of the intangible assets, attention should be drawn to the principle of the *numerus clausus* of rights on intangible assets, which governs them. This principle assumes that it is not possible to create new subjective rights of an absolute nature other than by means of a statutory act, in particular by means of a legal act or a court decision (Kurosz,

2021; Dybowski, 2003). Therefore, in order to protect the organisation's management method, it is necessary to qualify it as one of the subjects of exclusive rights specified by the legislator.

First of all, it should be pointed out that Article 1(2<sup>1</sup>) of the Act of 4 February 1994 on Copyright and Related Rights (consolidated text of Journal of Laws of 2022, item 2509, hereinafter referred to as the CRRA) explicitly excludes, inter alia, procedures, methods and principles of operation from copyright protection. It is emphasised that, on the one hand, they are a part of reality, inherent in it, although they have not been noticed so far for various reasons, and thus cannot be regarded as the result of creative activity, and, on the other hand, that granting property rights to such intangible goods would mean their monopolisation and the impossibility of free access to them by others (Ferenc-Szydełko, 2021). It is in this way that the methods (procedures, principles) of managing an organisation listed in the provision of Article 1(2<sup>1</sup>) CRRA will have to be assessed. Managing an organisation on the basis of certain principles, procedures, or methods was previously possible, although this possibility was not recognised, and the monopolisation of a certain method (e.g. benchmarking or controlling) would prevent its use in relation to a given type of organisation by other entities.

At this point, a distinction should be made between a given method of managing an organisation as a potential subject of exclusive rights and its description. The method itself, just as its description has an intangible form, with the difference that the description of a given management method may be fixed on a material carrier (*corpus mechanicum*). While the management method itself cannot be, in the light of Article 1(2<sup>1</sup>) of CRRA, the subject of copyright, which clearly results from this provision, its description can already be qualified as a work within the meaning of Article 1(1) of CRRA. In order for this to take place, the description of a management method has to meet four conditions - be a result of human activity, have a creative character, i.e. be a result of creative activity aimed at the creation of a new product, have an individual character, i.e. bear the stamp of the author, be original and be established, i.e. be externalised in a way that allows it to be perceived by third parties. The fact that a description of a management method as a work of literary character (Article 1(2)(1) of CRRA) meets the prerequisites qualifying it as a work should not pose major difficulties. Only that the object of protection as a work will then not be the method embodied in that description, but the description itself. In other words, copyright monopoly will cover the use in any field of exploitation (Article 50 of CRRA) of a description of a management method, but not the method itself. This means that although the specific description of the method will be protected as a work, the use of the method for the purpose of managing another organisation will be allowed.

Turning to the assessment of the possibility of protecting a method of managing an organisation on the grounds of the Act of 30 June 2000 Industrial Property Law (consolidated text of Journal of Laws of 2023, item 1170; hereinafter referred to as the IPL), it should be indicated that Article 28(1)(3) of IPL, which, based on Article 100(1) of IPL finds appropriate application to utility models, excludes the possibility of qualifying as an invention, as well as

a utility model, schemes, rules and methods of performing mental processes, playing games or conducting business activities. The lack of technical character of such solutions is cited as justification for this exclusion (Demendecki et al., 2015; Kostański, 2010). The sphere of technology does not go beyond the domain of the natural sciences, while its subject is the use of inanimate or animate matter. The sphere of technology, therefore, does not include solutions whose object is ideas of an abstract-intellectual nature, including organisational ones, as they solve intellectual or organisational problems (Kondrat, 2021), which is what organisational management methods are. The enumeration included in Article 28(1)(3) of IPL - similarly to the enumeration included in Article 1(2<sup>1</sup>) of CRRA - mentions directly the methods of conducting thought processes, and therefore it should be considered that methods of managing an organisation are excluded from industrial property protection due to their non-technical but organisational character.

However, while it should be excluded - due to the lack of possibility to qualify the method of managing an organisation as a solution of technical nature - to qualify it as an invention, utility model or topography of an integrated circuit, as well as industrial design, it seems to be possible to qualify it as a rationalisation project. This is because, according to Article 7(2) of IPL, any exploitable solution which is not a patentable invention, utility model, industrial design or a topography of an integrated circuit. This means that an organisational management method could be qualified as a non-technical, organisational solution comprising a set of techniques, indications and processes serving to solve a specific problem, which is the implementation of specific strategic and operational objectives in the conditions of an organisation of a given type. However, the condition for recognising such a method as a rationalisation project is that the entrepreneur recognises this type of solution as a rationalisation project in the rationalisation regulations adopted by the entrepreneur (Article 7(2) *in principio* in conjunction with Article 7(3) of IPL). As it follows from the above, the possibility of qualifying a method of organisational management as a rationalisation project applies only to such organisations that have the attributes of an entrepreneur and, moreover, have adopted the rationalisation regulations (Article 7(1) of IPL).

### **3. Qualification of a management method as know-how**

In view of the impossibility to qualify a management method as an object of exclusive rights specified in CRRA and IPL, the possibility of protecting a management method as specific know-how should be considered. This term includes both know-how which is generally known (so-called explicit know-how) and that which is confidential in nature (so-called secret, confidential know-how).



The basis for this protection of the latter should be seen in the regulation of Article 11(2) of the Act of 16 April 1993 on Combating Unfair Competition (consolidated text of Journal of Laws 2022, item. 1233, hereinafter referred to as the CUCA), which indicates that a trade secret is understood as not only technical or technological information, but also organisational information of the company or other information having economic value, which as a whole or in a specific juxtaposition and collection of its elements is not generally known to persons usually dealing with this type of information or is not easily accessible to such persons, provided that the person authorised to use or dispose of the information has taken, with due diligence, measures to keep it confidential.

As organisational information of an enterprise that may be qualified as company secrets, literature points to methods of quality control of goods and services, methods of marketing, or methods of work organisation (Szwaja, 2019), as well as principles of cooperation between individual departments of an enterprise (Nowińska, Szczepanowska-Kozłowska, 2022). Therefore, there can be no doubt that the business secrets subject to protection under Article 11 of CUCA may include management methods, provided that they fulfil the remaining statutory conditions of protection. At the same time, it should be borne in mind that due to the scope of application of the CUCA, only methods of managing an enterprise, and not other organisations, may be covered by this protection.

In turn, the condition for the information in question to be covered by the concept of business secrecy is that it is confidential and that it is covered by the entrepreneur's activities aimed at maintaining this confidentiality, as well as its economic value (Szwaja, 2019; Nowińska, Szczepanowska-Kozłowska, 2022). By its very nature, this excludes the possibility of the previously indicated well-known methods of managing an organisation to be covered as a business secret. On the other hand, it is not necessary for such information to be usable in another company (Szwaja, 2019), i.e. the management method of a given company due to its specifics may not be usable in other companies.

The disclosure, use or acquisition of someone else's information constituting a business secret constitutes an act of unfair competition (Article 11(1) of CUCA). Acquisition of such information is subject to qualification as an act of unfair competition, in particular when it takes place without the consent of the authorised person to use or dispose of the information and results from unauthorised access, appropriation, copying of documents, objects, materials, substances, electronic files comprising the information or making it possible to infer its content (Article 11(3) of CUCA). The use or disclosure of such information constitutes an act of unfair competition, also if it is done without the consent of the person authorised to use or dispose of the information and violates the obligation to restrict its use or disclosure arising from a statute, legal act or other act, or if it was done by the person who obtained the information by committing an act of unfair competition (Article 11(4) of CUCA) The disclosure, use or acquisition of such information also constitutes an act of unfair competition if, at the time of its disclosure, use or acquisition, the person knew or, exercising due diligence, could have known

that the information had been obtained directly or indirectly from the one who used or disclosed it in the circumstances specified in Article 11(4) of CUCA (Article 11(5) of CUCA). The use of such information consisting in manufacturing, offering, marketing, as well as importing, exporting and storing goods for these purposes constitutes an act of unfair competition if the person performing the indicated act knew or, exercising due diligence, could have known that the properties of the goods, including their aesthetic or functional properties, the process of their manufacture or sale, were substantially shaped as a result of the disclosure, use or acquisition of someone else's information constituting an enterprise secret, performed under the circumstances specified in Article 11(4) of CUCA (Article 11(6) of CUCA).

Acquisition of information constituting a business secret does not constitute an act of unfair competition if it was made as a result of independent discovery or manufacture or observation, examination, dissection, testing of an object available to the public or possessed in accordance with the law by a person who acquired the information and whose right to acquire the information was not restricted at the time of its acquisition (Article 11(7) of CUCA). The disclosure, use or acquisition of information constituting an enterprise secret shall also not constitute an act of unfair competition where it has occurred in order to protect a legitimate interest protected by law, in the exercise of freedom of expression or in order to disclose irregularities, misconduct, acting in breach of the law for the protection of the public interest, or where the disclosure of information constituting an enterprise secret to employee representatives in connection with the performance of their functions under the provisions of the law was necessary for the proper performance of those functions (Article 11(8) of CUCA).

#### **4. Claims for infringement of a business secret in the form of a management method**

As can be seen from the above, a method of managing an organisation - if the statutory requirements are met - can be qualified as a rationalization project, or can be protected as a company secret. In practice, however, a specific method of managing an organisation will be protected under the provisions of the CUCA. This results from the fact that the legislator has adopted a different model of protection for rationalization projects than for other industrial property rights, which have been shaped as subjective rights of an absolute nature. Consequently, an entrepreneur whose employee has created a rationalization project in the form of a specific management method is not entitled to the protection belonging to civil subjective rights of an absolute nature. (judgment of the Voivodship Administrative Court in Wrocław of 12 January 2010, I SA/Wr 1602/09, LEX no. 559606; Skubisz, 2012; Żelechowski, 2021)

The basic catalogue of claims to which the entitled organisation is entitled includes, first of all, the claim for discontinuance of the prohibited acts (Article 18(1)(1) of CUCA) and for removal of the effects of the prohibited acts (Article 18(1)(2) of CUCA). In addition, an entrepreneur affected by an act of unfair competition may claim the release of wrongfully obtained benefits (Article 18(1)(5) of CUCA), however the release of the wrongfully obtained benefits should be made in accordance with the general rules, i.e. the rules specified in the Act of 23 April 1964 - Civil Code (consolidated text of Journal of Laws of 2022, item. 1360; hereinafter referred to as the CC). The entrepreneur affected by the act of unfair competition should also compensate for the damage caused to the aggrieved party by the act of unfair competition in accordance with general principles specified in the CC (Article 18(1)(4) of CUCA). Moreover, an entrepreneur affected by an act of unfair competition, in a situation where the act of unfair competition was of a culpable nature, may claim an award of an appropriate sum of money for a specific social purpose related to the support of Polish culture or protection of national heritage (Article 18(1)(6) of CUCA), the so-called "penance". Irrespective of the abovementioned claims, an entrepreneur affected by an act of unfair competition may demand one or several announcements of a declaration of appropriate content and form (Article 18(1)(3) of CUCA). This demand includes the possibility to demand dissemination of the statement not only in the press, but also in any other manner not excluding the press and the Internet. Finally, pursuant to Article 18(2) of CUCA, the court, upon the motion of the entitled party, may also rule on products, their packaging, advertising materials and other objects directly related to the commission of the act of unfair competition. In particular, the court may order that they be destroyed or credited as damages.

Irrespective of the above claims, the provisions of the CUCA provide for specific legislative solutions addressed to the situation of committing acts of unfair competition consisting in infringement of business secrets. Firstly, due to difficulties in determining the causal link between the act of the perpetrator of an act of unfair competition and the damage, as well as the amount of the damage itself, an entrepreneur affected by an act of unfair competition in the form of infringement of its business secrets may seek, as an alternative to damages on general terms (Article 18(1)(4) of CUCA), lump sum damages. It takes the form of payment of a sum of money in the amount corresponding to the remuneration which, at the moment of its enforcement, would be due for granting by the authorised party consent to the use of information constituting a business secret (Article 18(5) of CUCA).

Secondly, an entrepreneur affected by an act of unfair competition consisting in an infringement of business secrecy may demand that the defendant is obliged to publish information about the judgement or the content of the judgement, in a specified manner and to a specified extent, if it is justified by the circumstances of the act of unfair competition, in particular the manner in which the act was committed, the value of the information to which the act relates, the effect of the act and the likelihood of the commission of the act of unfair competition in the future and, where the defendant is a natural person, if it is not precluded by

the defendant's legitimate interests, in particular the protection of the defendant's personal rights. However, the manner and scope of public disclosure of information on the judgement or its content may not lead to disclosure of a business secret (Article 18(3) of CUCA), thus in the case in question, of the management method used in the given enterprise.

Thirdly, in the case of an act of unfair competition consisting in the infringement of a business secret, the court, instead of granting a request for the cessation or elimination of the effects of the prohibited acts, or a ruling on the products, their packaging, advertising materials and other objects directly related to the commission of the act of unfair competition, may, at the defendant's request, oblige the defendant to pay the claimant appropriate remuneration, in an amount not higher than the remuneration which, at the time of the claim, would have been due as a result of the right holder's consent to use the information, for a period of time not exceeding the cessation of the state of secrecy, if three conditions are met, i.e. the defendant, at the time of using or disclosing the information constituting the business secret, did not know or, with due diligence, could not have known that the information had been obtained from the person who used or disclosed it in the circumstances referred to in Article 11(4) of CUCA, the granting of the demand for abandonment would cause disproportionate damage to the defendant, and the obligation to pay remuneration does not infringe the plaintiff's legitimate interest. (Article 18(4) of CUCA)

## **5. Investigating claims for infringement of a business secret in the form of a management method**

As of 1 July 2020, by virtue of the regulation of the Minister of Justice of 29 June 2020 on transferring to certain district courts the examination of intellectual property cases from the jurisdiction of other district courts (consolidated text of Journal of Laws of 2022, item 1398), intellectual property divisions were separated in the structure of district courts in Gdańsk, Katowice, Lublin, Poznań and Warsaw. Thanks to this procedure and to entrusting the cognizance of appeals against decisions of these district courts to the Courts of Appeal in Poznań and Warsaw, a structure of specialised courts (hereinafter referred to as intellectual property courts) dealing with the cognizance of intellectual property cases was created (Kurosz, 2021).

The notion of intellectual property case was defined in the introduction to the Act of 17 November 1964 - Code of Civil Procedure (consolidated text Journal of Laws of 2021, item 1805 as amended; hereinafter referred to as the CPC) by virtue of the Act of 13 February 2020 amending the Act - Code of Civil Procedure and certain other acts (Journal of Laws of 2020, item 288) Article 479<sup>89</sup> of CPC. In the light of Article 479<sup>89</sup> § 2(1) of CPC, intellectual property cases are also cases for combating unfair competition. Thus, in the situation where the

management method of an organisation may be qualified as a business secret, the enforcement of claims in the case of infringement of such a secret, i.e. committing an act of unfair competition, as specified in Article 11(1) of CUCA, will take place before the intellectual property court.

Classification of the above-mentioned case as an intellectual property spray entails not only subjecting it to the jurisdiction of intellectual property courts, but more importantly, their examination within the framework of separate proceedings in intellectual property cases covered by the regulation of Article 479<sup>89</sup>-479<sup>129</sup> of CPC. Thanks to it, an entrepreneur who has been harmed by an act of unfair competition will be able to use a specific legal institution which is characteristic only of proceedings in intellectual property cases and which facilitates the pursuit of his/her claims, in particular claims for compensation and return of unjustified benefits, such as securing evidence (Article 479<sup>96</sup>-479<sup>105</sup> of CPC). This request may be made by an entrepreneur both before bringing an action and during the proceedings (Article 479<sup>97</sup> § 1 of CPC).

On the other hand, such an entrepreneur will not be able to use the two remaining auxiliary measures provided for in the regulations on proceedings in the field of intellectual property, i.e. disclosure or issuance of evidence (Article 479<sup>106</sup>-479<sup>111</sup> of CPC) and request to provide information (Article 479<sup>112</sup>-479<sup>121</sup> of CPC). In the case of an application for disclosure or issuance of a measure of evidence and a request for information, the application of these institutions is limited - as follows respectively from Article 479<sup>106</sup> *in principio* of CPC and Article 479<sup>113</sup> § 1 of CPC - only to cases of infringement of exclusive rights referred to in Article 479<sup>89</sup> § 1 of CPC, thus it is not possible in cases of acts of unfair competition (so the Court of Appeal in Warsaw in its decision of 15 December 2021, ref. no. VII AGz 498/21, not published; differently the Court of Appeal in Poznań in its decision of 5 April 2022, I AGz 5/22, not published).

Furthermore, it should be noted that an entrepreneur who has been harmed by an act of unfair competition has the possibility to use the institution of securing a claim (Article 730-757 of CPC), which allows him/her in particular to discontinue the use of his/her business management method by a competitor even before the decision allowing the action has been obtained. This procedural institution in intellectual property cases is characterized by certain specificity resulting from the changes introduced by the Act of 9 March 2023 amending the Act - the Code of Civil Procedure and certain other acts (Journal of Laws of 2023, item 614). It is expressed, in particular, in the departure in these cases from the principle of *ex parte* proceedings, which is the rule, in favour of a hybrid model with adversarial proceedings dominating and exceptions in favour of *ex parte* proceedings in the case of securing non-pecuniary claims (Antoniuk, 2023).

## 6. Concluding remarks

The considerations carried out lead to several conclusions. Firstly, it is not possible to protect the method of managing an organisation under copyright law as such, but only its description, which can be qualified as a work within the meaning of PrAut. Secondly, the possibility of protecting a method of managing an organisation as a solution subject to exclusive rights should also be excluded. Thirdly, it is possible to qualify it as a rationalisation project, provided that such a method is recognised as a rationalisation project by the entrepreneur in the rationalisation regulations adopted by it.

Fourthly and finally, an original management method used in an organisation may be protected as a business secret provided that the method meets the requirements to qualify as a business secret. In such a situation, an entrepreneur affected by an act of unfair competition will be entitled to a wide range of claims provided for in the CUCA. Pursuing these claims will take place within the framework of separate proceedings in intellectual property cases before specialised intellectual property courts, which is intended by the legislator to increase the quality of decisions in intellectual property cases.

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## DEVELOPMENT OF ENERGY COMPANIES BASED ON RENEWABLE ENERGY SOURCES

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**Purpose:** The aim of the article is to analyze the actions taken by enterprises aimed at implementing renewable energy sources (RES) in order to achieve a zero-emission economy. Analyzing these initiatives will provide insight into the development of the renewable energy sector and the impact of companies on global efforts to reduce greenhouse gas emissions.

**Design/methodology/approach:** The research was carried out on the basis of secondary sources and own observations. The literature on renewable energy was analyzed, including photovoltaics and reports from energy companies. The use of the desk research method based on reliable sources allowed us to obtain a large amount of data constituting the basis for drawing conclusions.

**Findings:** The results of the conducted research will show the direction in which energy companies are developing and which segments related to renewable energy will develop the most and fastest. The research results will support enterprises in implementing appropriate strategies related to achieving a zero-emission economy.

**Practical implications:** Energy companies can leverage the findings of this research to formulate and execute strategies for attaining a zero-emission economy. The insights from these studies offer direction on optimal approaches, technologies (e.g. photovoltaics farms and their orientation) and business models that can effectively mitigate greenhouse gas emissions and minimize adverse environmental effects.

**Social implications:** The implementation of renewable energy sources by energy companies contributes to achieving a zero-emission economy, which at the same time reduces the negative impact on the environment. These activities generate significant social effects, such as improving the quality of life, weather conditions and reducing energy poverty, enabling universal access to electricity. Additionally, the development of renewable energy technologies and improved energy efficiency can attract foreign investment, opening new opportunities for the export of green technologies, which in turn translates into economic growth and the creation of new jobs.

**Originality/value:** The novelty of the research is the presentation of the directions in which enterprises will develop to adapt to external requirements and enable the implementation of tasks in the field of renewable energy and energy efficiency. This provides the basis for the development of new technologies and innovative solutions. east-west orientation of photovoltaic panels. Enterprises can use this research to design and implement modern

solutions, such as digitalization, developing more efficient photovoltaic panels, building energy storage facilities or smart energy grids.

**Keywords:** energy, photovoltaics, renewable energy, zero-emission, strategy, innovations.

**Category of the paper:** Research paper.

## 1. Introduction

Energizing the development of renewable energy sources (RES) across all sectors is becoming a pivotal element in addressing contemporary challenges, such as energy independence, national sovereignty, and enhancing quality of life through environmental preservation. Given the current economic and political situation in Europe, restricting the ability to import energy resources from the Russian Federation, European Union member states are compelled to take actions aimed at increasing the utilization of RES (Borowski, 2022).

Renewable energy sources constitute a significant element in diversifying the electricity generation mix, crucial for the energy security of nations (Bigerna et al., 2021; Borowski, 2022). The goal by 2050 is for over half of the electricity production to originate from renewable sources. In this context, further development of wind and solar power capacities plays a crucial role, along with intensified efforts to leverage weather-independent RES.

The year 2023 marks another stage in the dynamic development of the renewable energy sector, setting a new record for the increase in installed capacity. The undeniable leader in this trend is photovoltaics, maintaining not only its dominant position but also gaining importance as the main player in the RES market (Alkan, Ates 2023). The growth in installed capacity from photovoltaics results not only from technological advancements but also from growing societal awareness and government initiatives supporting sustainable development (Biermann et al., 2022). Photovoltaic panels are becoming increasingly efficient, cost-effective, and simultaneously more accessible to various societal sectors.

Future forecasts are promising, indicating that the upward trend in installed capacity from photovoltaics will continue until 2050. This period is anticipated as a time of systematic development in this technology, encompassing both the improvement of panel efficiency and the advancement of more sophisticated energy storage systems (Agrawal et al., 2022).

The increasing installed capacity from photovoltaics reflects global efforts to transition away from traditional energy sources, such as fossil fuels, in favor of more sustainable and environmentally friendly alternatives. Companies, governments, and consumers are increasingly recognizing the benefits of using renewable energy, including reducing greenhouse gas emissions and decreasing dependence on non-renewable resources.

## 2. Methods

In this study a qualitative approach was applied, which is suitable for this type of scientific analysis. In the first stage, data were collected and examined from available materials already published, encompassing an extensive review of existing literature, including energy policy frameworks, scientific articles, statistical data, and industry reports. The analysis of these secondary data plays a crucial role in situating the strategies of energy companies aiming for a zero-emission economy. In the study, the qualitative approach was employed in the context of the changing energy landscape, i.e., the transition from fossil fuels to renewable energy sources and the imperative to implement sustainable development. The integration of diverse data sources and robust qualitative analysis techniques facilitated a comprehensive analysis of companies facing environmental challenges, enhancing energy efficiency and shedding light on the role of renewable energy-based energy companies in shaping the future of sustainable energy.

For the analysis of the research findings obtained through desk research, a content analysis method was employed. This method involves a systematic examination and categorization of textual data from published policy documents, academic literature, and industry reports.

Such an approach aids in the identification of key policy frameworks, trends, and regulatory influences impacting the strategies of energy companies. The integration of diverse data sources and robust qualitative analysis techniques facilitated a comprehensive analysis of companies' responses to environmental challenges.

## 3. Literature review

As part of the literature review, the focus was placed on analyzing key and leading scientific positions, primarily from the years 2022 and 2023, with the aim of identifying the latest trends related to the use of renewable energy sources (RES) (Zhang et al., 2023). The presented studies contribute significantly to understanding the current situation and development directions in the field of renewable energy (Zhang et al., 2023). A compelling trend in global energy production is the gradual replacement of energy from fossil fuels, such as coal and oil, with renewable energy (Liu, Feng, 2023). The primary factor influencing climate change is primarily human activity and the functioning of enterprises (Zastempowski, 2023). Electricity generated from renewable sources, coupled with research and development in renewable energy, and the implementation of new environmentally friendly technologies, significantly reduce emissions resulting from consumption and encourage environmental sustainability (Gao, Chen, 2023; Czepło, Borowski, 2024).

When analyzing the efficiency of energy production from renewable sources, particular attention must be paid to the dependence on natural conditions, especially concerning solar and wind power plants. Problems arise with their participation in the balancing process of the power system (Smolarz et al., 2023; Halkos, Tsirivis, 2023). In analyzing the energy system, dealing with planning future scenarios with a high level of variability associated with renewable energy sources is essential (Chang et al., 2021). Developing a model of the energy system requires integrating and optimizing the use of renewable energy sources, mainly consisting of hydro, solar, and biomass energy, through the implementation of new management strategies (Gul et al., 2023).

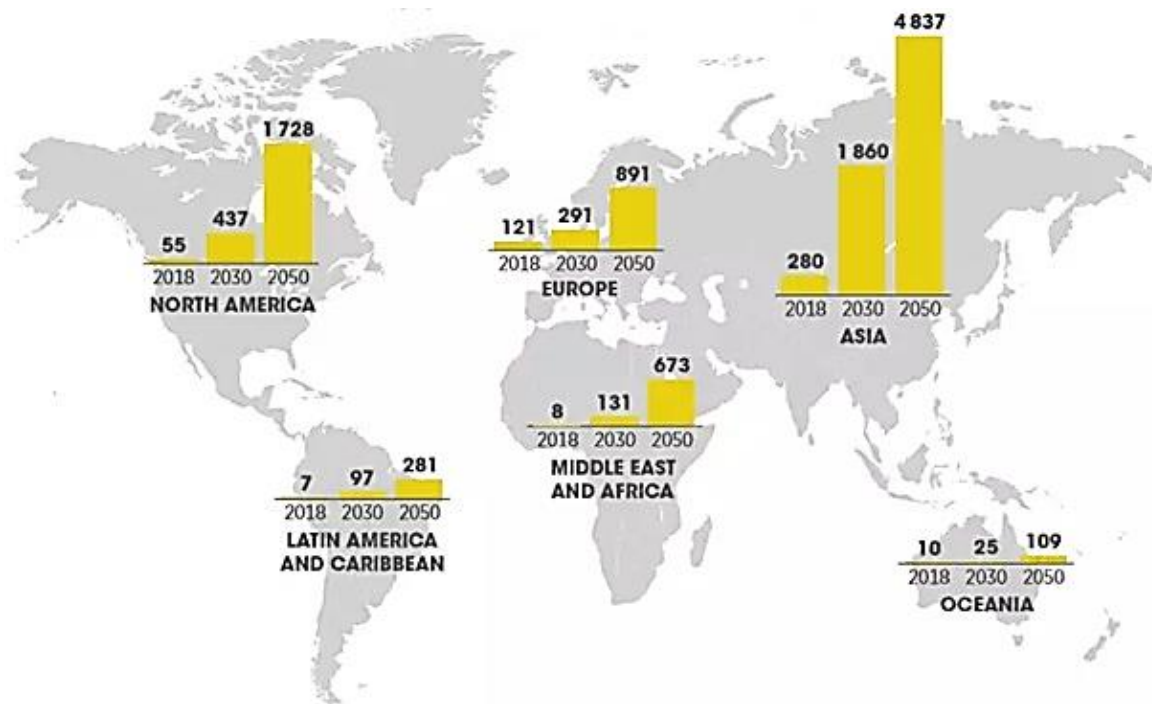
One of the crucial renewable sources is solar energy (Czepło, Borowski, 2024). Solar photovoltaics (PV) is a clean and sustainable technology with unlimited potential (Agrawal et al., 2022) and exponential growth (Naraghi, Atefi, 2022) in terms of global installed capacity (Ballif et al., 2018). Photovoltaics can play a vital role in achieving sustainable development goals (Nwokolo et al., 2023). In terms of the efficiency of photovoltaic panels, the mounting angle (Yoon et al., 2023) and orientation relative to the sun are crucial factors (Alkan, Ates, 2023; Czepło, Borowski, 2024).

Among the examined publications from the last two years, efforts were made to extract key observations and innovations regarding the use of RES. This analysis covered various aspects, such as technologies used in renewable energy production, innovative technical solutions, market trends, and the impact of RES on sustainable development. The results of the literature review shed light on the latest achievements and challenges in the field of renewable energy, revealing dynamic changes that have occurred in recent years (Alam et al., 2023; Khaleel et al., 2023). It provides current knowledge that can be significant for both the scientific community and practitioners involved in the development and implementation of renewable energy sources.

## **4. Results and discussion**

### **4.1. Development of renewable energy sources**

In the context of global challenges related to climate change and environmental pollution, the development of photovoltaics by 2050 can be a crucial element of energy transformation. It is expected that investments in this sector will continue, supporting the development of photovoltaic infrastructure on a global scale. As a result, photovoltaics will not only provide an increasing amount of energy but also contribute to job creation, technological innovations, and a global improvement in the environment. The forecast for the growth of installed capacity is presented in Figure 1.



**Figure 1.** Solar PV installed capacities [GW].

Source: (Informatic Global Solar PV).

The global trend of constructing new renewable energy farms is clearly noticeable, with a growing installed capacity worldwide. In the recent period, out of 510 GW of new installed capacity, nearly 400 GW is attributed to solar energy (Renewables, 2023). This distinctly attests to the dominance of photovoltaics in the global energy transformation landscape (Naraghi, Atefi, 2022). Solar energy becomes the undisputed leader among renewable sources, and its increasing share in new installations confirms the effectiveness of this technology in producing clean energy. The growth in installed capacity from photovoltaics results from several key factors (Ballif et al., 2018).

Firstly, the continuously evolving technology of solar panels contributes to increased efficiency, making solar energy more attractive and cost-competitive compared to traditional energy sources.

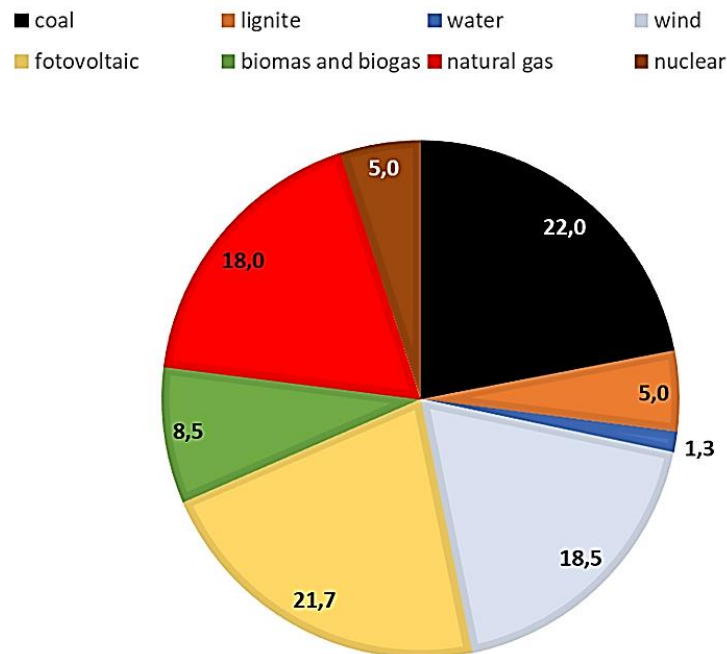
Secondly, the growing awareness of society and governmental initiatives for sustainable energy accelerates the adoption of solar energy. Consumers, businesses, and countries increasingly recognize the benefits of using renewable energy sources, and photovoltaics become one of the most attractive solutions.

Thirdly, the ecological and economic benefits associated with solar energy translate into global governmental support. Subsidies, tax incentives, and regulations favoring renewable energy create favorable conditions for the development of new photovoltaic farms.

Forecasts suggest that the trend of increasing installed capacity from photovoltaics will persist, bringing not only increased energy production but also creating new jobs, stimulating technological innovations, and accelerating the decarbonization process of the global economy.

Solar energy becomes a key element in the global energy transformation, aiming for a more sustainable and ecological future.

In second place is wind power, followed by biomass, hydropower plants, and other energy sources. The forecast for 2040 predicts a 40% share of renewable energy in the energy mix. Figure 2 illustrates the percentage share of individual elements in the energy mix.



**Figure 2.** Energy mix in 2040.

Source: own elaboration based on (IEA, 2023).

The development of utilizing wind, solar, water energy, biomass, biogas, or geothermal heat will become a significant goal, allowing for the maximum utilization of diverse natural resources. Particularly crucial will be directing efforts towards technologies enabling the efficient use of energy in any conditions, allowing independence from weather instability (Zhang et al., 2023).

In the social and economic context, a significant aspect will be the development of renewable energy sources (RES) in energy clusters and energy cooperatives. Establishing local energy structures not only increases efficiency but also activates local communities and creates job opportunities. Furthermore, hybrid installations that combine various energy sources represent an innovative solution, enabling flexible and stable energy production.

The dynamism in the development of RES constitutes a key strategy for achieving energy independence, national sovereignty, and improving the quality of life. In the context of contemporary challenges, such as limitations on the import of energy resources, the integration of RES becomes imperative for the member states of the European Union.

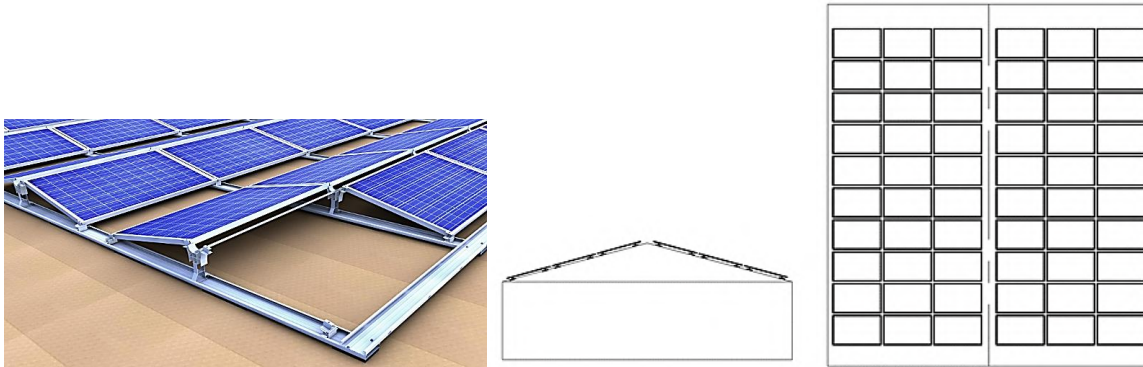
## 4.2. Improving energy efficiency

In a general sense, energy efficiency refers to the ratio of used energy to achieved results or benefits. In the context of energy use, it involves taking actions to maximize the obtained effects based on the used energy to achieve the desired outcome with minimal energy consumption (Wojdalski et al., 2023). This encompasses various sectors such as manufacturing, transportation, industry, construction, and other economic sectors. Improving energy efficiency involves implementing measures to reduce the amount of consumed energy while maintaining the level of performance or increasing efficiency with constant energy consumption. There are several ways to enhance energy efficiency in different areas. One of the key actions is technological modernization. Technological modernization, concerning energy efficiency, aims to replace older and less efficient devices and technologies with more modern and innovative solutions that consume less energy to achieve the same or better results. Several crucial aspects can be considered to understand how technological modernization contributes to improving energy efficiency. Innovative technological solutions employ advanced materials and utilize innovative designs. Modern technologies often incorporate more advanced materials and engineering, resulting in lighter, more durable, and more efficient components. This, in turn, translates into reduced energy consumption during production, transportation, and usage. Modern materials and innovative technological solutions play a crucial role in improving energy efficiency across various economic sectors. Introducing innovative manufacturing processes based on advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), or robotics can lead to reduced energy consumption in industrial processes (Khaleel et al., 2023; Nwokolo et al., 2023). Monitoring and optimizing energy consumption are becoming more accessible through advanced production management systems. The use of modern technologies within smart energy grids allows better management of energy distribution (Zhang et al., 2023). These systems enable the optimization of consumption, the monitoring of faults, and more effective responses to changes in demand, contributing to increased energy efficiency. In energy companies and other industrial sectors, more efficient devices, machines, engines, and technologies are applied. Modern engines, machines, and devices are usually optimized for energy efficiency. They can operate more smoothly, generate less heat during operation, and more efficiently convert input energy into output energy (Wojdalski et al., 2023). Modern automation and control systems enable more precise management of processes. Optimizing production processes and introducing innovations and improvements in industrial processes help minimize energy losses. This allows adjusting energy consumption to actual needs, avoiding excessive consumption when full power is unnecessary. Smart energy management systems and the introduction of intelligent solutions enable optimal adjustment of energy consumption to changing conditions and demand. Smart energy grids enable coordinated actions of different devices to optimize energy consumption. Through technological modernization, both companies and consumers can use

energy more efficiently, saving natural resources and simultaneously reducing costs associated with its usage. This approach also has a significant impact on reducing greenhouse gas emissions and related environmental benefits. Improving energy efficiency not only reduces energy consumption but also contributes to limiting greenhouse gas emissions and mitigating the impact on the natural environment. In many cases, it is also economically beneficial as it lowers costs associated with energy consumption.

#### 4.3. Improving the energy efficiency of photovoltaic panels through the use of an east-west orientation

Orienting solar panels in an east-west direction is a strategy aimed at optimizing the efficiency of solar energy generation by these panels (Hartner et al., 2015). In contrast to the traditional arrangement of panels facing south, an east-west orientation allows for better utilization of available solar energy throughout the day. The layout of panels on a flat roof and the east-west installation scheme are illustrated in Figure 3.



**Figure 3.** Installation scheme of PV panels, east-west orientation.

Source: (*PV Montagesysteme für Flachdach*; Czepło, Borowski, 2024).

Orientation of solar panels in an east-west direction also brings cost-related benefits in terms of installation and maintenance. This is derived from several key factors, such as a reduced number of installed frames, improved sunlight exposure, and easier integration with existing infrastructure. The east-west layout allows for the use of fewer supporting frames for the panel structure compared to the traditional north-south orientation. Consequently, costs related to the production, transport, installation, and maintenance of these supporting structures can be reduced. Integration with existing infrastructure is also facilitated. In many east-west layouts, panel structures can be more easily integrated with existing infrastructure, such as building roofs or areas with limited space. This, in turn, can lead to a reduction in the cost of adapting existing space for solar panel installation.

In an east-west direction, there is a lower risk of shading between panels. With an east-west panel arrangement, the risk of shading between panels is lower compared to the traditional south-facing orientation. Less shading means fewer panels are exposed to efficiency loss, translating into long-term return on investment.



Due to the reduced number of frames and better access to individual panels, maintenance, servicing, and potential repairs can be more efficient and less costly. A lower number of structures also facilitates monitoring and diagnosing potential issues. An east-west orientation provides greater flexibility in installation planning, allowing for better adaptation to specific terrain conditions and avoiding costly land modifications. Orienting solar panels in an east-west layout can bring cost benefits associated with fewer installed frames, a significant factor when assessing the feasibility of photovoltaic projects. This approach may be particularly attractive in situations where infrastructure costs are a key decision-making factor.

East-west panel orientation allows for the even utilization of solar energy throughout the day. As a result, energy generation begins early in the morning on the east side, peaks at noon, and continues until sunset. This sustainable temporal distribution can be especially beneficial for energy systems that require constant access to electricity throughout the day. Orienting panels east-west, rather than southward, enables the generation of more energy in the morning, with panels facing west generating power in the late afternoon.

Compared to a unidirectional panel arrangement, an east-west orientation helps minimize production losses during momentary shading or the appearance of clouds, which can affect panel efficiency. This makes the system more resilient to variable weather conditions. Improving energy efficiency through east-west orientation is particularly effective in regions with unstable weather conditions or changing sunlight intensity during the day.

East-west orientation may be particularly effective in areas with specific geographic conditions, such as narrow valleys, where natural obstacles may affect access to sunlight from one direction. Similarly, favorable placement occurs in urban areas where access to space may be limited. East-west orientation can be a more flexible option, allowing for panel installation on building roofs without the need for always precise south-facing alignment.

However, the decision to orient panels east-west should be tailored to specific local conditions, sunlight availability, and installation goals. In some cases, especially in areas with more stable sunlight access, traditional south-facing orientation may still be more efficient.

## **5. Summary**

The use of renewable energy sources is a crucial factor in reducing greenhouse gas emissions, which becomes essential in the context of global challenges related to climate change. Simultaneously, the transition from fossil fuels to renewable energy sources allows for independence from raw material imports, especially in the context of current difficulties associated with the energy crisis.

Increasing the share of renewable energy sources in the energy mix has the potential for development, enabling the evolution of the economy towards a zero-emission model. This is not only a step towards sustainable development but also a significant factor influencing the improvement of air quality and the overall environmental condition. Energy efficiency plays a non-negligible role in the context of sustainable energy use, both in energy companies and on an economy-wide scale. Effective energy management and process optimization form the foundations upon which sustainable development is built.

Photovoltaics, as one of the most dynamically developing areas of renewable energy, plays a crucial role in this transformation. Research on optimal technical solutions, such as the orientation of photovoltaic panels in an east-west layout, is a significant element in the pursuit of maximizing the efficiency of solar energy production.

Therefore, the continuation of scientific research, investments in the development of modern technologies, and the strengthening of international cooperation in the field of renewable energy sources are crucial for building a sustainable energy future. Striving for a zero-emission economy requires joint efforts, innovative approaches, and ongoing commitment from both the public and private sectors.

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## VIRTUAL COOPERATION – A CONTEMPORARY VIEW ON THE COLLABORATION BETWEEN BUSINESSES IN THE 21ST CENTURY

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**Purpose:** To analyze the four key pillars of virtual organizations and assess the impact of business management solutions on the quality of information management.

**Design/methodology/approach:** The study deeply analyzed the four primary pillars that support a virtual organization, namely its primary goal, common telecommunication/IT network, mutual trust, and people. The research adopted both descriptive and comparative analytical methods, as well as synthetic methods, to study and compare various approaches to managing a virtual organization. The Shapiro-Wilk test determined the adoption of parametric significance tests.

**Findings:** The management process in a virtual organization is intricately connected to the quality of the four main pillars. Especially significant is the role of people, who are considered the primary capital in this organizational model. Efficient management of a virtual organization leads to flexibility, innovation, and achieving effective results through the adept utilization of human and technological resources.

**Research limitations/implications:** While the research provides an extensive understanding of the workings and factors influencing virtual organizations, the findings are based on the views of the 355 respondents, which may limit its generalizability.

**Practical implications:** The findings offer pragmatic guidance for managers and practitioners in the realm of managing virtual organizations. It emphasizes the need to focus on the quality and efficiency of the four main pillars, especially on human resources, to ensure the success and innovation of the virtual organizational model.

**Originality/value:** The article offers a fresh perspective on the research of virtual business cooperation in the 21st century. By amalgamating various research methods and analyzing responses from a diverse group of respondents, it reveals a deeper understanding of the factors that influence the success and management of virtual organizations. It underscores the significance of human resources and technology in this modern business model.

**Keywords:** virtual organization, virtual cooperation, human resources, technology resources.

**Category of the paper:** research paper.

## 1. Introduction

During the times of the digital transformation, businesses operating in every sector have to adapt their strategies and organizational structures to new challenges and opportunities. In this context, the concept of virtual cooperation has been gaining importance as a contemporary view on the collaboration among enterprises in the 21st century. Throughout the era of digital technologies and continuous technology advancement, ways of communication and collaboration has undergone dramatic transformation. Against this background, the new concept of virtual cooperation has come into existence. The article attempts at investigating modern enterprises defining this form of collaboration for themselves to face the challenges and the rapidly changing reality of the 21st century.

Virtual cooperation, meaning a system of coordinated intentional activities undertaken by business operators in the online space, has revolutionized the traditional business models. Teams, often scattered around the world, connecting with each other via new technologies, are capable of operating in an efficient and productive manner, overcoming the limits of time and space. This is much more than simply online work; this is a new philosophy of management, a new model of interaction and interdependence. Virtual organizations, which operate in the virtual space, are new on the market. Unlike traditional organizations with their physical presence, virtual organizations are characterized by gradually disappearing physical components such as offices or production buildings. Instead of managing a concrete physical structure, virtual organizations tend to develop into flexible networks with undefined borders. The virtual space is dominated by knowledge and imagination instead of the senses. To start a virtual organization, first you need to build an appropriate virtual space. Virtual space is a completely innovative phenomenon that contributes to dramatic change, eliminating the physical space limitations typical of states of nations, thus becoming a harbinger of globalization. The size of a virtual space depends on the system's capability to cover multiple users. Organizations have to continuously create and obtain knowledge to be able to fully benefit from the virtual space. Management of virtual organizations requires compromise in terms of the corporate culture, knowledge base and range of control. Flexibility, creativity and control systems are essential for the performance of virtual organizations. Hence, design of virtual organization consists of balancing the conceptual space with technological space and cultural space. Technology is a tool enabling transformation of an organization's vision into reality. It is important for virtual organizations to have a clearly defined vision, understanding of how virtual space works, and appropriate knowledge management capabilities. Therefore, it is reasonable to ask a question of how virtual cooperation affects the strategies of enterprises, which technologies are essential for its effective implementation, which advantages and challenges are involved in this revolutionary concept. Is virtual cooperation the future of all businesses, or is it perhaps only a transitional trend, bound to disappear as soon as another innovation emerges?

## 2. Literature review

A virtual organization, also known as a virtual enterprise, is based on four main pillars. The first of these pillars is the primary goal, fundamental and determining the actions of all partners. The second pillar is the shared IT/communication network as necessary infrastructure for the functioning of the organization (Chung, Huang, 2021). The third pillar is the mutual trust among members of a virtual organization (Hacker et al., 2019, p. 23.), which helps eliminate the consequences of limited control in a virtual environment. Finally, the fourth yet most important pillar is the people who contribute their knowledge and experience, constituting the only capital of a virtual organization (Zahar, Ismail, Rashid, 2021, pp. 8-14). Use of this potential may lead to quick and effective accomplishment of the intended goals (Brütsch, Frigo-Mosca, 1996, p. 33). There are a lot of various forms of virtual organizations (Dulebohn, Hoch, 2017, pp. 569-574), such as partnership in creating joint ventures, joint ventures as such, strategic alliances, combination of business organizations into a new corporation, building a network of businesses for the purposes of joint production and supply of distribution services. Virtual organizations may also be formed on the basis of cooperation agreements and contracts, copyrights, or purchases of contract licenses (Burton, Turner, Bettis, Burton, 2002, pp. 49-73).

Considering their nature, virtual organizations offer multiple benefits which may be particularly attractive for other businesses, particularly taking into account their flexibility, quick response to market changes (Eseryel, Crowston, Heckman, 2021, pp. 424-460.), more innovation, reduced costs, access to expert knowledge and resources (Liu, Gou, Camarinha-Matos, 2020, pp. 263-272), ability to compete globally (Lockwood, 2018, pp. 137-152).

It should be noted, however, that virtual organizations are not free of challenge (Robertson et al., 2022, pp. 451-464). In order to succeed, they need a strong IT/communication infrastructure for stability, data security and efficient exchange of information (Afsarmanesh, Camarinha-Matos, Msanjila, 2009, pp. 209-219). Moreover, for a virtual organization to perform successfully, it needs good management of relationships among partners (Morrison-Smith, Ruiz, 2020, pp. 1-33), based on mutual trust, collaboration and development of effective communication systems (Alfieri et al., 2004, pp. 33-40).

There are three main motives in a virtual organization which create and shape the competition. First, there is the need to share resources, implement new methodologies and division of competence to accomplish a global competitor's position in markets or their segments; second, the systems used in a virtual organization represent the complexity of the most profitable products by creating prototypes, production processes, design, marketing systems; thirdly, a virtual organization supports fast creation and gathering of production, financial and human resources in response to the shortening return periods for products and services (Al-Karkhi, Fasli, 2019, pp. 6-11).

Building a virtual organization is an opportunity for setting up such a management system that would enable risk sharing, defining infrastructure costs at appropriate levels, improvement of workforce qualifications and skills (Martyniuk, Korolov, 2022, pp. 111-116). A virtual organization is an organizational network constituting a foundation for a virtual organization by focusing on an unrestricted group of partners (Walker, 2006, pp. 25-41) that accept the organization's primary goals and principles. Such a perspective was presented by B. Mikula who treats a virtual organization as a networked organization (Mikula, 2018, pp. 34-46). In practice, a virtual enterprise is an arrangement in which specialized business units, being leaders in their narrow fields of expertise, can merge into a powerful whole, with practically no weak points (Bagga, Gera, Haque, 2023, pp. 120-131). Nevertheless, even though the implementation of a virtual enterprise model and operating principles may seem easy (Burrell et al., 2021, pp. 209-222), it is not easy to draft the concept and to manage it in practice. A virtual organization requires an aggressive strategy, excellent solutions, advanced technologies, overcoming barriers, and building a positive image of the company (Mitchell, 2023, pp. 1982-2008). With its characteristic features, it has a greater chance of hiring highly qualified staff (Zuofa, Ochieng, 2021, pp. 1083-1088) and using their abilities in project work. Staff members often manage their own operations and communicate with customers in ways that promote the company's image of excellence (Żukowska-Budka, 2006, p. 4). Managers are required to manage the relations between staff working out of office and the headquarters. All staff members have to be aware that they are part of a single organization and they are responsible for its functioning, reputation and prestige (Żukowska-Budka, 2006, p. 4).

The key purpose of a virtual organization is to focus on the customer, take the opportunities that emerge on the market, and avoid risks arising from continuous changes of the market environment. To ensure adequate competences and to respond to new opportunities emerging on the market, a virtual organization (Blanchard, 2021, pp. 290-296) combines the basic functions of its particular members. Members of a virtual organization have to behave (Kisielnicki, Ochowski, 2005) in an ethical and trustworthy manner versus each other. Building consensus based on common interests is essential for effective performance of an organization (Newman, Ford, Marshall, 2020, pp. 452-473). Distrust and unethical behaviors cause deterioration of collaboration and may ultimately lead to bankruptcy.

Based on a detailed review of literature on virtual organizations, the role of management solutions, and their impact on information quality, three research questions and corresponding hypotheses have been formulated.

Research questions:

1. How do different management solutions impact the quality of information management in virtual organizations?
2. What role does the IT/communication infrastructure play in determining the efficiency of information exchange in virtual organizations?



Hypotheses:

H1: Advanced IT/communication infrastructure directly correlates with enhanced quality of information management in virtual organizations.

H2: Effective relationship management among partners in virtual organizations leads to better collaboration and improved information quality.

### 3. Research methodology

The conducted study aimed to understand the impact of IT solutions on the quality of information management in virtual enterprises. To thoroughly investigate this matter, the following research hypothesis was formulated: the quality of information management in enterprises is positively correlated with the following management solutions: open training, organizational culture.

#### **Knowledge, development, salaries**

This hypothesis is consistent with the results of the t-test, which showed that enterprises with a higher level of information management more often use open and closed training, focusing on development, knowledge, and communication, and in enterprises with a higher organizational culture. The multiple regression analysis also confirmed this hypothesis, showing that open training, organizational culture, knowledge, development, and salaries are significant factors explaining the quality of information management.

To verify this hypothesis, a survey was used in which respondents were asked to evaluate various aspects of information management using a Likert scale ranging from 0-5, where 0 indicates the least importance of knowledge in a given area, and 5 signifies the greatest importance.

A total of 355 respondents participated in the study, including 25% women and 75% men. Of these respondents, 25% held managerial positions, 20% were supervisors, 55% were directors of various departments, and the remainder were knowledge workers from different sectors of virtual enterprises.

To ensure the reliability and validity of the data, statistical analysis was conducted, including the Shapiro-Wilk test to verify the normal distribution of the studied traits. Since the p-value was greater than 0.05, it was assumed that the probability density distributions did not significantly differ from a normal distribution, allowing for the application of parametric significance tests to analyze the data.

This methodological approach allowed for a deep understanding of the impact of IT solutions on the quality of information management and provided tangible value to managers and other specialists involved in managing virtual enterprises.

## 4. Research results

The aim of the study was to assess the influence of enterprise management solutions on the quality of information management.

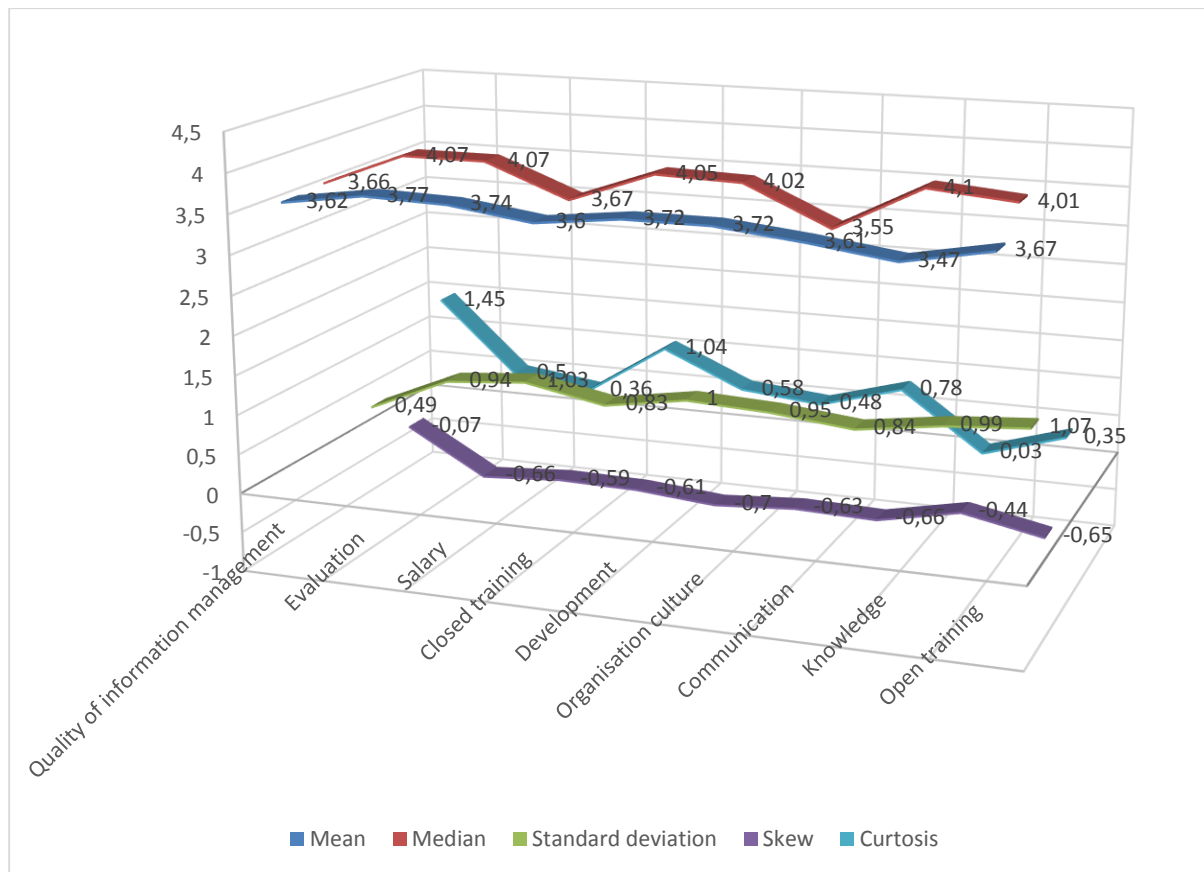
Table 1, figure 1 presents the descriptive statistics for the measured variables and the Shapiro-Wilk test results which was used to verify the normal distribution of measured traits. Given that  $p > 0.05$ , it was assumed that the probability density distributions were not significantly different from a normal distribution, and parametric significance tests were consequently employed.

**Table 1.**  
*Descriptive statistics*

	Mean	Median	Standard deviation	Skew	Curtosis	Shapiro-Wilk W-value
Quality of information management	3,62	3,66	0,49	-0,07	1,45	W=0,979; p=0,441
Evaluation	3,77	4,07	0,94	-0,66	0,50	W=0,912; p=0,322
Salary	3,74	4,07	1,03	-0,59	0,36	W=0,933; p=0,122
Closed training	3,60	3,67	0,83	-0,61	1,04	W=0,932; p=0,231
Development	3,72	4,05	1,00	-0,70	0,58	W=0,911; p=0,322
Organisation culture	3,72	4,02	0,95	-0,63	0,48	W=0,944; p=0,455
Communication	3,61	3,55	0,84	-0,66	0,78	W=0,923; p=0,233
Knowledge	3,47	4,10	0,99	-0,44	0,03	W=0,976; p=0,122
Open training	3,67	4,01	1,07	-0,65	0,35	W=0,967; p=0,233

Source: own elaboration.

In the subsequent steps, differences between lower and higher levels of information management quality were tested. It was statistically significant ( $p < 0.05$ ) that enterprises with a higher level of information management quality also had higher employee ratings, higher salaries, more frequently employed both open and closed trainings, emphasized on development, knowledge, communication, and had a superior organizational culture (table 2, figure 2 & 3).



**Figure 1.** Descriptive statistics.

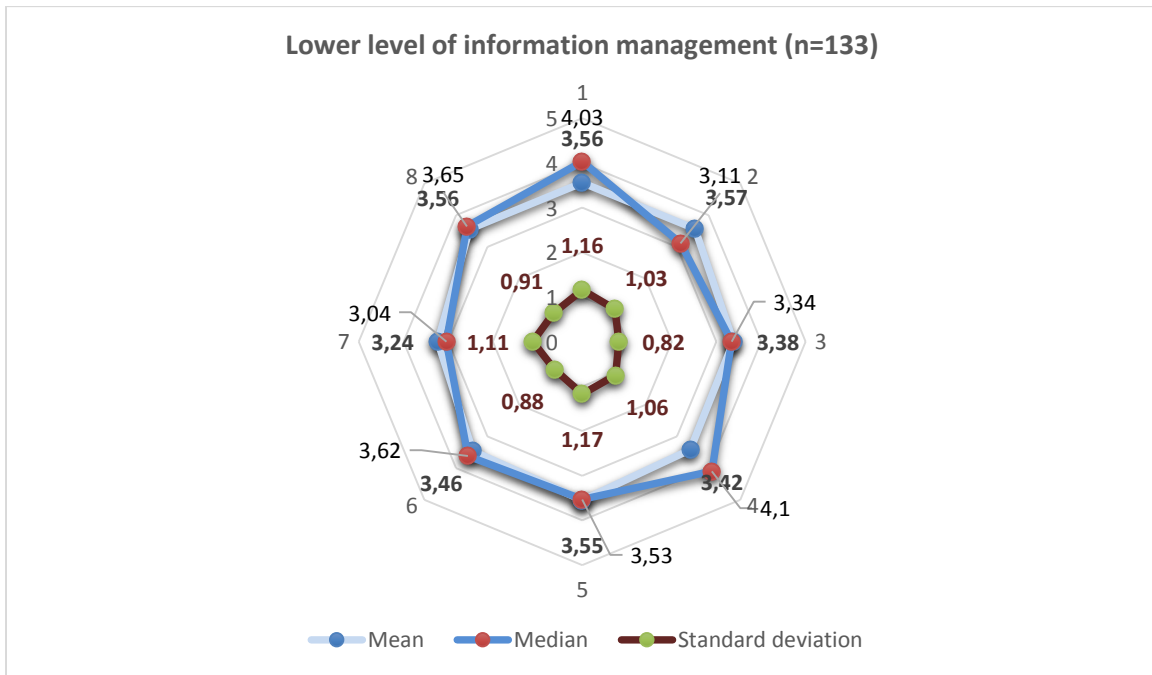
Source: own elaboration.

**Table 2.**

*Descriptive statistics with Student's t-test of differences between lower and higher levels of information management*

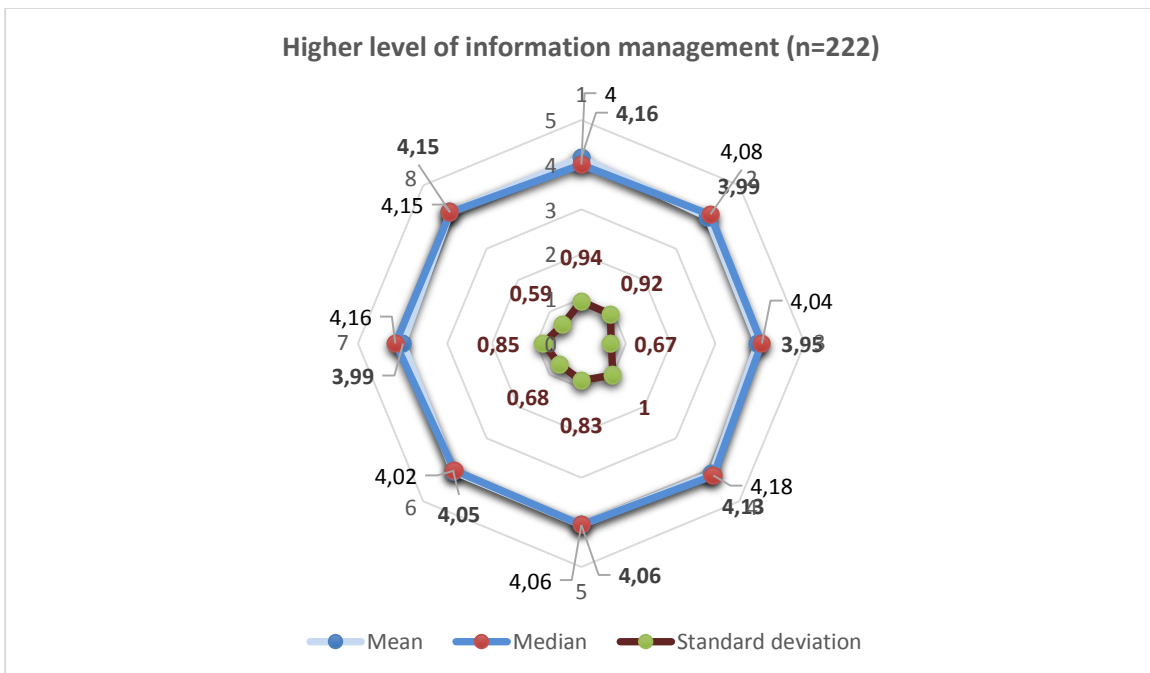
	Quality of information management						T-test	
	Lower level of information management (n = 133)			Higher level of information management (n = 222)				
	Mean	Median	Standard deviation	Mean	Median	Standard deviation	t-value	p-value
Evaluation	3,56	4,03	1,16	4,16	4,00	0,94	-6,53	<0,01
Salary	3,57	3,11	1,03	3,99	4,08	0,92	-7,33	<0,01
Closed training	3,38	3,34	0,82	3,95	4,04	0,67	-10,58	<0,01
Development	3,42	4,10	1,06	4,13	4,18	1,00	-7,70	<0,01
Organisation culture	3,55	3,53	1,17	4,06	4,06	0,83	-7,82	<0,01
Communication	3,46	3,62	0,88	4,05	4,02	0,68	-9,18	<0,01
Knowledge	3,24	3,04	1,11	3,99	4,16	0,85	-8,13	<0,01
Open training	3,56	3,65	0,91	4,15	4,15	0,59	-10,62	<0,01

Source: own elaboration.



**Figure 2.** Lower level of information management (n = 133).

Source: own elaboration.



**Figure 3.** Higher level of information management (n = 222).

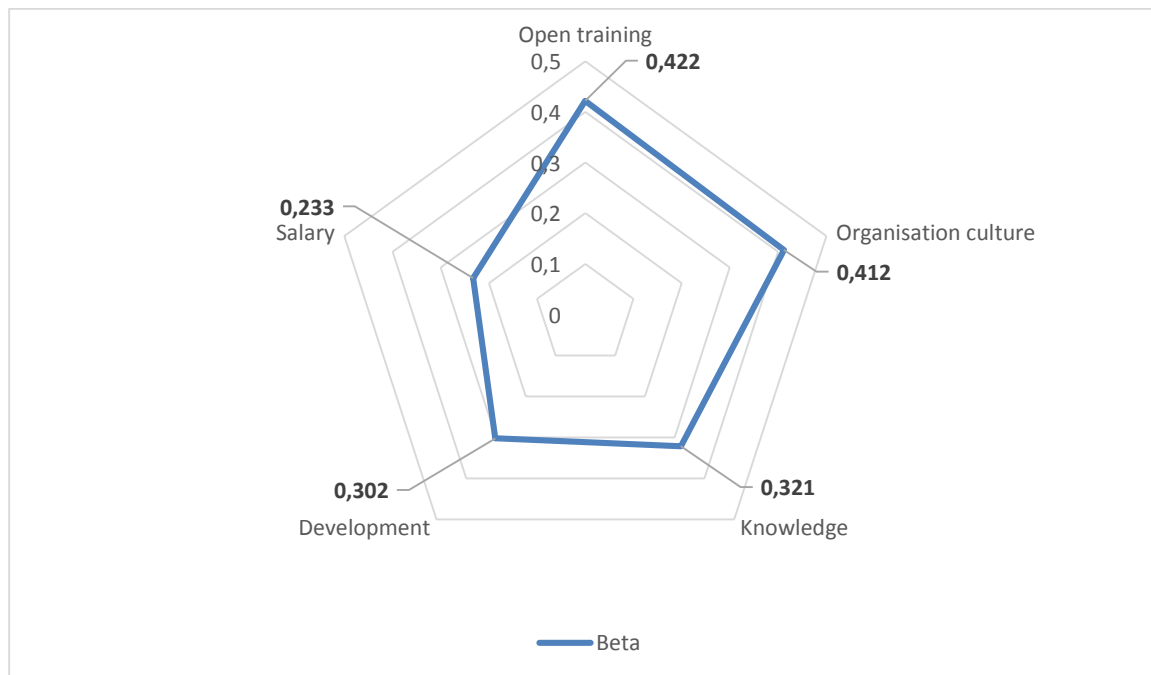
Source: own elaboration.

A multiple regression analysis was also carried out. It accounted for 59.8% of the variance and was higher with the more frequent application of open training, and the greater the organizational culture, knowledge, development, and salaries (table 3, figure 4).

**Table 3.**  
Regression coefficients

Statistics	Regression coefficients		
	Management solutions	Beta	p-value
Quality of information management R = 0,787; R <sup>2</sup> = 0,598; F = 343,22; p < 0,01	Open training	0,422	<0,01
	Organisation culture	0,412	<0,01
	Knowledge	0,321	<0,01
	Development	0,302	<0,01
	Salary	0,233	<0,01

Source: own elaboration.



**Figure 4.** Regression coefficients.

Source: own elaboration.

Given the findings, the previously formulated research hypothesis – the quality of information management in enterprises is positively correlated with the following management solutions: open training, organizational culture.

Knowledge, development, salaries - has been verified.

This hypothesis is consistent with the results of the t-test, which showed that enterprises with a higher level of information management more often use open and closed training, focusing on development, knowledge, and communication, and in enterprises with a higher organizational culture. The multiple regression analysis also confirmed this hypothesis, showing that open training, organizational culture, knowledge, development, and salaries are significant factors explaining the quality of information management.

Open training can help employees develop the skills and knowledge they need to manage information effectively. Organizational culture can promote the sharing of information and the collaboration of employees. Knowledge is essential for making informed decisions about information management. Development can help employees stay up-to-date on the latest information management trends. Salaries can help attract and retain talented employees who

are committed to information management. The results confirm that management solutions, especially training (both open and closed), organizational culture, knowledge, and employee compensation, play a significant role in determining the quality of information management in virtual enterprises.

## **5. Discussions**

The above may lead to the conclusion that virtual enterprises have countless opportunities and strong points that drive their success and competitive advantage. Flexible management is one of the crucial aspects enabling virtual businesses to adapt to the changing market realities and to respond quickly to new opportunities. It makes them capable of surpassing conventional enterprises which frequently have to overcome more significant difficulties involved in their structures and decision-making processes. Another advantage is the proactive competition policy with which virtual businesses are able to break ground for changes in the industry and be ahead of competition. By monitoring the market, trend analysis and adjusting their strategies accordingly, these enterprises have the ability to build their competitive advantage and to maintain their leading positions. Catering to customer needs is the essential goal of every business, while virtual enterprises have certain extra tools that help them accomplish this goal. With the use of such advanced technologies as artificial intelligence and data analysis, they can learn more about the preferences and expectations of their customers so as to personalize their proposal and adapt to individual needs. This is extremely important because in the contemporary competitive environment, customers want to receive such products and services that would be tailored specifically to their needs. Creation of new competences is another advantage available to virtual enterprises. As they operate in a rapidly changing technology environment, they have the opportunity to grow continuously and to acquire new capabilities. They can invest in personnel training, develop their in-house competence centers and liaise with other operators to gain new knowledge and skills. This, in turn, translates into innovative management and the ability to place new and unique products on the market. Cost reduction is another factor speaking to the advantage of virtual enterprises. With the use of such advanced IT and communication technologies as cloud and online collaboration tools, they may reduce the costs of maintaining traditional offices and infrastructures. Staff can work efficiently online, thus generating cost savings on office leases, purchases of equipment and maintaining other operating costs. Improvement of quality and management innovation is another positive effect generated by virtual businesses. With the use of advanced IT utilities and systems, they are capable of streamlining their management processes, optimizing information flows and take better decisions. With automation of routine tasks, staff can focus on more value adding, creative tasks, which helps the quality of their work and the level of innovation of the entire

organization. Good reputation on the market is another advantage of virtual enterprises. With their flexibility, innovation and adaptability to the changing market needs, they are received positively among customers and business partners. Virtual enterprises are often associated with modernity, advancement of technology and commitment to the development of digital communities. Shorter product launch cycles are another important aspect contributing to the competitive edge of virtual enterprises. With the use of the Internet and digital technologies, they are capable of placing new products and services on the market faster. Testing, production, distribution and marketing processes can be more efficient and fast, thus enabling virtual organizations to gain competitive advantage and win a larger share of the market. Higher numbers of prospective customers are yet another advantage available to virtual enterprises. With the Internet and global accessibility, they can reach customers all over the world. They can operate online, offer their products and services through e-commerce platforms and attract customers from various regions and cultures. This opens up new market and new growth opportunities for them. Successful direct marketing is the next aspect of virtual enterprises' superiority. Through the use of the marketing tools available over the Internet, such as online advertising, social networks or e-mail campaigns, they can successfully reach their target group and build their brand awareness. Direct communication with customers further enables them to collect feedback and adjust their marketing strategies in real time. Efficient management of human capital is another strong point virtual enterprises can rely on. With the online work options and flexible time schedules, they are capable of attracting and retaining highly qualified employees. Staff can enjoy more freedom and a better work-life balance, which gives them stronger motivation and commitment to their jobs. Facilitated financial handling of sales is the final aspect worth emphasizing here. By using electronic payment systems, virtual enterprises can smoothly process their transactions and handle their sales. Offering diverse payment options and secure online solutions gives them higher confidence from customers and streamlines closing their sales. Ergo, virtual enterprises have multiple opportunities and strong points that drive their success and competitive edge. Flexible management, proactive competition policies, satisfying customer needs, creating new competences, reduction of costs, improvement of quality and innovation of management, good market reputation, shortened product launch cycles, higher numbers of prospective customers, successful direct marketing, good management of human capital and streamlined financial handling of sales - all these features are the driving force for growth and success of virtual enterprises. Virtual organizations, a contemporary model of doing business, bring forth a myriad of advantages and opportunities but also face inherent challenges and threats.

Virtual organizations adapt swiftly to changing business landscapes, ensuring their operations remain fluid and responsive. The digital nature of these organizations leads to quicker transaction closures. Overhead costs related to transaction processing are drastically reduced. The legal intricacies associated with transactions are minimized. These organizations can implement production, pricing, and other strategies at scales surpassing the capabilities of

traditional enterprises. With lesser infrastructural and overhead costs, capital expenditures are substantially lower.

However, there's an inherent risk of collaborating with businesses that might not uphold professional standards in virtual organizations. The absence of predefined standards can lead to inconsistencies in operation. On the brighter side, virtual organizations can promptly fill market gaps, ensuring they stay ahead of competitors. They have the aptitude to close deals even in the face of legal or corporate hindrances. The decentralized nature allows these organizations to harness the best professional offerings of every partner. Virtual organizations are often at the forefront of adopting cutting-edge management methods. They can collaborate with entities that might be inaccessible in conventional organizational structures. The operations of virtual organizations inherently align with the tenets of globalization.

The key problems with managing a virtual organization are the following:

- Coordination of the competence center with the providers of additional competences.
- Integration of the service providers' network in the process of pursuing the global strategy of the enterprise.
- Building the corporate identity and culture, particularly in the case of online work.

Virtual computer networks are extremely versatile and are broadly used in operations of companies as effective communication tools. However, their development is based on a much broader spectrum of factors and technologies driving performance and business efficiency. The first essential aspect which determines growth of virtual computer networks is their availability. With the continuously improving Internet access, businesses can easily set up connections among teams and branches worldwide. This streamlines the process of sharing information, collaboration over distance and quick decision making. Moreover, with the availability of virtual computer networks, organizations are capable of effectively managing their IT resources and providing rapid support. Simplicity for users is another important factor. Virtual computer networks are designed to be intuitive, easy to operate for users with various levels of technical proficiency. A transparent user interface and customization options facilitate working with a system, which in turn offers higher productivity and less training requirement. Low costs can also be seen as a key advantage of virtual computer networks. By using this technology, enterprises can significantly reduce their spending on IT infrastructure, such as servers, local area networks or software. Virtualization of corporate operations will also lower the costs of business travel, as meetings can be held over distance through teleconferencing and videoconferencing. In addition to the factors enumerated above, growth of virtual computer networks is also based on diverse IT systems. Workflow management systems facilitate effective monitoring and coordination of activity at an organization, thus leading to higher efficiency of business processes. Group work systems support team work through sharing documents, schedules and tasks. Moreover, knowledge management systems offer knowledge gathering, retention and accessibility within an organization, thus contributing to higher innovation and competitive advantage. Teleconferences and video conferences are available as



means to hold meetings over distance, which in turn offers time savings and business travel cost efficiency. Nowadays, organizations use virtual organization-dedicated systems more often as well. These advanced platforms provide options for building virtual work environments in which personnel can collaborate and share information efficiently. The advancement of virtual computer networks is linked to the development of news portals. These enable the personnel to access most recent information about the organization, the industry or the market, thus being able to take more informed decisions. With the advancement of technology, speech and handwriting recognition systems are being improved as well. They offer automated processing of voice and text data, thus improving communication and data processing efficiency. Thus, growth of virtual computer networks is based on multiple diverse IT systems and technologies. With their availability, user-friendly interfaces, low costs and integration of various systems, virtual computer networks are highly valuable tools for businesses, improving their performance, innovation and competitive advantage.

Virtual organizations foster growth of new markets and increase the performance of design, operations and communication processes. Virtual enterprises have numerous advantages, such as the use of synergies of different companies, short project execution times, flexibility and responsiveness to changes in demand, ability to consolidate resources and competences, effective use of information, online learning, reduction of costs, decentralization of management, flatter corporate structures, equal positions of business operators, no rigid hierarchies, fluid roles in the organization, process orientation, effective use of IT networks, focus on key success factors, influence on the organizational structure, interactive communication with customers and the environment. Virtual organizations support taking advantage of the partners' strong points, thus shortening the time to market and leading to business growth. In addition, virtual enterprises offer access to new markets, market segmentation, building customer loyalty and offering integrated solutions.

In light of the conducted research, the analysis of the impact of IT solutions on the quality of information management in virtual enterprises emerges as crucial for modern organizations. The main research hypothesis, suggesting that the quality of information management in enterprises is positively correlated with management solutions such as open training, organizational culture, knowledge, development, and compensation, has been confirmed. Companies with a higher level of information management quality often use both open and closed training, focus on development, knowledge, and communication, and also have a higher organizational culture. Moreover, employee compensation also plays a key role, underscoring the value of compensation in attracting and retaining talented workers dedicated to information management.

Considering the ever-increasing importance of knowledge and human capital in organizations, as well as the growing complexity and necessity of effective information management, these results highlight the value of investing in the right tools and managerial

practices. How organizations manage their knowledge and human capital becomes a key to their success in today's dynamic business environment.

Although the study provided significant findings, there are certain limitations. The number of respondents, as well as the primary focus on virtual enterprises, might limit the generalization of the results to a broader business context.

For managers and specialists dealing with the management of virtual enterprises, it is recommended to continue investing in training (both open and closed), promoting an organizational culture conducive to knowledge sharing, and appropriately compensating employees for their contribution to information management. Additionally, continuous monitoring and evaluation of the tools and strategies used for information management are essential to ensure their relevance and effectiveness in the changing business environment.

## **6. Summary**

Summing up the discussion above, organizations nowadays tend to appreciate the importance of knowledge and human capitals more and more. Many businesses invest in data gathering and sharing systems, while their corporate structures undergo transformation. The tools to support this process include the Internet and advanced computer networks, enabling enterprises to communicate with their environment. Virtual organizations, acting on the basis of network models, are able to quickly respond to customer needs and to expand their operations accordingly. Knowledge is becoming the primary source of competitive advantage, while good knowledge management drives the rapid growth of the organization. Nevertheless, it should be emphasized that there is still a group of business owners and managers who fail to perceive the role of knowledge as the key success factor for a business undertaking. The human capital and knowledge are the most valuable resources of advanced corporate organizations. They optimize their operations through maximizing the use of the intellectual capital. The prevailing management methods include learning, knowledge management, building the corporate culture and project management. Interpersonal relations in advanced organizations are collaborative, involving joint learning, knowledge transfer and frequent instability of the governing system. Most communication takes place on the horizontal level in an informal manner. Personal identity is often linked to group identity. The essential management methods and tools include learning, training, mentoring, coaching, intellectual capital management, knowledge management, and project management.

The following general conclusions have been drawn from the discussion in this paper:

- Virtual organizations are gaining popularity as a new form of organization, engaging advanced technologies and computer networks.
- Virtualization gives organizations flexibility, scalability and adaptability to changes in their environment.
- Virtual organizations use knowledge and human capital as their key resources, drivers of the competitive edge.
- However, there are also certain barriers and threats relating to virtual organizations, such as technology challenges, lack of legal regulations, Internet addiction and its negative consequences.

As we discuss the aspects of virtual organizations, the following lines of further research can be proposed:

- Study of technology solutions that may contribute to streamlining the operations of virtual organizations, such as data transmission security, new models of virtualization, and growth of infrastructure.
- Study of psychological and social aspects of virtual organizations, including the consequences and ways of managing Internet addiction.
- Study of knowledge and intellectual capital management strategies at virtual organizations, such as effective gathering, sharing and using knowledge.
- Study of the impact of virtual organizations on the corporate culture and interpersonal relations, particularly on the development of group identity and collaboration.
- Study of successful project management methods at virtual organizations, taking into account the unique challenges involved in distributed teams and online communication.

Continued research in these areas will foster further understanding and improvement of virtual organizations, thus contributing to their performance, innovation and long-term success in the rapidly changing business environment.

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## RELATIONS BETWEEN LEADERSHIP FEATURES AND ATTRIBUTES OF MANAGERS AND ORGANIZATIONAL RESOURCES OF SOCIAL CAPITAL IN ENTERPRISES

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**Purpose:** The paper presented concentrates on the illustration of the role of leadership in terms of creating the resources of social capital in an enterprise. The aim of this paper is to identify the impact of the features of the manager and his/her leadership attributes on the growth of the resources of social capital in enterprises.

**Design/methodology/approach:** The survey method was applied in the research with the following mixed techniques: CATI (Computer-Assisted Telephone Interviewing) and CAWI (Computer-Assisted Web Interview). On the basis of the method of random selection, a research sample encompassing 179 companies was created. The respondents were representatives of these enterprises, among others, personnel directors, HR department heads, while also HR specialists.

**Findings:** As a result of the research, an identification was made of the features of a manager that have the strongest impact on the resources of social capital, namely, the level of interest in enhancing the qualifications of the subordinates, while also being guided by ethical principles in relations with the subordinates, as well as the perception of trust as an important source of competitive advantage. Likewise, there is a definition of the relations between the leadership attributes associated with managing the organization, managing the personnel, trust and the creation of their own leader of the resources of social capital by indicating that the attributes associated with trust have the strongest impact on the majority of resources.

**Research limitations:** The acquired research findings with regard to their quantitative nature (survey research) constitutes the basis for the limited findings.

**Practical implications:** The research findings indicate the significant meaning of leadership in the process of developing the social capital of enterprises on the market.

**Social implications:** Drawing attention to the importance of leadership attributes in terms of creating social capital.

**Originality/value:** In a cognitive sense, the research findings lead to the familiarization with the role of a manager in social capital.

**Keywords:** organizational social capital, inter-group social capital, enterprise, organizational processes.

**Category of the paper:** Research article.

## 1. Introduction

The success in the contemporary economy, the success of an enterprise on the market is increasingly decided by intangible values. One of these is the skill of cooperation within groups and organizations with the aim of realizing common interests. This skill depends on the degree of which the particular organization acknowledges and shares sets of norms and social values. This constitutes the foundation of social capital which is a significant cultural value and economic value. The concepts of social capital are varied – at both the levels of conceptualization and operationalization. In analysing the various approaches, it is possible to group them as follows: firstly, as a theory of networks that indicates that social capital is in precise terms a social network, or in other words, a structure of relations between two or more participants (Coleman, 1988). Secondly, as a theory of criteria which claims that social capital refers to integrity, criteria and values embedded in the social network (Fukuyama, 1997). Thirdly, as a theory of collective properties which included the network, norms and trust facilitating coordination and cooperation on behalf of mutual benefits (Putman, 1994). Fourthly, as a theory of resources according to which social capital is the set of actual and potential resources that are associated with having a long-lasting network, while also more or less institutionalized relations based on mutual contacts and acknowledgement (Bourdieu, 1986). The afore-mentioned notions of social capital indicate its double nature. On the one hand, it may take on a particular shape and be used for the realization of egoistic individual and group interests. On the other hand, it may be used for supra-individual purposes in order to build social relations built on cooperation in which all partners and the society as a whole gain benefits.

Social capital relates to the potential tangible and intangible resources that a particular person may acquire by means of his/her social ties in the organization. Examples of tangible resources are those of money, taking care of matters for other people and even teaching other people how to implement a skill. Examples of intangible resources encompass offering emotional support, providing advice, sharing detailed information and presenting recommendations (Spottswood, Wohn, 2020).

In organizations, social capital has multiple advantages, one of which is the faster flow of information, knowledge about what results in the reduction of costs associated with the coordination of the realized goals. It determines the cooperation and communication between employees and facilitates the building of identity and trust within the organization. Likewise, it leads to the greater integration of employees and strengthens the ties between the enterprise as an institution and its employees. It also has an impact on the feeling of job satisfaction and loyalty of employees, while also facilitating the creation of ties and networks, streamlining the communication processes, strengthening flexibility, innovativeness and entrepreneurship (Chomiuk, 2016). In addition, it acts as a management tool that enables more efficient and



cheaper realization of the goals of the organization. In other words, social capital facilitates sharing knowledge, creating values, gaining a competitive advantage, while also better and faster operations, as well as further development of the organization (Salajegheh, Pirmoradi, 2013). Likewise, it enables mutual cooperation and coordination of units on behalf of common interests, while also facilitating common action.

A significant factor that has an impact on the level of social capital in an organization is that of the leader. Leaders that have charisma inspire their imitators and stimulate their minds and are frequently supportive of an open line of communication and share their new ideas in the firm (Becker et al., 2022), which is favourable to the building of social capital.

In this paper, both theoretical and empirical observations are developed with regard to the subject of the impact of leadership on social capital in an enterprise. The aim of research was to make two fundamental contributions in terms of the perception of the significance of leadership with regard to developing the resources of social capital. Firstly, the research serves to identify the features of the manager that have an impact on the creation of the resources of social capital in enterprises. Secondly, it also serves to illustrate the significance of leadership attributes of the manager in terms of creating the resources of social capital

## 2. Theoretical background

Analysis of the numerous papers relating to organizational social capital illustrates that it is difficult to formulate unequivocally the definition of this notion. Some authors concentrate on its social function. This is exemplified by Coleman (1988), where he stated that social capital relates to the social functions in an organization, such as trust, norms and networks that may improve the efficiency of society, as well as the organization by facilitating coordinated action. In their definition, Lean and van Buren (1999) place emphasis on social relations. According to them, the social capital of an organization may be defined as a resource that reflects the nature of social relations in the organization. The nature of relations is embodied by the level of orientation of the employees with regard to conducting common activities and the realization of common goals, as well as mutual trust. In turn, Inkpen and Tsang acknowledge resources as a significant element in their definition. According to them, social capital is *the aggregate of the available resources that are derived from the network of ties for physical entities or organizations. The members of the organization may avail of benefits from the resources derived from the network of ties in the organization, yet not necessarily participating in its development* (Inkpen, Tsang, 2005, p. 151).

Out of all these approaches, the resource approach is worthy of greater attention, whereby social capital in an organization is perceived to be as a group of existing or potential resources of a productive nature that are to be found in the structure of the organization (Skawińska,

2012). In accordance with this approach, organizational social capital may be defined as a resource that reflects the nature of social ties in an organization. The nature of ties is embodied by the level of orientation of the employees in terms of undertaking joint action and the realization of common goals, while also mutual trust (Lean, van Buren, 1999). In turn, Nahapiet and Ghoshal (1998) perceive social capital as *the actual and potential resources that are built in and available by means of and derived from the network of ties held by the unit or social unit* (Nahapiet, Ghoshal, 1998, p. 243). In the most general terms, it is possible to say that organizational social capital is the resource of an organization that is based on social ties connecting employees and creating the atmosphere of cooperation that is essential for the efficient realization of collective aims by the employees and the enterprise itself.

Salajegheh and Pirmoradi (2013) identified the principal resources of social capital in an organization, which is sometimes defined as social values, in the following manner: honesty, good relations, affinity, friendship, participation, etc. Hence, it is a group of valuable resources with the right social ties among the employee groups and the organization as a whole. They develop during the course of repetitive interactions between the parties involved, which leads to the development of the mutual goodwill, trust and friendship (Kale et al., 2000). Thanks to these resources, the ties between the members of the organization run more easily, faster and in this way helps them in the accomplishment of the common social aims.

In literature related to social capital, it is said that in an organization the key is to differentiate between internal and external social capital (Adler, Kwon, 2002). Internal social capital is included within the structure of the organization, in employee groups that generate internal cohesion, identity and social ties (Tsai, Ghoshal, 1998). They are characterized by the development of ties in the firm (e.g. between employees) (Shaw et al., 2005). However, external social capital is located outside the structure of the organization and is based on external networks and ties with entities from the external environment. External resources of social capital are reflected by the developed ties with entities outside the company, e.g. with clients) (Dyer, Singh, 1998).

The composition of internal capital consists of ties between the employees within an employee team and the inter-group ties that combine the members of various teams. The fundamental assumption of this approach is the conviction that involvement and participation in the organization may bring more benefits to both the organization and the participants. Hence, it is possible to agree with the statement of J.S. Coleman (1988), who opines that the skill of interpersonal cooperation within groups and organizations facilitates the realization of common goals. The perception of internal social capital of organizations is similar in the case of Bolino et al. (2002), according to whom, it occurs at the level of the orientation of the participants of the organization towards the common goal and shared trust, which creates values and supports the efficient collective action. Internal social capital is built by means of the repetitive interactions with co-workers that lead to the sense of familiarity amongst the co-workers (Huckman et al., 2009), while also more efficient

coordination and communication (Reagans et al., 2005). It also leads to the development of transactive systems of memory – the effective cognitive sense of what is happening in the group or the entire organization (Argote, Guo, 2016). This constitutes the basis for the development of capital that is specific to the team whose loss may have an unfavourable impact on the level of productivity of the employees (Jaravel et al., 2018).

Of all the factors influencing the level of social capital in an organization, leadership may be deemed to be the most important. Jiang et al. (2014), defined leadership as the process of a leader guiding the organizational members to practice the plans for changes and move toward the objective of changes. First of all, the leader establishes the direction with the aid of a drawn out vision and subsequently communicates with and encourages the employees to overcome the obstacles and to create cooperation with the aim of creating innovations (Duffy et al., 2012). Leadership has an impact on the development of social capital in a twofold manner, namely, by means of stipulating goals, structures and processes, while also taking everyday personnel decisions and communication with the subordinates. The personnel decisions are particularly conditioned by the values that are characteristic for the organization, which is favourable towards the creation of a good or bad vibe in the organization. The communication between the management and the employees also has an impact on the quality of social ties in the organization. Good communication between the manager and the employee team gives rise to positive ties. Elements of good communication are fast and reliable flows of information with regard to important organizational issues, effective feedback and the so-called “open ear” for co-workers. The indicator of leadership capital is the orientation towards the employees. A high level of orientation towards subordinates on the part of managers gives rise to the creation of positive emotions amongst employees, which evokes consequences in terms of increasing the efficiency of employees. Badura (2008) indicates that the orientation towards employees is illustrated by the level of interest in the personal issues of the employees and the perception of the individual achievements of the employees.

The orientation towards the employee is the basis of the styles of leadership, namely, ethical leadership, inclusive leadership and transformational leadership. Ethical leadership may be defined as *a demonstration of normatively appropriate conduct through personal actions and interpersonal relationships, and the promotion of such conduct to followers through two-way communication, reinforcement, and decision-making* (Brown et al., 2005). The term “normative appropriate behaviour” indicates a moral component for leaders which encompasses responsibility, honesty, credibility and sincerity (Piccolo et al., 2010). An ethical leader is a role model to follow and who inspires employees to develop positive attitudes and behaviour. An ethical leader initiates moral decision making on the part of the subordinates, while also pro-social behaviour and ultimately has an impact on the level of satisfaction, involvement and motivation of the employees (Grobler, Grobler, 2021). Likewise, he/she has an impact on the nature of work in the organization by placing greater requirements on the employees and simultaneously ensuring them greater autonomy, while also creating social ties based on trust

and psychological security, as well as creating the feeling of being appreciated thanks to the skills and performance achieved (Bahadori et al., 2021). Ethical leadership is an approach that may support the development of the social capital of the employees, which in turn may give rise to high returns, profits and benefits for stakeholders (Ullah et al., 2022).

Inclusive leadership relates to the leaders who illustrate openness and availability in terms of their interactions with subordinates. This is concentrated on the case whereby the subordinate feels that the manager is available, listens to him/her and pays attention to his/her needs (Carmeli et al., 2010). This places emphasis on the acceptance of the employees for what they are and by allowing them to contribute their own unique abilities and views, while also encouraging them to become involved in the organizational operations. The inclusive leadership plays an important role in making the best team, creating an environment in the workplace that enhances worker capabilities and contributing to company well-being (Sürücü et al., 2023). One of the characteristic features of the inclusive leader is the development of relations with the employees and stimulating relations between them, which causes the network of internal relations in the organization to become a valuable resource. Treating team members fairly, valuing different voices, and celebrating uniqueness are the behaviors that successful inclusive leaders exhibit and role models within the workplace (Cohen, 2023).

Transformational leadership is inspiring and leads people to greater accomplishments in the pursuit of high efficiency. Robbins and Judge (2015), claim that transformational leadership is a strategy applied by leaders with the aim of inspiring employees to come out of pursuing their own interests and has a profound and extraordinary effect on them. Thus, this style encourages employees to transgress the scope of professional requirements in order to be innovative out of their own initiative. This is why it requires visionary thinking and openness to ideas. Transformational leadership significantly influences the development of social capital in the organization (Chen et al., 2016). This, first of all, results from the fact that transformational leaders fulfil the role of those who are admired, trustworthy and respected managers, who inspire them to show behaviour that is in accordance with the high ethical and moral standards. Secondly, by preferring the individual approach to the team members, the transformational leaders improve the perception of justice with relation to the leader and the organization itself. Thirdly, transformational leaders inspire the subordinates to share information. Fourthly, they simulate cooperation thanks to establishing the norms of cooperation and open communication, which in turn, leads to the wider scope of exchanging information. Fifthly, they encourage the subordinates to focus on the creation of a common vision and the accomplishment of common goals.

From the perspective of social capital in an organization, it would seem that each of these styles is favourable towards its growth. Depending on the type of organization, its structure and internal circumstances, the managers should choose such a style of leadership that would be favourable towards the development of social capital.

### 3. Methods

Research on the impact of the features of the manager and the attributes of leadership on the resources of social capital was conducted in the largest enterprises chosen in Poland. Their goal was to find an answer to the following three research questions: *What is the scope of occurrence of the resources of social capital in large enterprises in Poland? What relations exist between the features of the manager and the resources of social capital? To what extent do the attributes of leadership have an impact on the creation of the resources of social capital in enterprises?* In order to answer these questions, empirical research was conducted, in which the survey method was applied. The research tool was a standardized survey questionnaire. The analysis of the enterprises involved the application of mixed techniques: CATI and CAWI, which constituted a database of 500 of the largest enterprises (according to the ranking of the portal called Rzeczpospolita). On the basis of the random selection method, a research sample encompassing 179 companies was created. As a result of the random selection method, a research sample was chosen according to the following parameters: the total population in general – 500, estimation error 6%, level of reliability 95%. A total of 74 manufacturing enterprises participated in the research, while also 35 trading enterprises, 25 service firms, 20 manufacturing-service enterprises and 25 manufacturing-trading enterprises. The respondents were representatives of these enterprises, among others, personnel directors, HR department heads, while also HR specialists. The selection of enterprises for research involved the application of the random selection method.

### Results

The concept of organizational social capital is still poorly analysed in an empirical sense in Poland. There is a lack of knowledge on the subject of indicators that specify the resources of social capital in the organization. The author of this paper proposes the resource approach for the purpose of analysing social capital on the basis of the classification of the dimensions of social capital – structural, regulative, cognitive and behavioural. Theiss (2005), built indicators which facilitated the identification of the resources that include cooperation, solidarity, participation, loyalty and values. In Table 1, there is a presentation of the research findings on the resources of social capital in the analysed enterprises. One of the most important features, in the opinions of those analysed, was that of participation, which belongs to the structural element of social capital. On the one hand, it encompasses the sense of belonging of employees to informal groups, mutual informal contacts in the workplace, as well as taking part in integration events, while on the other hand, membership of trade unions. In this area, significant

differences exist in the degree of their assessment due to the type of business activities of the company. The attributes of this resource are the most highly rated in service and trading enterprises.

Another highly rated resource is that of cooperation, which is a component of behavioural social capital. Research reveals that this resource was most highly rated by the representatives of services and trading enterprises. The skill of cooperation depends on the degree in which the particular organization acknowledges and shares a set of norms and social values. Values constitute a significant resource of social capital as when it is shared by the members of groups, it facilitates cooperation between them. In the research, this resource was quite highly rated by the representatives of trading and services firms.

Loyalty belongs to the cognitive elements of social capital which encompasses social norms and values. It is evidenced by being loyal with regard to the firm and co-workers, while also the readiness to provide help for other colleagues at work, as well as keeping your word. In the analysed enterprises, this attribute was most highly rated in manufacturing and services enterprises, particularly loyalty with regard to the company where they work.

A component of regulative social capital is that of solidarity. In the analysed enterprises it is relatively lower in terms of evaluation when compared with the other resources. This particularly relates to the attribute of placing the common interest over your own, which is rated at a low level. The degree of occurrence of the attribute of solidarity is different depending on the type of business activities of the enterprises. Solidarity exists to the greatest extent amongst the employees of trading enterprises.

**Table 1.**

*Evaluation of resources of social capital (in Mean)*

Specification	Total	Enterprises		
		Manufacturing	Services	Trading
SCR - Cooperation resource	3,19	3,17	3,26	3,2
SSR -Solidarity resource	3,05	3,03	3,12	3,01
SPR - Participation resource	3,22	3,20	3,33	3,32
SLR - Loyalty resource	3,10	3,11	3,13	3,10
SVR- Value resource	3,14	3,14	3,29	3,18
Total social capital	3,14	3,13	3,23	3,16

Scale: 1 – I strongly disagree, 2 – I disagree, 3 – I neither agree nor disagree, 4 – I agree, 5 – I strongly agree.

Source: Author's own study.

Significant entities that operate on behalf of creating the resources of social capital are managers who create the conditions for strengthening the social ties between the members of the organization by means of passing on information, advice and social support (Burt, 1997). In the analysed enterprises, the respondents acknowledged the most important features to be keeping secrets, keeping your word, the conviction that the majority of people are open, respect for norms and values, while also the level of interest in enhancing qualifications on the part of the subordinates (Table 2). These are features associated with trust, which constitutes the basis for the manager-employee relations.

**Table 2***Degree of the features of managers (FM) of the enterprises surveyed*

Specification	Mean	Standard deviation
FM1 - They self-develop their knowledge	3.13	1.316
FM2 - They keep secrets	3.24	1.428
FM3 - They have a strong tendency to trust others	2.95	1.295
FM4 - They keep their word	3.20	1.379
FM5 - They think that most people are open-minded	3.19	1.276
FM6 - They have respect for norms and values	3.15	1.356
FM7 - They believe that trust is an important source of competitive advantage	3.12	1.347
FM8 - They enter into informal relationships with employees	3.12	1.285
FM9 - They limit contacts to immediate associates	3.08	1.205
FM10 - They are interested in the improvement of qualifications by their subordinates	3.18	1.327
FM11 - They are guided by ethical values in their relations with subordinates	3.11	1.319
FM12 - They help break down barriers to the implementation of innovation	3.12	1.365
FM13 - They are mentors for their subordinates	3.10	1.384
FM14 - They have the traits of a leader who supports innovation	2.99	1.317

Grading scale: 5 – to a very high degree, 4 – to a high degree, 3 – to a medium degree, 2 – to a low degree, 1 – to a very low degree.

Source: own research.

One of the aims of the research was the identification of the impact of the features of the managers on the development of the resources of social capital. For the purposes of evaluating this impact, the Spearman rank correlation coefficient was applied. Its magnitude illustrates the strength of the impact of the features of the manager on the resources of social capital. Analysis of the research findings reveals that the resources of cooperation are influenced by the following features of the manager: great inclination to trust, the level of interest in increasing the qualifications for the subordinates, respect for norms and values, keeping his/her word and keeping secrets. The resources of solidarity are influenced by the following: the level of interest in increasing the qualifications of the subordinates, providing help in breaking down the barriers in the process of implementing innovations and being a leader who supports innovation. The resources of loyalty are influenced by the following: the level of interest in increasing the qualifications of the subordinates, respect for norms and values, keeping secrets, the acknowledgement that trust is an important source of competitive advantage. The resources of values are determined by the following: respect for norms and values, the level of interest in increasing the qualifications of the subordinates, keeping secrets, being guided by ethical values in relations with subordinates and possessing the features of a leader who supports innovation. The resource of participation is influenced by the features of the manager: respect for norms, the acknowledgement that trust is an important source of competitive advantage and keeping his/her word.

By way of conclusion, the key features of a manager are the level of interest in increasing the qualifications of the subordinates, being guided by ethical values in relations with subordinates and perceiving trust as an important source of competitive advantage. Managers who possess these features support activities aimed at building the resources of cooperation and values.

**Table 2.**

*Spearman correlation indicator between between features of manager (FM) and resources of social capital (SC)*

	FM1	FM2	FM3	FM4	FM5	FM6	FM7	FM18	FM9	FM10	FM11	FM12	FM13	FM14
SCR	0,174 **	0,228 **	0,200 **	0,224 **	0,177 **	0,259 *	0,175 **	0,076	0,148 **	0,268 *	0,224 **	0,140 **	0,209 **	0,226 **
SSR	0,109	0,176 **	0,086	0,071	0,105	0,139	0,154 **	0,068	0,147 **	0,175 **	0,210 **	0,164 **	0,053	0,197 **
SPR	0,059	0,040	0,083	0,209 **	0,069	0,163 **	0,268 *	0,155 **	0,059	0,195 **	0,181 **	0,090	0,172 **	0,133
SLR	0,161 **	0,247 **	0,032	0,078	0,069	0,224 **	0,236 **	0,093	0,082	0,241 **	0,167 **	0,148 **	0,158 **	0,096
SVR	0,080	0,221 **	0,167 **	0,239 **	0,078	0,241 **	0,185 **	0,102	0,166 **	0,294 *	0,217 **	0,187 **	0,118	0,279 *

\*  $p < 0,01$ , \*\*  $p < 0,05$ .

Source: own research.

A significant role in building the resources of social capital is played by the leadership attributes of the managers. For the purposes of measuring the leadership attributes in enterprises, a tool consisting of five dimensions was applied as follows: managing the organization, managing the employees and managing himself/herself (creation of self-leader), which was created by Paliszkiwicz et al. (2015), while also building trust in the organization. The research findings presented in Table 4 reveal that in managing the organization, the most important leadership attribute is the ability to shape the organization, people and the manager himself/herself in a positive sense by establishing the vision and translating it to the business strategies and the expected results. Likewise, the skill of implementing change in the organization is also important.

**Table 3.**

*Leadership attribute – managing the organization (LAMO)*

Specification	Mean	Standard deviation
LAMO1 - Managers make changes in the enterprises	4.49	1.882
LAMO2 - It is necessary for the manager to lead/manage innovation in the organization	4.40	1.980
LAMO3 - Managers in the enterprise can positively shape the organization, people, and themselves by setting a vision and translating it into business strategies and expected outcomes	4.59	1.918
LAMO4 - Managers respect values and respect diversity by including them in the organization. This inclusion ensures proper conditions for everyone to develop and work together to increase organizational effectiveness.	4.44	1.878
Total	4.48	1.985

Grading: 1 – I totally disagree, 2 – I mostly disagree, 3 – I partially disagree 4 – I neither agree nor disagree, 5 – I partially agree, 6 – I mostly agree, 7 – I totally agree.

Source: own research.

Leadership attributes have a varying impact on the resources of social capital. They have the biggest impact on the resource of cooperation, particularly the attribute associated with respecting values and respecting variety in the organization. Apart from this fact, there is a noticeable impact on the resource of loyalty, which relates to the attribute associated with the ability to shape the organization in a positive way. Apart from this fact, a significant impact is



exerted by the attribute of implementing change in the enterprise on the resource of values. In sum, a key attribute associated with managing an organization that has an impact on the resources of social capital is the respect for values and respect for variety amongst the employees and the general environment. This is favourable towards making new ties with external entities, e.g. external stakeholders of the organization.

**Table 4.**

*Spearman correlation indicator between between leadership attributes associated with managing the organization (LAMO) and the resources of social capital*

<b>Social capital</b>	<b>LAMO1</b>	<b>LAMO2</b>	<b>LAMO3</b>	<b>LAMO4</b>
Cooperation resource	0,182**	0,189**	0,199**	0,269*
Solidarity resource	0,145	0,092	0,231**	0,116
Participation resource	0,096	0,212**	0,057	0,244*
Loyalty resource	0,191**	0,084	0,213**	0,173**
Value resource	0,242**	0,168**	0,128	0,099

\*  $p < 0,01$ , \*\*  $p < 0,05$ .

Source: own research.

Another group of leadership attributes is associated with managing personnel. Of all the analysed attributes, the respondents under analysis assessed the ability to build and maintain good relations with subordinates, while also the skill of using interpersonal communication with the aim of arousing employees to work effectively. Likewise, strengthening the power of employees to carry out the tasks allocated to them is a significant leadership attribute.

**Table 5.**

*Leadership attribute – managing employees (LAME)*

<b>Specification</b>	<b>Mean</b>	<b>Standard deviation</b>
LAME1 - Managers motivate employees to work more effectively and bring out the best in them	4.25	2.052
LAME2 - Managers empower/strengthen employees to perform their assigned tasks	4.51	1.867
LAME3 - Managers are good listeners and can calm others	4.44	1.878
LAME4 - A manager's interpersonal communication is essential to stimulate employees to work effectively	4.54	2.050
LAME5 - Managers can build and maintain good relationships with subordinates	4.59	1.938
LAME6 - Managers are not afraid of conflict: a manager's attitude should be to see conflict as something good and therefore should not avoid conflict	4.09	1.902
Total	4,40	1,953

Grading: 1 – I totally disagree, 2 – I mostly disagree, 3 – I partially disagree 4 – I neither agree nor disagree, 5 – I partially agree, 6 – I mostly agree, 7 – I totally agree.

Source: own research.

Leadership attributes associated with managing personnel have a varying impact on the resources of social capital (Table 5). The most important ties occurred between the leadership attributes and the resource of cooperation, whereas to a lesser extent between the resources of participation, loyalty and values. A detailed analysis of these relations facilitated the definition of their power. The most significant relations occurred between the resource of cooperation and the possession of the skills of building and maintaining good relations with subordinates,

the lack of fear of conflict and the acknowledgement that interpersonal communication is essential in order to arouse employees to more effective work. Apart from this fact, significant relations occurred between the resource of loyalty and possessing the skill of being a good listener and calming others down. There was also the observation of ties between the resource of skills and the lack of fear of conflict, while also the resource of justice and the acknowledgement that the interpersonal communication of the manager is essential in order to arouse employees to more effective work. Hence, the most important leadership attribute associated with managing personnel is the lack of fear of conflicts, which are an immanent part of every organization. The attitude of the manager that involves the perception of conflict as not only bad, but also something “good” strengthens the social capital, particularly the resources of cooperation and participation.

**Table 6.**

*Spearman correlation indicator between leadership attributes associated with managing employees (LAME) and resources of social capital*

<b>Social capital</b>	<b>LAME1</b>	<b>LAME2</b>	<b>LAME3</b>	<b>LAME4</b>	<b>LAME5</b>	<b>LAME6</b>
Cooperation resource	0,222**	0,180**	0,204**	0,247*	0,262*	0,252*
Solidarity resource	0,148**	0,116	0,065	0,202**	0,092	0,120
Participation resource	0,113	0,153**	0,156**	0,084	0,168**	0,202**
Loyalty resource	0,188**	0,116	0,225**	0,093	0,166**	0,102
Value resource	0,128	0,165**	0,167**	0,166**	0,132	0,178**

\*  $p < 0,01$ , \*\*  $p < 0,05$ .

Source: own research.

Another analysed group of leadership attributes is the creation of the self-leader, who describes his/her ability to take responsibility for his/her past experiences and future aims, while also uses this awareness to create a positive version of himself/herself. Of the attributes associated with the creation of a leader, the analysed representatives of large companies rated self-awareness the most highly (awareness of your own weak sides and strong sides, while also readiness to improve the weak sides), the search for opportunities to continuously learn, while also to search for and use feedback from others at work.

**Table 7.**

*Leadership attribute – self-creation of leader (LASC)*

<b>Specification</b>	<b>Mean</b>	<b>Standard deviation</b>
LASC1 - Managers are based on principles and values when making decisions	4,48	1,906
LASC2 - A manager should be self-aware (know his or her strengths and weaknesses and be willing to improve the weaknesses)	4,58	2,030
LASC3 - Managers seek and use feedback from others	4,51	1,941
LASC4 - Managers know how to manage their time effectively	4,42	1,959
LASC5 - Managers seek opportunities for continuous learning	4,54	1,920
Total	4,51	1,948

Grading: 1 – I totally disagree, 2 – I mostly disagree, 3 – I partially disagree 4 – I neither agree nor disagree, 5 – I partially agree, 6 – I mostly agree, 7 – I totally agree.

Source: own research.

Leadership attributes associated with the creation of the self-manager is most strongly associated with the resource of cooperation, particularly the search for and use of feedback from employees. Apart from this fact, a significant impact was observed in terms of the leadership attributes on the resource of loyalty, particularly the attribute associated with knowledge of how to manage your time effectively. These attributes are most weakly associated with the resource of participation, as there was only an identification of a relation with taking decisions based on principles and values. By way of conclusion, the strongest impact on the resources of social capital was exerted by the self-awareness of the manager that was evidenced in terms of the familiarity with his/her weak and strong points, while also being ready to improve the weak points.

**Table 8.**

*Spearman correlation indicator between attributes of a manager associated with self-creation (LASC) and resources of social capital*

Social capital	LASC1	LASC2	LASC3	LASC4	LASC5
Cooperation resource	0,185**	0,251*	0,269*	0,275*	0,156**
Solidarity resource	0,132	0,211**	0,223**	0,145	0,188**
Participation resource	0,190**	0,117	0,060	0,090	0,136
Loyalty resource	0,107	0,184**	0,176**	0,346*	0,161**
Value resource	0,218**	0,203**	0,083	0,180**	0,158**

\*  $p < 0,01$ , \*\*  $p < 0,05$ .

Source: own research.

Organizational trust is not a feature of an organization that arises from its very essence, thus it is necessary to build it in a conscious manner. In an organization, the most important entity that undertakes action on behalf of building organizational trust is the manager himself/herself. Simultaneously, it must be a person who generally arouses trust. Placing trust in him/her on the part of the employees is the basis for building the culture of trust in an enterprise. The manager running the organization or employee group should have the leadership attributes that are favourable towards the building of organizational trust. Research reveals that the most highly rated are the attributes of the manager such as: transparency in the behaviour of the manager, the existence of the attitudes of acceptance of others and an open mind, while also reliability in terms of activities.

**Table 9.**

*Leadership attribute – building trust (LABZ)*

Specification	Mean	Standard deviation
LABT1 - Attitude of partnership and understanding demonstrated by the manager builds trust.	4.42	1.959
LABT2 - Cohesion in taking decisions by the manager creates trust between the employees.	4.54	1.920
LABT3 - The displayed reliability and ethics by the manager develops and creates trust among the employees.	4.51	1.948
LABT4 - Honesty and adherence to the principles by the manager has an impact on the increase in trust between the employees.	4,51	1,99

Cont. table 9.

LABT5 - Attitudes of acceptance of others and an open mind demonstrated by the manager has an impact on the increase in the level of trust.	4,65	2,01
LABT6 - Displaying reliability in activities by the manager develops and creates trust among the employees.	4,55	2,05
LABT7 - Transparency in the behaviour of the manager is the key to building trust between the employees.	4,70	2,03

Grading: 1 – I totally disagree, 2 – I mostly disagree, 3 – I partially disagree 4 – I neither agree nor disagree, 5 – I partially agree, 6 – I mostly agree, 7 – I totally agree.

Source: own research.

Analysing the relations between the leadership attributes favouring the building of organizational trust and the resources of social capital illustrated significant dependencies, particularly with the resources of cooperation and loyalty, whereas to a lesser extent with the resources of justice. The resource of cooperation was most strongly influenced by the following: reliability in the activities of the manager, reliability and ethicality, while also demonstrating the basics of partnership and understanding. However, the resource of loyalty was significantly influenced by the attitude of partnership and understanding, while also transparency in terms of behaviour and displaying reliability in terms of the activities of the manager. In turn, showing reliability in activities, demonstrating the basics of acceptance of others and an open mind, while also displaying reliability and ethicality exerted an impact on the resource of solidarity.

**Table 10.**

*Spearman correlation indicator between leadership attributes associated with building trust (LABT) and resources of social capital*

Social capital	LABT1	LABT2	LABT3	LABT4	LABT5	LABT6	LABT7
Cooperation resource	0,275*	0,158**	0,276*	0,245*	0,190**	0,283*	0,161**
Solidarity resource	0,036	0,188**	0,247*	0,204**	0,236**	0,287*	0,193**
Participation resource	0,110	0,128	0,194**	0,216**	0,117	0,129	0,123
Loyalty resource	0,346*	0,164**	0,188**	0,193**	0,188**	0,200**	0,201**
Value resource	0,092	0,158**	0,122	0,122	0,210**	0,110	0,185**

\*  $p < 0,01$ , \*\*  $p < 0,05$ .

Source: own research.

## Discussion and summary

From the point Social capital is the important factor influencing the success of an enterprise on a competitive market as it facilitates the effective use of the employee potential and managerial staff. It is just as important as a type of capital in an enterprise as financial capital, or human capital (Kriesi, 2007). It is favourable towards building cooperation based on trust, while also leading to the faster flow of information, as well as the creation of knowledge and creativity, which results in the reduction of costs associated with the coordination and control of employees. Social capital also brings benefits to employees in the form of building ties with

other employees and the enterprise as an institution. A significant role in the process of creating capital is played by the manager. The degree of the occurrence of social capital in the organization depends on his/her skills and level of involvement.

The findings of the research conducted facilitated the acquisition of answers to the formulated research questions. Firstly, the research findings relating to the extent of the occurrence of the resources of social capital in the analysed enterprises indicate their average level of occurrence, while simultaneously the resource of cooperation existed to the highest degree, particularly its attributes, namely, sharing information, knowledge and learning from each other, while also applying knowledge from one area to resolve problems that appear in another area of the firm and the resource of participation, including the following attributes: creating informal groups based on cooperation and participation in integration events. The resource of social capital was most highly rated in services enterprises, in which the skill of cooperation is required and is based on solidarity and loyalty.

Significant entities operating on behalf of creating social capital in an enterprise are managers who have an impact on building positive social relations in the organization. The level of social capital depends on their level of involvement in the activities on behalf of the organization and trust with regard to other employees. Of the analysed features of managers, it was observed that respect for norms and values, while also being mentors for their subordinates, possessing the features of a leader who supports innovations, while also possessing respect for norms and values, as well as the conviction that the majority favour the realization of aims in enterprises that are oriented towards the building of the resources of social capital, particularly cooperation and values.

In activities on behalf of the creation of social capital in an organization, an important role is played by the leadership attributes associated with the management of the organization, management of personnel, building trust and the creation of the self-manager. In the analysed enterprises, these attributes had an impact on the majority of the resources of social capital, while simultaneously the power of this impact was varied. Of the leadership attributes associated with managing the organization, respect for values and respect for variety amongst employees had the most important impact on the resource of cooperation. This attribute strengthens the pursuit of expanding relations with new business partners. In turn, the most important leadership attribute associated with personnel management is the lack of fear of conflict. The skill of coping with conflict favours the building of the resources of cooperation and participation in the organization. However, the key attribute associated with the creation of the self-leader was the self-awareness of the manager that was evidenced in the familiarity with the weak and strong points, while also being ready to improve his/her weak points that first and foremost has an impact on the resources of cooperation and solidarity. The final group of leadership attributes was associated with trust. Of all these attributes the most important relation was the one observed between showing reliability in terms of the activities of the manager and the resources of solidarity and cooperation.

Research on the impact of leadership attributes on the resources of social capital displayed close ties with inclusive leadership, which had an impact on building positive relations between the team members of employee teams, as well as psychological strengthening and work performance (e.g. creativity, work efficiency, reduced staff turnover) (Randel et al., 2018).

The author of this paper wishes to indicate the limitation of the use of the research findings on the role of managers in terms of stimulating the resources of human capital in Poland. The research conducted with the use of the survey method was aimed at outlining the intricate problematic issue of the impact of leadership on creating social capital and constitutes a starting point in further research on the internal mechanisms of this impact. Further research on the impact of leadership on the development of social capital may adopt a longitudinal approach for the purposes of research.

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## THE RELATIONSHIP BETWEEN THE WEALTH OF THE COUNTRY AND THE QUANTITY AND DEVELOPMENT OF SMART CITIES

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**Purpose:** The primary purpose of this study is to investigate and analyze the relationship between a country's wealth and the number and development of smart cities in its territory. This study aims to understand how a country's economic status affects its ability and willingness to invest in smart city initiatives.

**Design/methodology/approach:** The article uses a literature search. This study will adopt a mixed approach, combining quantitative and qualitative analysis. Statistical data on GDP, investments in smart city technologies, and urban development indicators from various countries will be used.

**Findings:** In research, the application of artificial intelligence in smart cities identified several key areas where AI has a significant impact: traffic and transport management, energy management and sustainable development, public safety, waste and natural resource management, citizen services, and spatial planning and urban development. These results can serve as a basis for further research and development of AI implementation strategies in urban contexts.

**Originality/value:** The study revealed several critical conclusions regarding the relationship between the country's wealth and the number and development of smart cities. There is a significant correlation between GDP per capita and the level of investment in smart city infrastructure and technologies. Wealthier countries are more likely to initiate and implement advanced smart city projects, investing their financial resources in innovative technologies and sustainable urban solutions.

**Keywords:** smart cities, GDP, smart city index.

**Category of the paper:** Research paper.

## 1. Introduction

In the face of the dynamic changes taking place in the world in the 21st century, cities are becoming not only centers of human activity but also laboratories of innovation and social change. In this context, the "smart city" concept has gained importance as a model for future urban development. Smart cities, using advanced technologies, strive to optimize urban functions, improve residents' quality of life, and increase resource and service management efficiency. However, a key question in global development is to what extent a country's wealth influences the number and development of these innovative cities.

The first step in analyzing this phenomenon is to understand what precisely the term "smart city" means. This concept is defined in many ways in the literature on the subject. Still, most definitions agree that smart cities use information and communication technologies (ICT) to improve operational efficiency, manage urban resources, and increase citizen involvement in city life. These technologies cover a wide range of solutions, from advanced traffic management systems through intelligent energy management systems to digital platforms for communication between residents and city authorities.

Another essential aspect is understanding how the wealth of a country affects the ability to implement and maintain smart city infrastructure. Rich countries often have more financial resources that can be allocated to investments in modern technologies and infrastructure. However, wealth is not the only factor that determines the success of smart cities. Other factors, such as government policies, education levels, innovation culture, and society's willingness to adapt to new technologies, also play a crucial role. However, it is worth paying attention to the fact that the development of smart cities is not only a matter of financial investments. It is also a process that requires a change of thinking among decision-makers and residents. Education and public awareness about the benefits of smart city solutions are crucial for their effective implementation and acceptance by society.

This article seeks to understand the complex relationships between the state's economy and the aspirations and implementation of the smart city concept. The purpose of this article is not only to examine the relationship between a country's wealth and the development of smart cities but also to understand whether a country's wealth can influence long-term sustainable development and improve the quality of life of city residents. The article consists of a review of the literature on gross domestic product. The second part concerns smart city indicators. This section overviews the most popular indicators and their brief characteristics. The third part compares the Cities in Motion Index (CIMI) and gross domestic product in individual countries.

## 2. Gross domestic product in the world

GDP, or Gross Domestic Product, is one of the fundamental economic indicators used to measure the total value of all goods and services produced in a given country during a specific time, usually a year. GDP is widely used as a measure of the size of a country's economy and as an indicator of its productivity and health. GDP is often used to assess the size and health of a national economy, providing a basis for international comparisons and assessment of economic progress. A high GDP usually indicates a strong economy and is seen as a sign of a country's prosperity. However, GDP does not consider income inequality within a country, which means that high GDP does not always translate into a high standard of living for all citizens.

GDP per capita, which divides total GDP by population, is used to assess a country's average level of well-being. Countries with a high GDP per capita are often considered more prosperous and developed. However, significant social and economic inequalities may exist even in countries with high GDP per capita. GDP is also used to assess the effectiveness of monetary and fiscal policies, and its growth is often seen as an indicator of economic success.

**Table 1.**  
*GDP in the twenty richest countries in the world*

1	United States	25,439,700
2	China	17,963,171
3	Japan	4,232,174
4	Germany	4,082,469
5	India	3,416,646
6	United Kingdom	3,089,073
7	France	2,779,092
8	Russian Federation	2,240,422
9	Canada	2,137,939
10	Italy	2,049,737
11	Brazil	1,920,096
12	Australia	1,692,957
13	Korea, Rep.	1,673,916
14	Mexico	1,465,854
15	Spain	1,417,800
16	Indonesia	1,319,100
17	Saudi Arabia	1,108,572
18	Netherlands	1,009,399
19	Türkiye	907 118
20	Switzerland	818 427

Source: Own study based on: <https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fdatacatalogfiles.worldbank.org%2Fddh-published%2F0038130%2FDRO%2F046439%2FGDP.xlsx&wdOrigin=BROWSELINK>

In globalization, GDP is essential in analyzing and comparing economies worldwide. Countries pursue GDP growth because it brings greater economic power and influence on the international stage. GDP growth is also related to improvements in infrastructure, health, education, and other critical aspects of society. However, excessive emphasis on GDP growth may lead to neglecting other vital elements, such as sustainable development, environmental protection, and social well-being. Table 1 shows the GDP of the twenty wealthiest economies in the world.

### 3. Smart city indices

Smart City indices play a crucial role in shaping the future of cities. Not only do they enable you to measure progress and identify areas for improvement, but they also stimulate competition and cooperation between cities worldwide. By focusing on diverse dimensions such as infrastructure, technology, public management, environment, community, and economy, these indices provide a comprehensive picture of a city's ability to adapt to modern challenges. Indicators, a set of measurable criteria, allow for assessing, comparing, and improving various aspects of urban life, from technology and innovation to sustainable development and urban management. The most popular indicators measuring the level of smart cities are the Broadband Penetration Rate, Air Quality Index, Renewable Energy Utilization Rate, Urban Mobility Index (Vidović 2019), Waste Management Index, and Cities in Motion Index (CIMI). These indicators are widely used to evaluate and compare smart cities worldwide, reflecting their technological progress, sustainability, mobility, and environmental management.

Broadband Penetration Rate (Leogrande, 2021) is an index showing what percentage of the population has access to broadband internet in a given area. That is a crucial indicator for smart cities because high availability and internet connection quality are necessary to implement and effectively use various smart city technologies. Broadband Penetration Index The rate is significant for supporting innovation and technology, economic development, education, and access to information. It shows the city's digital infrastructure assessment, so it is an essential tool for assessing the city's readiness to adopt and implement smart city solutions and the overall digital accessibility and inclusion in a given area.

Another smart city index is the Air Quality Index (AQI) (Wojtylak 2009), which is the simplest way to determine the level of air pollution on a scale from 0 to 500. The higher the index, the more polluted the air. Air quality assessment primarily covers the level of suspended dust PM<sub>2.5</sub> and PM<sub>10</sub>, but also some gaseous pollutants - sulfur dioxide (SO<sub>2</sub>), ozone (O<sub>3</sub>), nitric oxide (NO), carbon monoxide (CO), and benzene, which are most often the result of fuel combustion. Measurements are made continuously (automatically or manually) or periodically.

Advanced mathematical methods are used to assess air quality. The collected data on the concentrations of individual pollutants are compared with the so-called reference levels that create standards. It is a critical index in the context of smart cities. Air quality has a direct impact on the health of residents. High concentrations of pollutants can lead to health problems such as respiratory and cardiovascular diseases and even contribute to premature death. AQI monitoring allows us to identify and respond to unsafe levels of contaminants. Smart cities strive for sustainable development, including minimizing negative environmental impacts. AQI is an indicator that helps assess the effectiveness of environmental policies and activities to reduce pollutant emissions. As a result, AQI is not only an indicator of the state of the environment but also a tool enabling smart cities to make informed decisions that affect residents' quality of life and sustainable urban development (Kuang, 2016).

Renewable Energy Utilization Rate (Kuang, 2016) is a metric used in the context of smart cities to assess the extent to which a city uses renewable energy sources compared to traditional energy sources. The index reflects the city's commitment to sustainability and reducing its carbon footprint using cleaner and more sustainable energy sources. It is usually measured as the percentage of a city's total energy consumption from renewable sources such as solar, wind, hydropower, biomass, or geothermal. Therefore, the renewable Energy Utilization Index Rate is essential in assessing and promoting sustainability in smart cities, highlighting their commitment to reducing carbon footprints and promoting clean energy technologies (Giffinger, 2020).

The Urban Mobility Index is an essential tool for smart cities that allows for the assessment and continuous improvement of transport systems toward greater efficiency, sustainability, and innovation (Liponhay, 2023; Ali, 2021). In particular, it allows for assessing improvement in the quality of life by reducing commuting time availability of services and jobs. It is also essential in determining the sustainable development of cities because it helps assess how well a city copes with the challenges of congestion, exhaust emissions, and energy consumption in transport. A high score on the index indicates effective traffic management and the promotion of sustainable forms of transportation, such as public transport, cycling, and walking (Liszewski, 2012).

The Waste Management Index, an indicator (Mishra, 2022) used to assess the effectiveness of waste management systems in cities, is very important in the current reality. In the context of smart cities, this index is crucial because effective waste management is essential for sustainable urban development, environmental protection, and improving residents' quality of life. The index is significant when assessing recycling rates because it measures the percentage of recovered and reused waste. In addition, it also considers the effectiveness of activities aimed at reducing the amount of waste produced. By managing waste effectively, cities can significantly reduce greenhouse gas emissions, soil and water pollution, and other negative environmental impacts. Effective waste management is critical to sustainable urban development, saving resources, and minimizing environmental negative impacts.

Another index - the Cities in Motion Index (CIMI), is a vital tool for assessing and comparing cities worldwide, highlighting their performance in various key areas. It is a valuable tool for urban decision-makers, researchers, and investors interested in development and innovation in urban areas. This index helps you understand what factors contribute to cities' success as intelligent and sustainable places to live, work, and invest. This index evaluates cities based on various dimensions such as technology, urban governance, sustainability, mobility, community, economy, and more. The Cities in Motion Index is an aggregated measure based on indicators from the following areas: human capital, social cohesion, technology, international profile, urban planning, mobility and transportation, environment, governance, and economy. It allows you to compare cities worldwide, offering insight into how different cities cope with urbanization and globalization challenges. It provides policymakers, urban planners, and researchers with valuable information that can be used to formulate urban development policies and strategies. It helps identify areas where cities can improve their actions for sustainable development, innovation, and improving residents' quality of life.

#### **4. Cities in Motion Index and gross domestic product in individual countries around the world**

Smart city indices and a country's gross domestic product should be closely linked. The complex dynamics between economic development and urban innovation demonstrate that. GDP, as a measure of the size of an economy and its efficiency, often correlates with investments in infrastructure and technologies necessary for smart cities. Wealthier countries with higher GDP usually have more significant financial resources that can be allocated to developing smart cities, including innovative technologies, sustainable urban solutions, and digital infrastructure. Figure 1 shows the gross domestic product in individual countries of the world.

GDP is the primary comparative indicator between countries, enabling comparison of their standard of living and economic potential. GDP growth may result from factors such as increased labor productivity, investments, or new technologies. Although GDP is an important indicator, it does not consider many factors, such as quality of life, social equality, or environmental impact. Therefore, it should not be the only criterion for assessing the country's economic condition.



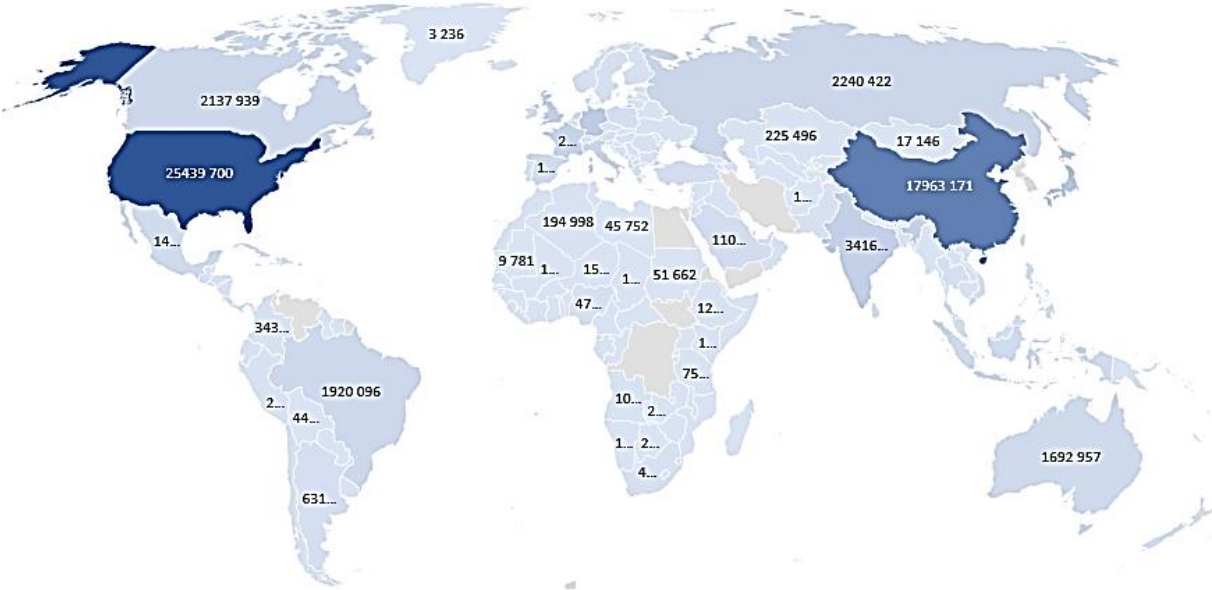


Figure 1. Global GDP in individual countries.

Source: Own study based on: [https://view.officeapps.live.com/op/view.aspx?src=https %3A%2F%2Fdatacatalogfiles.worldbank.org%2Fddh-published%2F0038130%2FDR0046439%2FGDP.xlsx&wdOrigin=BROWSELINK](https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fdatacatalogfiles.worldbank.org%2Fddh-published%2F0038130%2FDR0046439%2FGDP.xlsx&wdOrigin=BROWSELINK), 10.09.2023.

Smart city indices such as Cities in Motion assess cities across various dimensions, including technology, urban governance, mobility, environment, social cohesion, and economy. These indicators often show that cities in countries with higher GDP perform better in many areas. For example, access to advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and big data is often greater in wealthier countries, translating into better city management and services for residents.

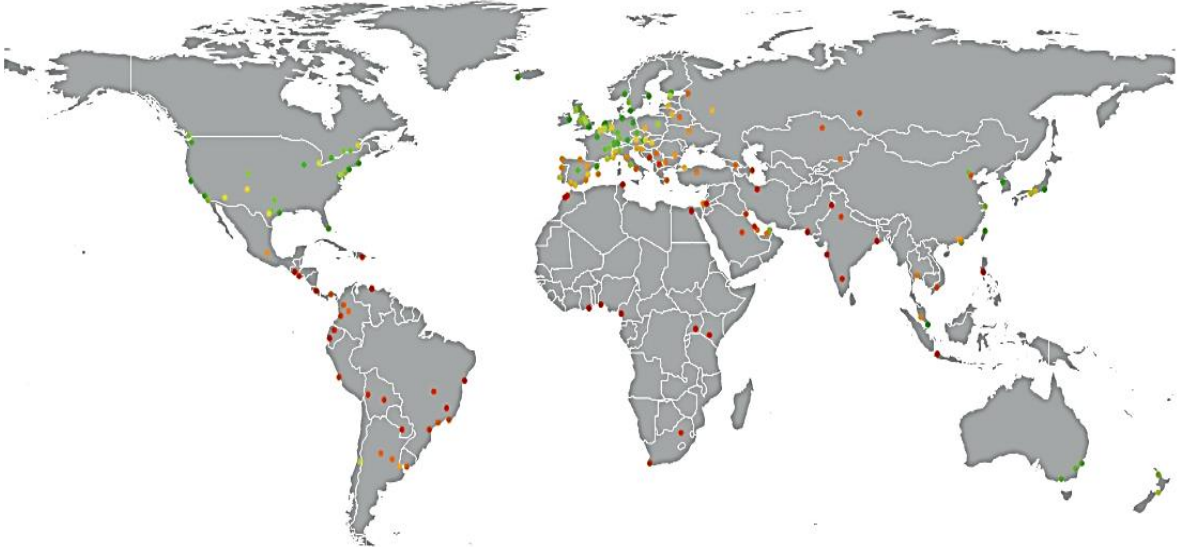


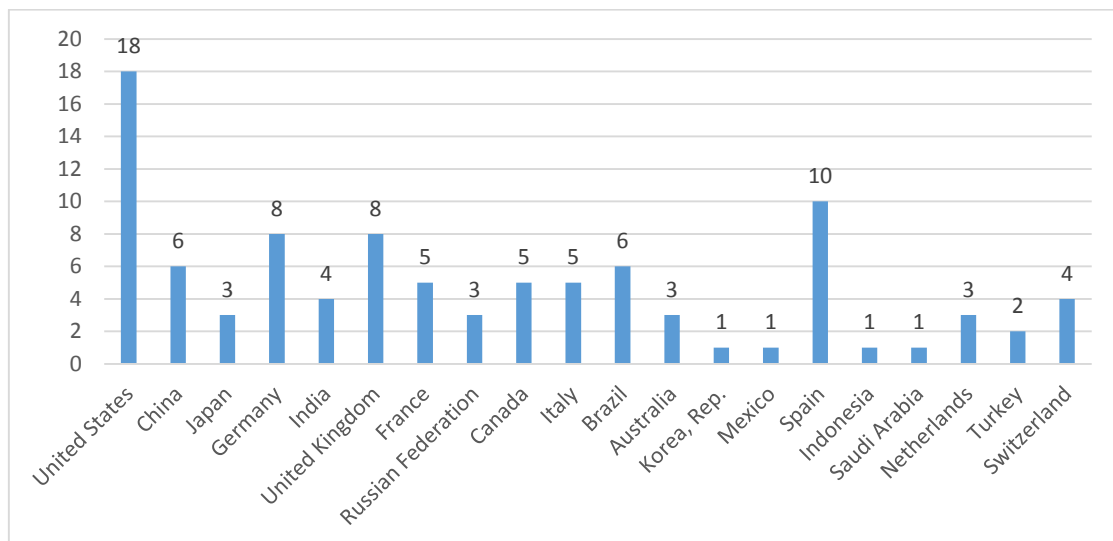
Figure 2. Smart cities.

Source: Own study based on: IESE Cities in Motion Index <https://www.iese.edu/media/research/pdfs/ST-0633-E.pdf>, 10.09.2023.

**Table 2.**  
*GDP in the twenty richest countries in the world*

Country	Smart city amount
United States	18
China	6
Japan	3
Germany	8
India	4
United Kingdom	8
France	5
Russian Federation	3
Canada	5
Italy	5
Brazil	6
Australia	3
Korea, Rep.	1
Mexico	1
Spain	10
Indonesia	1
Saudi Arabia	1
Netherlands	3
Turkey	2
Switzerland	4

Source: Own study based on: IESE Cities in Motion Index, <https://www.iese.edu/media/research/pdfs/ST-0633-E.pdf>, 10.09.2023.



**Figure 3.** Smart cities.

Source: Own study.

The analysis of the data presented in the table and graph indicates an interesting dissonance: the number of smart cities is not always proportional to the size of the GDP of a given country. This fact emphasizes that high GDP may indicate economic potential but is not an explicit guarantee of success in developing smart cities. Several other factors play a crucial role in this dynamic.

First, efficient use of resources is essential. Cities in countries with higher GDP may have more financial resources, but how these funds are used is crucial. Investments in smart city technologies must be purposeful and focused on long-term benefits for residents, not just short-term economic gains. Innovative approaches to urban planning are equally important. The development of smart cities requires creative thinking and readiness to experiment with new solutions. In this context, cities in countries with lower GDP often demonstrate the capacity to innovate as they have to cope with limited resources and often more complex socio-economic challenges. The involvement of local communities is another critical factor. The development of smart cities is not just about technology; it's also about people and their needs. Cities involving their residents in planning and implementing smart city solutions often achieve better results. Residents can provide valuable information about local needs and challenges, translating into more effective and user-friendly solutions.

In some cases, cities in lower GDP countries are making significant progress in smart city solutions. That often happens through creative use of available resources, international cooperation, and focusing on specific challenges such as mobility or waste management. These cities usually take a more integrated and holistic approach to development, including public-private partnerships, community-based initiatives, and low-cost technologies.

Developing smart cities is a complex process that requires more than just solid financial investments. It requires strategic planning, innovation, social involvement, and adapting to local conditions and needs. High GDP can be helpful, but it is not the only or most important factor determining success in creating intelligent, sustainable, and citizen-friendly cities.

## **5. Conclusions**

The conclusions from the article on the relationship between the wealth of the country and the number and development of smart cities are multidimensional and emphasize the complexity of this relationship. First, the analysis showed a clear correlation between the level of GDP per capita and investments in infrastructure and technologies necessary for the development of smart cities. Countries with higher GDP tend to invest more in innovative technologies, which translates into more advanced and integrated smart city solutions.

However, high GDP is not the only factor determining success in developing smart cities. Innovation, strategic planning, community engagement, and international cooperation proved equally noteworthy. In some cases, cities in lower GDP countries have shown significant progress in smart city solutions, often by creatively using available resources and focusing on specific challenges. High GDP can also lead to increased urbanization and associated challenges like pollution, traffic congestion, and social inequality. Smart cities in wealthier

countries often need to address these issues using innovative technologies and urban management approaches to improve residents' quality of life and sustainable development.

Overall, this study highlights that while a country's wealth significantly impacts smart city development, other factors such as innovation, strategic planning, community engagement, and international cooperation are also crucial. High GDP may support the development of smart cities, but it is not the only factor determining their success. In the future, it will be essential to balance economic growth with the principles of sustainable development, environmental protection, and improving residents' quality of life.

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## THE SITUATION OF WOMEN IN THE CONTEXT OF CONTEMPORARY LABOUR MARKET CONDITIONS

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**Purpose:** An analysis of the situation of women on the Polish labour market and identification of arguments in favour of measures supporting the professional activation of women.

**Design/methodology/approach:** This study is an overview and attempts to analyse the situation of women in the Polish economy on the basis of recent Polish and foreign reports.

**Findings:** Macroeconomic benefits and the potential to improve business performance are arguments in favour of measures to activate women in the labour market, to support their career development and to promote gender diversity in companies to attract talent.

**Research limitations/implications:** The paper identifies the micro- and macro-economic benefits of increasing women's participation in the labour market.

**Practical implications:** The author characterises the changes taking place on the labour market in the context of the situation of women, with particular reference to Polish socio-economic policy regulations and European Union directives on equality policy.

**Originality/value:** Given the dynamic changes on the Polish labour market, which is already facing very strong supply pressures, seeking solutions to encourage as many people as possible on the labour market, including women, to remain economically active for as long as possible is a necessary condition for the development of the modern economy. Harnessing the potential of women brings tangible results for economies and businesses, hence measures should be taken to redress the gender imbalance in various areas of the wider labour market.

**Keywords:** labour market, woman, equality policy, professional activation.

**Category of the paper:** The paper is a review.

### 1. Introduction

The Polish labour market is experiencing dynamic changes that employers are facing. The age structure of Polish society indicates that the labour market is currently dominated by the baby boomers of the late 1980s and early 1990s. Just behind the current 30- and 40-year-olds, there is a serious reduction in the population of both women and men. This means that over the next five years, the domestic labour market will face strong supply pressures.

The situation will gradually worsen with every five years. This means that now is the last moment to encourage the current baby boomers to stay economically active for as long as possible. Otherwise, the economic development to make up for the gap between Poland and other Western European countries will be hampered, and the economy itself will be subject to many burdens, e.g. social (solvency of the pension system) (Zielonka, 2021, pp. 3-4). The ageing of the population has therefore become one of the reasons why women will have to fill the labour market gaps.

As Tom Peters says, with the 21st century we have 'entered the Age of Talent' (Peters, 2005, pp. 250). In today's business, people matter above all. The aforementioned demographic changes mean that it is becoming increasingly difficult to attract above-average people into businesses. Access to talent is declining as fewer and fewer young people graduate and enter the labour market, and the global economy means that you can work in virtually any country in the world. Talented people therefore choose those companies that offer more favourable working conditions not only in terms of money, but also in terms of development. Diversity - especially gender diversity at top management levels - is nowadays seen primarily as a creator of higher profitability (Adler, 2001; *The Bottom Line...*, 2011; *Women at the Top...*, 2010; Lisowska, 2010, pp. 3-12) and company competitiveness (Griffin, 2004, pp. 15, 190; Wróbel, 2010, pp. 72-79). A focus on diversity fosters the attraction of talent, especially women, who, as half of any society, are a hitherto undervalued source of talent.

The aim of this paper is to analyse the situation of women on the Polish labour market and to identify arguments in favour of taking measures to support the professional activation of women.

## **2. Situation on the Polish labour market**

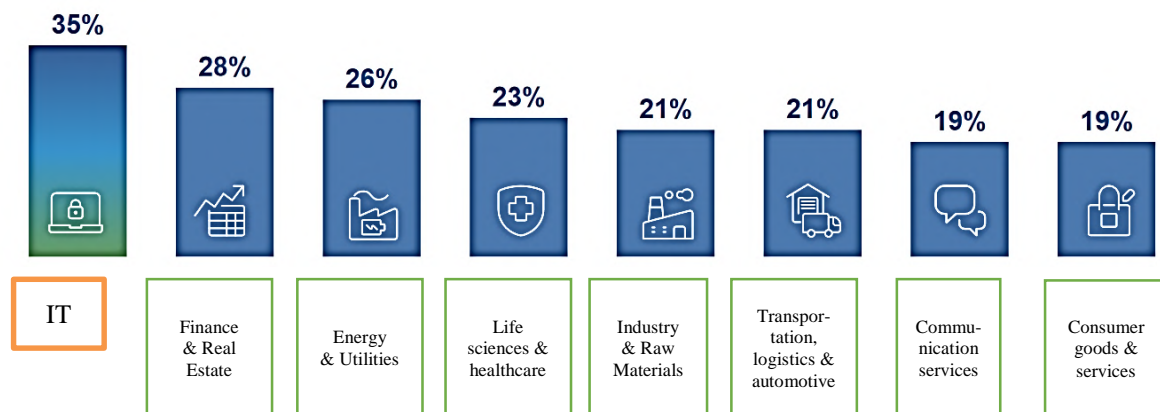
The current changes in the Polish labour market are dictated by far-reaching factors in the external environment, such as, above all, the war in Ukraine, high inflation, rising loan instalments and the increasing cost of doing business in the broadest sense. Although hiring decisions have been taken very cautiously since the beginning of 2023, companies are starting to build strategies and plans for the coming months anew, which looks quite promising for the labour market.

In the third quarter of 2023, 31% of businesses plan to hire new employees, according to the ManpowerGroup Employment Outlook Survey (ManpowerGroup Employment..., p. 4). According to the report's authors, the Outlook for Poland, which reflects the recruitment sentiment of organisations, is plus 12%, indicating a greater willingness to hire new talent than in recent months. This is 4 percentage points higher than the forecast declared for the period from April to the end of June, and an increase of 4 percentage points compared to Q3 2022. In practice, this means that the labour market is slightly more active than in recent times.



The global employment gap is projected to be as high as 453 million people (11.7%) in 2023, more than double the global unemployment rate (5.3%) (The reality of the labour market...). According to 'The Talent Shortages by Manpower' (Talent Shortage...), already 77% of employers worldwide report problems finding qualified talent.

In Poland, difficulties in finding qualified employees were reported by as many as 72% of employers, who anticipate strong global demand for talent in key sectors. Digitalisation continues to drive the job market globally: organisations in IT declare the most optimistic outlook (+35%). Employers in finance and real estate (+28%) and energy and utilities (+26%) also expect to expand their teams (figure 1).



**Figure 1.** Global demand for talent in key sectors of economies.

Source: ManpowerGroup Employment Outlook Survey Report. Data for the first quarter of 2023, [https://7370478.fs1.hubspotusercontent-na1.net/hubfs/7370478/Barometr\\_ManpowerGroup\\_Perspektyw\\_Zatrudnienia\\_dla%20Q1\\_2023-1.pdf](https://7370478.fs1.hubspotusercontent-na1.net/hubfs/7370478/Barometr_ManpowerGroup_Perspektyw_Zatrudnienia_dla%20Q1_2023-1.pdf), 22.08.2023, p. 19.

At the same time, the inferior position of women in the labour market compared to that of men is perpetuated. Their situation is characterised by lower labour force participation, and the low unemployment rate is not due to high employment - it reflects greater inactivity. There is also still a concentration of employment in lower positions and in low-paid industries. The gap between Poland and the leaders (Sweden, Denmark) in the European Union in terms of equal opportunities on the labour market also persists (Report of the Women's Congress..., p. 6).

Poland's female labour force participation rate is 68% - 4 p.p. lower than the average in European countries - as many as 430 000 Polish women are economically inactive. It is still primarily women who are involved in family responsibilities, childcare and elderly care, which affects their professional plans - according to Social Insurance Plant, in 2021, 99% of women and only 1% of men took advantage of parental leave. At the same time, an inefficient childcare system effectively makes it difficult to return to work after maternity or parental leave. A survey conducted by the Pracuj.pl website shows that more than 83% of professionally active women see difficulties in reconciling parental and work duties ([https://www.portalkadrowy.pl/...](https://www.portalkadrowy.pl/)).

Labour market research and CSO data indicate the persistence of horizontal (industries) and vertical (positions) segregation of employment. Women, despite being better educated, work in lower positions than men and in feminised sectors of the economy, in occupations that

are less well paid and often described as less prestigious (Report of the Women's Congress..., p. 11).

For the past decade or so, we have had virtually equal participation of women and men in the labour market. According to Eurostat (Does gender matter...), 44% of Polish women already hold managerial positions in the country. However, when we look at senior management, this share already falls to around 25%. In turn, research conducted by the Polish Economic Institute among the largest companies listed on the Warsaw Stock Exchange shows that the share of women on management boards is 12.6% and on supervisory boards is 17.3%. Even in the financial sector, where women make up 60% of the workforce, there are only 13 on company boards (Increasing the role of women...).

According to the results of the Women's Congress Association's report, "Kobiety, rynek pracy i równość płac" (Women, the labour market and equal pay), 53% of those surveyed, including 60% of women and 47% of men, agree with the statement that it is mainly men who hold managerial positions. 38% of respondents disagree with this statement (Report of the Women's Congress..., p. 13).

### **3. Contemporary labour market developments in the context of the situation of women**

Current trends in the labour market favouring an increase in women's labour force participation can be observed, which focus, among other things, on concrete action by all stakeholders - government, business, NGOs and societies.

One of the important incentives for improving the situation of women in the labour market is the gradual transition from the traditional family model to a partnership model, in which men are actively involved in childcare and household duties on an equal footing with women, which should significantly increase women's labour market participation.

Although, in retrospect, both the political will and the actions of the government should be critically assessed, several measures have so far been introduced in Poland at the socio-economic policy level to facilitate the combination of work and family responsibilities, such as:

- The possibility of combining parental leave with part-time work (Art. 1821d., § 1., Art. 1821e. § 1. - Journal of Laws 2015, item 1268; Art. 1, item 9 of the Act of 24 July 2015 amending the Act - Labour Code and certain other acts),
- Financing of nannies' insurance premiums from the state budget (Social Security Plant regulations in force since 1.01.2018) (<http://prawo.sejm.gov.pl/...>; <http://www.zus.pl/pracujacy/nianie/ubezpieczenie...>; <http://www.zus.pl/pracujacy/nianie/nianie...>).

In addition, three new European Union directives give directions and introduce tools for implementing equality policies in important areas for equal opportunities for women and men (Report of the Women's Congress..., p. 31):

- WORK-LIFE BALANCE - *Directive on work-life balance for parents and carers* (Directive (EU) 2019/1158...). It aims, among other things, to create an incentive for fathers to take leave, the possibility for parents raising a child under 8 to apply for flexible working hours and a non-transferable portion of parental leave of up to 9 weeks for the father and mother.
- PARITY IN BUSINESS - *Directive on improving the gender balance among non-executive directors of listed companies and related measures* (DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL (EU) 2022/2381...). Increasing the proportion of women on company boards - to increase to at least 40% on supervisory boards or at least 33% on company boards, i.e. management and supervisory boards combined, by the end of June 2026.
- PAY TRANSPARENCY - *Directive of the European Parliament and of the Council on strengthening the application of the principle of equal pay for men and women for equal work or work of equal value through pay transparency and enforcement mechanisms* (DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on enhancing...). Wage Transparency (Closing the Pay Gap) Directive - introduces an obligation to provide information on minimum pay or pay ranges - in the job advertisement or before the interview - and the right of male and female workers to information on average pay levels by gender for employees doing the same work or work of equivalent value. The directive also requires gender pay gap reporting from employers with more than 100 employees.

According to experts, as time passes and generational changes take place, an increase in the percentage of economically active women will become apparent, not only in industries stereotypically considered "female". In occupations associated with men, such as driver, warehouseman, logistician, production worker, construction worker, there are beginning to be more women. According to a survey of the Friendly TSL Employer 2022 (Raport Prezes nie zgodził się...), by Pracujwlogistyce.pl and TransLogistica Poland, the number of women working in the TSL industry has already reached 47% of the total workforce.

#### **4. Micro and macroeconomic benefits of increasing women's participation in the labour market**

The labour force participation of Polish women is low compared to other women in Europe. This has consequences at the macro level for the development of the economy, but also at the micro level for households themselves. The low activity of almost half of the population means a potential lost benefit in the growth of the Gross Domestic Product, a much greater burden on the social security system. In turn, at the micro level, it is a lost household income.

According to the Central Statistical Office (CSO) data from mid-2021, women account for 51.6% of Poland's total population. There were more than 10 million Polish women of working age, i.e. 18-59. If one were to assume that the working age of women is equal to that of men (18-65), it would turn out that, firstly, more than 1.3 million women constitute a potential lost labour market resource. Potential, as some women aged 60-64 are still active in the labour market despite acquiring pension rights. Secondly, as of mid-2021, we had potentially as large a resource of working-age women as men (Zielonka, 2021, p. 3).

Macroeconomic benefits and the possibility of improving the performance of companies are arguments in favour of taking action to activate women in the labour market and support their career development.

The economic activation of women will be important for the pace of the country's economic development. Due to demographic challenges such as the decline in the population aged 15-64 (by 2.3 million by 2025) (Difference between the population..., 2014) and the large labour emigration of young people in Poland, labour supply is declining dynamically. According to McKinsey estimates based on the McKinsey Global Institute model, by 2025, Poland's cumulative GDP could increase by an additional 7% (PLN 1.3 trillion) due to an increase in female labour force participation and an increase in average female productivity. In 2025 alone, the Polish economy could generate an additional PLN 270 billion above the baseline scenario, i.e. 11% more (McKinsey&Company report..., 2017, p. 30).

On top of this, companies that prioritise gender diversity reap real benefits. This is borne out by the McKinsey study 'Diversity Matters' showing that organisations in the top 25% most gender diverse are 15 per cent more likely to have higher financial performance than the median for their industry (Labour market gets...).

## 5. Summary

The analysis of the professional position of women on the Polish labour market presented in the paper indicates activities supported by both the state and the European Union, which implement numerous projects aimed at combating discrimination and equalising opportunities. Unfortunately, in spite of these initiatives, the professional potential of women is not adequately noticed and appreciated, and limiting their professional position minimises the development of diversity in the company. Organisations should increase female participation, including in high-level positions, making women equal business partners for men.

The examples cited by the author of the tangible benefits of increasing women's participation in the labour market give reason to hope that gender disparities in various areas will be closed sooner than predicted by the World Economic Forum report, whose authors claim that gender equality can only be achieved in 170 years, i.e. in 2186 (Słowik, 12.2016-01.2017, pp. R6).

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## THE EFFECT OF TALENT MANAGEMENT ON EMPLOYEES ATTITUDES AND BEHAVIOR: EXAMINING THE ROLE OF ORGANIZATIONAL JUSTICE

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**Purpose:** The purpose of this paper is to explore employees' reactions to talent management (TM), given the controversy around this issue. Specifically, the study presented here aims to determine the impact of TM practices perceived by the talent pool members on their work engagement and organizational citizenship behavior (OCB). The study also investigates the role of perceived distributive and procedural justice as an psychological processes that are involved in shaping the employees' reactions.

**Design/methodology/approach:** The authors surveyed 730 participants of talent pools from 33 large companies, each of which has its own well-developed TM program. A series of hierarchical regression analyses were performed to test the hypotheses.

**Findings:** The study shows that TM practices perceived by employees in talent pools have a positive direct and indirect (via perceived distributive justice) effects on their work engagement and OCB. The results also reveal that perception of procedural justice moderates the impact of perceived distributive justice on talent pool members' engagement and OCB.

**Originality/value:** Although TM has received considerable attention in the practitioner and academic literature, very little is known about its long-term consequences, especially on performance-related attitudes and behaviors of employees. This seems to be an important omission as their reactions should influence how effective TM programs are. Present study is one of very few studies to investigate the effects of TM practices at the individual level, thus delivering added value to the study domain.

**Keywords:** talent management, work engagement, organizational citizenship behavior, organizational justice.

**Category of the paper:** Research paper.

## 1. Introduction

Contemporary economic realities, characterised by intense market competition, high dynamics of changes in the organizations' environment and declining demand due to the recent lockdowns caused by the COVID-19 pandemic, have led to a significant increase in risk and uncertainty in managing the organization. These tendencies have contributed to the weakening of bonds between employees and employers who, facing difficult market conditions, are unable to provide their staff with stable, long-term employment. This elicits employees' dissatisfaction with their work, lower engagement and willingness to change the job (Rožman et al., 2021). In response to the economic challenges of the 21<sup>st</sup> century, organization's decision-makers implements TM programs to mitigate the loss of talented employees and meet the organization's current and future competency needs (Seopa et al., 2015; Mwila, Turay, 2018).

Presently, TM is perceived by academics and practitioners as one of the priorities in management of an organization (Khoreva et al., 2017; Anlesinya et al., 2019). This is primarily due to the growing competition among companies for a limited resources of talented employees, which is called in the literature 'the war for talent' (Joss et al., 2023). Despite the ongoing discussion on TM over the past few decades, this issue has still not reached theoretical maturity and requires further development. Specifically, there is a shortage of satisfactory empirical evidence confirming that companies' efforts in the field of TM have a positive impact on employees' attitudes and behavior. Some studies (e.g., Björkman et al., 2013; Gelens et al., 2014) confirm that such a relationship exists, while others report that TM causes negative reactions of employees, such as a feeling of stress and insecurity (Dries, Pepermans, 2008) or identity struggles at work (Tansley, Tietze, 2013). Owing to the existing research gap, managers lack scientific grounds to make decisions about talented individuals.

Therefore, the main purpose of this paper is to determine the impact of TM practices on the work engagement and OCB of talented employees, that is attitudes and behavior that have been associated with organizational outcomes in previous research. The study expands the knowledge of employees' reactions to TM and, consequently, provides an enhanced insight into the results of this process at the individual level, given the controversy around this issue. To better understand how TM affects employees' reactions, we also explored the underlying mechanism that link TM practices to work engagement and OCB. In addition, the manuscript advances current research on determinants of employees' attitudes and behavior. The research was carried out within the research project no. 2017/27/B/HS4/02172 and 2018/31/N/HS4/03936, funded by the National Science Centre, Poland.

## 2. Theoretical background and hypotheses

### 2.1. Talent management

TM is actually a multilevel construct consisting of distinct, hierarchically ordered components, that is, principles, policies, programs and practices (De Boeck et al., 2017). Existing literature operationalize these components at different, interdependent levels of abstraction. Ordered from more to less abstract, principles, policies and programs are all considered as global components designed by organizational leaders and human resources (HR) managers. In contrast, TM practices represent less abstract component that depend on how well TM programs are implemented by lower level managers (De Boeck et al., 2017). As the practices are situated at the lowest level of abstraction, in this paper TM is operationalized as a set of human resources management (HRM) practices focused on remarkably talented people in the organization, which includes networking, internal project teams, special tasks to stimulate learning, in-house development programs, cross-disciplinary project working, instructor-led off the job training, formal career plans, coaching, mentoring, assessment centers, graduate development programs, succession plans, high-flier schemes, university courses, training in international operations, short-term international systems, international project teams, internal and external secondments, and job rotation (Tatoglu et al., 2016).

### 2.2. Work engagement

Work engagement is defined as “a positive, fulfilling work-related state of mind that is characterized by vigor, dedication, and absorption” (Schaufeli et al., 2006, p. 702). *Vigor* is characterized by high level of energy and mental resilience while working, the willingness to invest effort in one’s work, and being persistent even in the face of difficulties. *Dedication* reflects a strong involvement in one’s work and feeling of significance, enthusiasm, pride, inspiration, and challenge. Finally, *absorption* refers to being fully concentrated and deeply engrossed in one’s work, whereby time passes quickly and one has difficulties with detaching oneself from work (Robijn et al., 2020). Engaged employees have a sense of energetic and effective connection with their work activities, and they see themselves as able to deal well with the demands of their jobs (Zhang et al., 2019).

### 2.3. OCB

OCB’s are work-related activities performed by employee that are discretionary, so do not directly or explicitly recognized by scope of job description (do not belong to the formal duties of employees) but foster the effective and efficient functioning of the organization (Jehanzeb, 2021). Podsakoff et al. (1990) organized different types of OCB’s into five categories or dimensions: altruism, conscientiousness, sportsmanship, courtesy, and civic virtue.

*Altruism* involves voluntarily helping others with organizationally relevant tasks or work-related problems. *Conscientiousness* entails behaviors that go well beyond the minimum role requirements of the organization in terms of attendance, obeying rules and regulations, taking breaks, and so forth. *Sportsmanship* is a willingness to tolerate the inevitable inconveniences of work without complaining, and maintaining a positive attitude even when things do not go our way. *Courtesy* refers to a person's behavior aimed at preventing work-related problems with others from occurring. Finally, *civic virtue* represents interest in, or commitment to the organization as a whole by active participation in, and involvement in the life of company, and looking out for its best interests.

#### **2.4. TM, organizational justice and their consequences**

In line with social exchange theory (Blau, 1964), employees negotiate exchanges with the organization in which actions of one party evoke reciprocation by the other. Therefore, they adjust their behavior depending how they think the organization perceived them in terms of value and potential. Applied to TM, such a social exchange would imply that, when the employer invests in the employment relationship by, for example, providing an access to a wide range of development opportunities or offering fast-track promotion, employees are then feel obligated to reciprocate these investments with beneficial attitudes and behavior (Khoreva, Maarten, 2016). Meeting obligations helps employees maintain the positive self-image of those who repay debts and avoid the social stigma associated with the reciprocity norm's violation (Caillier, 2017). In consequence, employees perceiving high support are more likely to show higher engagement to do the things that the organization values and prioritizes to compensate advantageous treatment they receive from the employer (Swales, Blackburn, 2015). Therefore, it is reasonable to assume that:

*Hypothesis 1: TM practices perceived by employees in talent pools are positively related to their work engagement.*

*Hypothesis 2: TM practices perceived by employees in talent pools are positively related to their OCB.*

Implementation of a TM program requires a careful differentiation of the workforce in terms of performance and potential prescribing diversification of HRM systems within organization on the basis of the returns the performance of different employee groups generate (Kwon, Jang, 2022). This differentiation refers to the investment of disproportionate resources where one expects disproportionate returns, in those specific people that help create strategic success (Gallardo-Gallardo et al., 2015). The underlying rationale of the differentiation is that it is believed that organizations suffer unnecessary high costs when they invest equally in all employees (Collings, 2017). Therefore, organizational decision-makers should target their HRM practices specifically at those employees they are least willing to lose, i.e. those who are of high value to the organization, and most difficult to replace (Dries et al., 2014). As a consequence the scarce resources of an organisation ought to be invested first and foremost

in attracting, developing and retaining of talented people, as they generate higher performance and higher returns, than non-talented. Differentiation creates inequalities in the distribution of resources, which affects the employees' perception of distributive justice, that is, perceived fairness of the allocation of resources within the organization (Al-Douri, 2020). Employees who are considered as talented experience greater distributive justice when given greater resources. In the light of preceding considerations, it is proposed that:

*Hypothesis 3: TM practices perceived by employees in talent pools are positively related to their perception of distributive justice.*

As equity theory (Adams, 1963) contends, the perceptions of organizational justice shape employees' attitudes and behavior. In line with this reasoning, the few studies have tested the impact of perceived distributive justice on work engagement and OCB. For example, Rangriz (2012), Jafari and Bidarian (2012), and Rahman and Karim (2022) have proved that employees who perceive that the distribution of resources in organization as fair showed a higher level of work engagement and when employees have a good perception of distributive justice, they have a greater tendency toward involving and participating in showing OCB. Therefore, we hypothesized that:

*Hypothesis 4: The talent pool members' perception of distributive justice is positively related to their work engagement.*

*Hypothesis 5: The talent pool members' perception of distributive justice is positively related to their OCB.*

#### *The mediating effect of perceived distributive justice*

Employees who are included in the organization's talent pool get a stronger recognition of their potential as they receive a higher status than others (Gelens, 2014). They also obtain access to wide range of development activities, additional incentives and fast promotion opportunities that are perceived as symptoms of preferential treatment (Lee, 2018). When talent pool members see the opportunities for promotion and growth offered to them, they consider the distribution of resources in the organisation as fair. The perceptions of justice they experience induce a willingness to reciprocate the investments made by the employer, which may lead to greater work engagement and OCB's (Godkin, 2014; Hurrell 2016). In line with this reasoning, we assume that TM practices affect distributive justice perceived by talented employees, which, in turn, enhances their work engagement and OCB. Therefore, the following hypotheses are formulated:

*Hypothesis 6: The perception of distributive justice mediates the relationship between TM practices perceived by employees in talent pools and their work engagement.*

## **2.5. The moderating effect of perceived procedural justice**

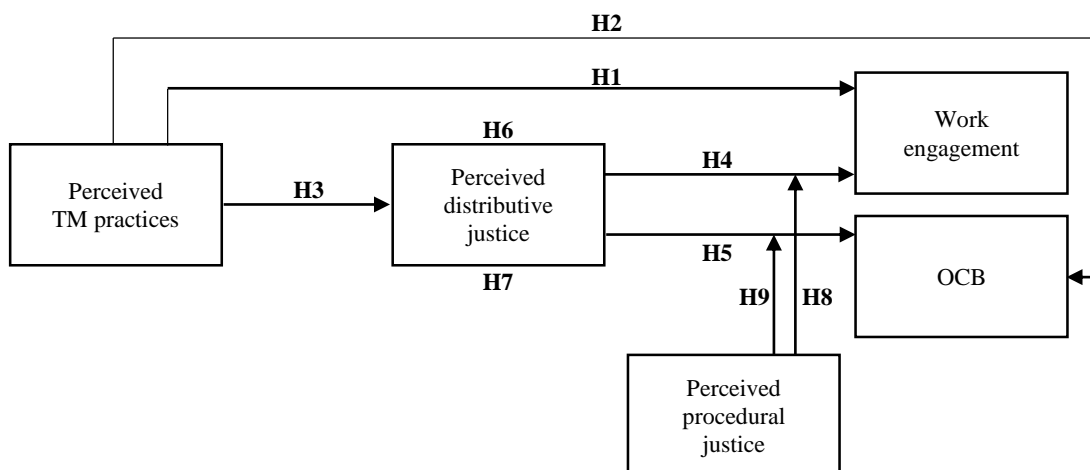
The TM process are often quite intransparent, with crucial information being withheld from employees, since companies are unwilling to disclose the status of talent pool members for the fear of their associates' reactions (e.g. jealousy, discouragement) and stigmatization of talented

employees as Primus (Dries, 2013). A lack of transparency in TM may negatively affect employee's perception of procedural justice, that is, perceived fairness of the process, rules and procedures by which resources are allocated within the organisation (Al-Douri, 2020). If the employees perceive the information they receive about TM to be incomplete, out of date or lacking in detail, they will feel unfairly treated. This could lead to negative reactions aimed at restoring the balance in the relationship with the employer (Ghosh et al. 2014), such as lowering of work engagement and discretionary effort, particularly extra-role or citizenship behavior (Agarwal, 2014; He, 2014; Daniel, 2016; Lyu, 2016). Given the above, the following hypotheses were proposed:

*Hypothesis 8: The perception of procedural justice moderates the relationship between distributive justice perceived by talent pool members and their work engagement in such a way that the relationship is stronger when employees in talent pools perceive the rules and procedures of resource allocation in an organisation as fairer.*

*Hypothesis 9: The perception of procedural justice moderates the relationship between distributive justice perceived by talent pool members and their OCB in such a way that the relationship is stronger when employees in talent pools perceive the rules and procedures of resource allocation in an organisation as fairer.*

In summary, we assumed that TM practices perceived by the talent pool members directly and indirectly (via perception of distributive justice) affect their work engagement and OCB. It is also expected that talent pool members' perception of procedural justice enhances the effect of perceived distributive justice on their work engagement and OCB. Based on the literature review an integrated conceptual framework for empirical investigations is proposed, where the relationships between the examined constructs are reflected (see Figure 1).



**Figure 1.** Conceptual framework and hypotheses.

Source: own work.

### 3. Methods

We surveyed 730 participants of TM programs (*so-called* talents) from 33 companies, each of which has its own well-developed TM program. At least 20 correctly and completely completed questionnaires were obtained in each of the examined organization. The survey allowed a significant number of replies to be obtained at a low cost, did not induce an immediate reply and gave the respondents a feeling of autonomy.

#### 3.1. Data collection and sample characteristics

The data were collected by means of an on-line questionnaire sent to 500 organisations on the 2020 list of the largest companies in terms of revenues operating in Poland (*so-called 500 List*), which is published annually by the economic and legal journal *Rzeczpospolita*. The rationale for conducting study on a sample of large companies is that the core research subject, that is TM, occurs mainly in this type of organisations. Small and medium-sized enterprises, due to the low level of formalization of HRM function (Singh, Vohra, 2009; Wickramasinghe, 2022), rarely decide to implement the TM programs. A similar assumption has been made by Ingram (2016) and Chodorek (2016). Purposive sampling was used, as in most studies on TM (*e.g.* Dries, Pepermans, 2007; Dries et al., 2012; Björkman et al., 2013; Gelens et al., 2015; Seopa et al., 2015; Swailes, Blackburn, 2016). Conducting the research on a random sample was not possible owing to the lack of a register of companies that managing talents in an deliberate and organised manner. As we were collecting data during the pandemic (from October 2020 to January 2021) and our target groups of respondents were hard to reach, we recruited participants through distributing questionnaires via contact persons in the HR departments. In each company, he or she reached out to employees identified as talent, explaining the aims of the study and the importance of their participation.

In total, 45.6% of surveyed employees were male and 54.4% were female. The average age of respondents was 29.76 ( $SD = 3.41$ ) ranging from 23 to 37 years, with an average of 4.06 years of job tenure ( $SD = 2.19$ ) and 5.59 years of organizational tenure ( $SD = 2.60$ ). Their average work experience was 5.93 years ( $SD = 2.95$ ). In terms of education, 69.4% of them had obtained a Bachelor's or Master's degree, and 30.6% held a secondary school diploma. 93.4% of talent pool members in our sample were full-time employees. They represented a wide range of industries such as: finance services, insurance, consulting, IT, telecommunications, retail, foodservice, and others.

#### 3.2. Variables and measures

Following Tatoglu et al. (2016) we measured **TM practices** through a total of twenty TM practices identified by Chartered Institute of Personnel and Development (2011) which serves as a reference to operationalizing TM in empirical studies. Participants of TM programs

were asked whether or not they perceived their employer as offering to them the opportunity to make use of particular TM practices. Responses were given on a five-point Likert-type scale in which 1 corresponds to “never used” and 5 to “used very extensively”. Among the practices included in scale were *i.a.* job rotation, cross disciplinary project working, training in international operations, external secondments, and high flier schemes. The scale had good reliability (Cronbach alpha 0.89).

The level of **work engagement** was measured using the shortened version of *Utrecht Work Engagement Scale (UWES-9)* developed by Schaufeli *et al.* (2006). The UWES-9 is rooted in Schaufeli *et al.*'s (2002) conceptualization of work engagement that has evolved from formative Kahn's (1990) concept. It allows to measure three dimensions of engagement: vigor, dedication and absorption. Respondents were asked to indicate how often they feel a certain way at work. They reported on a seven-point frequency rating scale ranging from 0 (never) to 6 (always). Sample items for each of three dimensions are: “At my work, I feel bursting with energy”, “My job inspires me”, “I am immersed in my work”. The scale had good reliability (Cronbach Alpha 0.89).

To measure **OCB**, the scale of Podsakoff *et al.*'s (1990) was adopted. It measures five dimensions of citizenship behavior identified by Organ (1988): altruism, conscientiousness, sportsmanship, courtesy, and civic virtue. We asked talent pool members to report the degree to which the items described their own behaviors. Minor modifications were done to fit the tool to the current study. All items were rated by a seven-point Likert scale where 1 is for “strongly disagree” and 7 is for “strongly agree”. The sample items are: “I willingly help others who have work related problems”, “I obey company rules and regulations even when no one is watching”, “I consume a lot of time complaining about trivial matters”. The scale had good reliability (Cronbach Alpha 0.91).

The perception of **distributive and procedural justice** was measured with the use of justice scale designed by Niehoff and Moorman (1993). This tool evaluate separate but related constituents from the three-component model of organizational justice proposed by Greenberg (1990). We ask participants to rate their agreement with the listed items. The answers were scored on a seven-point Likert-type scale, where 1 indicates “strongly disagree” and 7 means “strongly agree”. The example items include: “I think that my level of pa is fair”, “Overall, the rewards I receive here are quite fair”, “My general manager clarifies decisions and provides additional information when requested by employees”. The scale had good reliability (Cronbach Alpha 0.96).

Following Fornell and Larcker (1981), we test the convergent and discriminant validity of our measures. The average variance extracted (AVE) from our independent and dependent variables is close or over 0.5, supporting convergent validity. Discriminant validity is also supported because the AVEs are higher than the squared correlations among these constructs.



## 4. Results

The data obtained from the survey were subjected to statistical analyses. We started our analyses by calculating descriptive statistics and coefficients between the variables. The results of descriptive and correlations analyses are presented in Table 1.

Correlation coefficients showed strong relationships between perceived TM practices, the perception of distributive and procedural justice, work engagement and OCB. Almost all of the analysed inter-correlations among focal variables proved to be statistically significant at the level of  $p < 0.01$  and are positive.

Significant correlation coefficients raise a question about the possibility of multicollinearity. We have controlled for this threat by analyzing the variance inflation factor (VIF). A VIF greater than 5 would indicate overly high collinearity, and, consequently, a potential collinearity problem. The VIF value for employee's experience was greater than 5, so we excluded this variable from the regression models. Apart from this, the highest reported value (around 2.9) was observed for perceived procedural justice. This value is, however, within the acceptable range.

The values of correlation coefficients may be artificially overestimated due to the existence of apparent correlations and distortions in the research process (e.g. *common method bias*). Therefore, to test out hypotheses we carried out a series of hierarchical regression analyses. In each analysis, several control variables were included in the model to control for potential bias.

**Table 1.***Descriptive statistics and correlations of variables*

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9	10	11
1. TM practices	2.76	0.61											
2. Work engagement	3.88	0.90	0.250***										
3. OCB	4.99	0.77	0.107**	0.537***									
4. Distributive justice	4.78	1.13	0.198***	0.564***	0.633***								
5. Procedural justice	4.69	1.17	0.265***	0.522***	0.632***	0.797***							
6. Gender	0.54	0.50	-0.005	0.104**	0.110**	0.037	0.045						
7. Age	29.76	3.41	0.04	-0.008	-0.053	-0.061*	-0.030	-0.044					
8. Education level	5.15	0.86	-0.129***	-0.067*	-0.055	-0.007	-0.070	-0.044	0.215***				
9. Job tenure	4.06	2.19	0.081*	0.030	-0.088*	-0.098**	-0.081*	0.004	0.536***	0.076*			
10. Organizational tenure	5.59	2.60	0.073*	0.003	-0.147***	-0.143***	-0.165***	0.036	0.500***	0.087*	0.722***		
11. Work experience	5.93	2.95	0.081*	0.006	-0.124***	-0.123**	-0.136***	0.016	0.617***	0.091*	0.703***	0.910***	
12. Work status	0.93	0.25	0.058	0.078*	0.076*	0.026	0.005	0.157***	0.134***	0.053	0.048	0.109**	0.079*

**Notes:** *M* - mean; *SD* - standard deviation; 1–11 - inter-correlations for variables; gender was measured by a dummy variable coded as 0 = male and 1 = female; age, tenure and experience were self-reported in years; education was measured categorically ranging from 1 = primary school to 6 = Master's degree; work status was measured by a dummy variable coded as 0 = part time and 1 = full time; significance: \*\*\*  $p < 0.001$  \*\*  $p < 0.01$ ; \*  $p < 0.05$ .

Source: own study.

Firstly, we checked whether the TM practices had a direct impact on work engagement, OCB and perception of distributive justice. The results of the regression analyses are presented in Table 2. The first of the estimated models shows that TM practices are a significant predictor of work engagement of talented employees ( $b = 0.357$ ;  $p < 0.001$ ). This supports hypothesis 1. Another model confirmed that TM practices constitute a significant predictor of talent pool members' OCB ( $b = 0.139$ ;  $p < 0.01$ ). These results support hypothesis 2. We also found that TM practices significantly affects the perception of distributive justice ( $b = 0.396$ ;  $p < 0.001$ ). Therefore, hypothesis 3 is considered to be confirmed.

The second round of regression analyses evaluated the impact of perceived distributive justice on work engagement and OCB of employees included into TM programs. The results of this analysis are presented in Table 3.

The estimated models indicate that perceived distributive justice is a significant predictor of the work engagement and OCB of employees identified as talents ( $b = 0.452$ ;  $p < 0.001$ ;  $b = 0.423$ ;  $p < 0.001$ , respectively). Thus, hypotheses 4 and 5 are confirmed.

Subsequently, the possible mediating effect of distributive justice was examined (hypotheses 6 and 7). In doing so, we conducted another series of regression analyses following the three-step procedure of Baron and Kenny (1986). In this procedure a variable is assumed to play the role of a mediator when three conditions are met: (1) the independent variable is related to the dependent variable; (2) the independent variable is related to the mediator; and (3) the relationship between the independent variable and the dependent variable disappears (full mediation), or the strengths of the relationship is reduced (partial mediation), when the mediator is added to the model.

Firstly, we tested the mediating effect of distributive justice on the relationship between TM practices and work engagement of employees identified as talents. The estimated model showed that: (1) TM practices are a significant predictor of work engagement ( $b = 0.357$ ;  $p < 0.001$ ); (2) TM practices significantly predict distributive justice ( $b = 0.396$ ;  $p < 0.001$ ); and (3) the strength of the relationship between TM practices and work engagement is reduced when distributive justice is added to the model ( $b = 0.186$ ,  $p < 0.001$ ). The results obtained mean that perceived distributive justice partially mediates the relationship between TM practices and work engagement. The significance of the mediation effect was checked using the Sobel test, which proved that this effect is statistically significant ( $Z = 5.564$ ,  $p < 0.001$ ). This supports hypothesis 6.

**Table 2.**

*Results of regression analysis: TM practices as a predictor of work engagement, OCB and distributive justice*

	Work engagement	Work engagement	OCB	OCB	Distributive justice	Distributive justice
TM practices		0.357***		0.139**		0.396***
		(0.053)		(0.046)		(0.068)
Gender (female)	0.164*	0.174**	0.162**	0.165**	0.087	0.097
	(0.067)	(0.065)	(0.057)	(0.057)	(0.085)	(0.083)
Age	-0.004	-0.005	0.007	0.006	0.003	0.002
	(0.012)	(0.012)	(0.010)	(0.010)	(0.015)	(0.015)
Education level	-0.068+	-0.031	-0.042	-0.028	0.005	0.046
	(0.039)	(0.038)	(0.034)	(0.034)	(0.050)	(0.049)
Job tenure	0.030	0.024	0.014	0.011	0.006	-0.000
	(0.023)	(0.022)	(0.019)	(0.019)	(0.029)	(0.028)
Organizational tenure	-0.017	-0.019	-0.059***	-0.060***	-0.071**	-0.074**
	(0.019)	(0.018)	(0.016)	(0.016)	(0.024)	(0.023)
Work status (full time)	0.255+	0.202	0.245*	0.224+	0.165	0.106
	(0.136)	(0.133)	(0.117)	(0.116)	(0.172)	(0.169)
Constant	3.984***	2.923***	4.967***	4.553***	4.828***	3.650***
	(0.351)	(0.376)	(0.300)	(0.329)	(0.443)	(0.478)
Observations	730	730	730	730	730	730
F	2.65*	8.86***	5.55**	6.09***	2.95**	7.55***
R <sup>2</sup>	0.022	0.079	0.044	0.056	0.024	0.068

**Notes:** Standard errors in parentheses; significance: \*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ , +  $p < 0.1$ .

Source: own study.

**Table 3.**

*Results of regression analysis: distributive justice as a predictor of work engagement and OCB*

	Work engagement	Work engagement	Work engagement	OCB	OCB	OCB
TM practices		0.186***			-0.030	
		(0.046)			(0.037)	
Distributive justice	0.452***	0.430***	0.177*	0.423***	0.426***	-0.287***
	(0.024)	(0.025)	(0.081)	(0.020)	(0.020)	(0.060)
Procedural justice			-0.025			-0.409***
			(0.092)			(0.068)
Distributive justice × procedural justice			0.036*			0.127***
			(0.017)			(0.013)
Gender (female)	0.125*	0.132*	0.114*	0.125**	0.124**	0.103*
	(0.055)	(0.055)	(0.055)	(0.045)	(0.045)	(0.041)
Age	-0.005	-0.006	-0.010	0.005	0.005	-0.004
	(0.010)	(0.010)	(0.010)	(0.008)	(0.008)	(0.007)
Education level	-0.070*	-0.051	-0.054+	-0.044+	-0.047+	-0.018
	(0.032)	(0.032)	(0.032)	(0.026)	(0.026)	(0.024)
Job tenure	0.027	0.024	0.024	0.011	0.011	0.007
	(0.019)	(0.019)	(0.019)	(0.015)	(0.015)	(0.014)
Organizational tenure	0.015	0.013	0.024	-0.029*	-0.028*	-0.015
	(0.016)	(0.015)	(0.015)	(0.013)	(0.013)	(0.011)
Work status (full time)	0.180	0.156	0.183	0.175+	0.179+	0.161+
	(0.112)	(0.111)	(0.111)	(0.091)	(0.091)	(0.082)
Constant	1.804***	1.353***	2.410***	2.924***	2.996***	5.337***
	(0.311)	(0.327)	(0.463)	(0.252)	(0.268)	(0.344)

Cont. table 3.

Observations	730	730	730	730	730	730
<i>F</i>	53.05***	49.53***	44.57***	74.15***	64.92***	88.69***
<i>R</i> <sup>2</sup>	0.340	0.355	0.358	0.418	0.419	0.526

**Notes:** *Standard errors* in parentheses; significance: \*\*\*  $p < 0.001$ , \*\*  $p < 0.01$ , \*  $p < 0.05$ , +  $p < 0.1$

Source: own study.

Similar analysis was performed with OCB as the dependent variable. In this case, we found that: (1) TM practices are a significant predictor of OCB ( $b = 0.139$ ;  $p < 0.01$ ); (2) TM practices significantly predict distributive justice ( $b = 0.396$ ;  $p < 0.001$ ); and (3) the relationship between TM practices and OCB disappears when distributive justice is added to the model ( $b = -0.030$ , *n.s.*). Therefore, perceived distributive justice satisfied the requirements of being a full mediator between perceived TM practices and talent pool members OCB. The Sobel test confirmed the significance of the indirect effect ( $Z = 5.615$ ,  $p < 0.001$ ). Thus, the hypothesis 7 was also supported.

Finally, we examined the possible moderating effect of perceived procedural justice (hypotheses 8 and 9). At first, distributive and procedural justice and the two-way interaction between them as independent variables, as well as work engagement as a dependent variable, were added into the model (*see* Table 3). Subsequently, the analysis was repeated with OCB instead of engagement as the dependent variable. The estimated models show that the interaction between perceived distributive and procedural justice has a statistically significant impact on work engagement ( $b = 0.036$ ,  $p < 0.05$ ) and OCB ( $b = 0.127$ ,  $p < 0.001$ ). This means that the perception of procedural justice moderates the relationships between predictor and criterion variables. The results obtained confirm hypotheses 8 and 9.

## 5. Discussion

From the perspective of justice theory, the results obtained indicate that participants of TM programs believed that their potential and contributions to the organization are valued. Employees in talent pools gain not only a unique status, but also greater development opportunities, additional incentives and the possibilities of fast promotion. When talent pool members see the opportunities for promotion and grow offered to them, they consider the distribution of resources in the organisation as fair. Thus, it might be that they attitudes and behavior are not only affected by talent status itself but also by the resources that follow. This, in turn, triggers their work engagement and OCB.

Our findings seems to correspond to previous research. For example, Björkman et al. (2013) suggest that talent pool membership is taken as a signal that the organization values employees' contribution and that talent pool members feel that the company has fulfilled a part of the psychological contract by investing in their careers. On the other hand, Marescaux et al. (2013)

has reported that employees who experienced a less favorable treatment than others had a lower affective commitment compared with those who experienced an equal or a more favorable treatment.

The theoretical contributions described above give rise to certain implications for business practice. Organisational leaders must bear in mind the repercussions associated with implementing TM initiatives. By including employees to talent pools, a “Matthew effect” is brought about, by which privileged groups are allocated the lion share of development opportunities, causing them to land in a better position relative to others in the organization. A possible danger is that the unequal treatment might cause perception of injustice and consequently negative employee reactions. As only minority of workforce (usually from 1% to 5%) can be included into organization’s talent pool, it is clear that the risk of frustrating a large part of excluded staff is quite high. It is important that organizations should not neglect non-members of talent pools as they could represent a future source of potential. This is not to say that all employees should be offered a TM program of some sort, but organizations could be guided by a set of fair procedures in relation to workforce development (Swales, 2013). The process of nominating and selecting employees for development programs need to be objective and transparent with all employees getting a fair chance. Explaining the reasons and giving the objective criteria for identifying someone as a talent could not only trigger high engagement among talent pool members, but could also increase justice perceptions among non-talents. Giving such clarification reduces the odds of employees creating their own alternative story of their non-identification as a talent (Shaw et al., 2003).

In addition to fostering talents, supervisors can also trigger feelings of organizational support by listening to what employees have to say, expressing recognition for their ideas and efforts, involving them in decision-making processes, offering more autonomy or improving working conditions (Rhoades, Eisenberger, 2002). Furthermore, the HR strategy should consider how employees outside TM programs are benefitting, for example, through better performance in relation to the limited resources that are being diverted to them. In this way, companies can stimulate perception of organizational support among all employees while still making disproportionate investments in human resources.

To sum up, it is important to consider the potential long-term implications of TM programs, and to counterbalance the focus on talents with creative “talent solutions” (Beechler, Woodward, 2009) that capitalize on diversity, and involve broader approaches to TM.

Our study contributes to the recent debates on TM in three ways. First, it expands the knowledge of employees’ reactions to TM and, in consequence, verifies the assumption about the positive impact of TM on employees’ attitudes and behavior. Earlier publications (e.g., De Boeck et al., 2017) indicate that managers take this essential assumption for granted, even though research results in this area are not unequivocal. Second, it also identifies perceptions of organizational justice as an psychological mechanism that helps to explain the relationship between TM practices perceived by the talent pool members and their work and

engagement and OCB. The next contribution is to more general literature on organizational behavior, more specifically, to the studies on work engagement and OCB. Present study advances the knowledge on determinants of employees' attitudes and behavior. Our findings are also valuable for organizational decision-makers who are investing more and more funds into TM initiatives without confidence whether these are successful in achieving the expected results.

## **6. Limitations and directions for future research**

Like other studies, ours has some limitations that provide opportunities for future research. First, all the data for this study were gathered from a single source at a single point in time, raising concerns about common method bias. Future research would benefit from assessing attitudes and behavior before employees are included to TM program and afterwards. Any differences in their motivation or commitment could then be weight against the difference found among employees not included into talent pool. The involvement of non-talents in the study will allow to recognize and compare their outcomes.

Second, our study had a cross-sectional design. There is thus a possibility for reverse causality such that individuals who are seen to exhibit outcomes examined in the study are more likely than others to be included in talent pools. Longitudinal research is needed to examine the nature of causality within relationship analyzed in the study.

Third, although all examined organizations had well-developed TM program, there are a number of potential sources of exogenous variation that may influence employee reactions, including different business strategies, company policies, and specific nature of organization's TM. For instance, it is worth to explore whether employees response differently when 80% of available resources are invested in 5% of the workforce, compared to a situation when 50% of resources are invested in 25% of most talented staff. It was beyond the scope of present study to investigate such organizational factors, but this would be an interesting direction of future research.

In addition, further studies could focus on attitudes and behavior of employees that are nested in various sectors or cultures to investigate whether or not there are contextual limitations to the generalizability of the results. It would be also interesting, although very challenging, to conduct comparative studies at an international level.

## 7. Conclusions

The high level of interest in TM among academics and practitioners suggest that it has something to offer yet our understanding of the effects of TM on employees is light. Our paper aimed to fill the gap in existing literature by answering the question: What is the role of TM in relation to work-related attitudes and behavior of employees who are members of talent pools? We contribute to this gap by applying justice theory for HRM to develop and empirically test a number of hypotheses concerning employees' reactions to TM practices. The study reveals that TM seems to be successful in enhancing work engagement and discretionary effort of talent pool members via perception of distributive justice, and the impact of this perception on employees' engagement and OCB was stronger, when talented employees perceive the rules and procedures of resource allocation in an organization as fairer. Therefore, by pursuing the TM program employers may reasonable expect that there would be work-related attitudes and behavior, which in turn are critical to the achievement of organizational outcomes. Current study adds to the small body of research on employees' reactions to TM and, in consequence, it broadens the knowledge about the results of practices in this area at the individual level, responding to urgent calls in the literature for more research on implications of being identified as a talent (Björkman et al., 2013).

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## ANALYSIS AND EVALUATION OF URBAN PUBLIC TRANSPORT – SELECTED QUANTITATIVE AND QUALITATIVE INDICATORS

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**Purpose:** The main purpose of the article is to analyze and evaluate collective public transport provided by a public transport company in the Upper Górnśląsko-Zagłębiowska Metropolis.

**Design/methodology/approach:** The study used a desk research to conduct an indicator analysis. Indicator analysis makes it possible to both measure and evaluate the activities of the company under study. In addition, it makes it possible to learn about the scale of operations (e.g., by providing information on the amount of rolling stock owned or transport performed), as well as to assess the quality of transport services provided. In addition, indicator analysis can provide information on the trends of changes in specific spheres of bus transportation activity.

**Findings:** Empirical studies indicate that the process of transporting passengers as part of public transport is characterized by a good level of reliability. In addition, the results indicate high values of individual monitored measures and indicators.

**Research limitations/implications:** The main limitation is the receipt of the necessary data from the public transport company, which may affect the results of the research and limit the generalization of the results.

**Practical implications:** The conducted empirical research contributes to the science and practice of management by providing insight into the assessment of urban public transport in the Górnśląsko-Zagłębiowskiej Metropolis.

**Originality/value:** The results of this article may be useful in understanding the usefulness of logistic metrics and indicators.

**Keywords:** public transport, the city's transport system, Górnśląsko-Zagłębiowska Metropolis.

**Category of the paper:** Research paper.

### 1. Introduction

Passenger public transport is of great importance within urban agglomerations, enabling the rapid movement of large streams of passengers. It is an important element of the transport systems of many highly urbanized areas. Correct communication solutions of public transport

allow avoiding many threats of modern cities related to traffic accidents and time loss due to traffic congestion (Gramza, 2011).

An efficient public transport system competes with individual transport. Only such solutions can become competitive and attractive enough for potential customers - passengers, which will allow meeting specific requirements regarding the quality of traffic (Gramza, 2011).

The appropriate quality of the organization of transport services, including urban public transport, shapes the level of market service, and customer satisfaction and the company's experience affect its position on the logistics services market.

Considering the above considerations, the need to analyze and evaluate urban public transport becomes very important.

Therefore, the main purpose of the article is to analyze and evaluate the collective public transportation provided by the public transport company in the Upper Silesia-Zagłębie Metropolis. The research was carried out using the desk research method. An analysis was made of the current state of the studied enterprise in 2015-2020/2021 and the degree of reliability of the services it offers using selected quantitative and qualitative indicators.

## 2. Theoretical background

**The city's transport system.** The transport system as a separate subsystem of the socio-economic system of the city was the subject of consideration in the literature on the subject already in the second half of the 20th century (Ejdys, 2017). According to J. Brudlak (Brudlak, 2016), the transport system is a set of organizationally, legally, technically, economically and spatially ordered - due to the condition of transport infrastructure - entities of socio-economic processes that contribute to meeting transport needs within the framework defined by the transport policy countries. In turn, L. Hoffman (Hoffman, 1968) defines the transport system as: the entirety of technical, organizational, economic and legal issues that occur in the process of cooperation of individual transport branches and determine the nature of the main dependencies and relationships between transport and other areas of the national economy. Whereas J. Kurowski (Kurowski, 2017) claims that the transport system should be perceived in a much broader sense, as it is a rather complicated system which, in a model simplification, allowing for better understanding of it, has been schematically presented as a system of three subsystems: technical, organizational and economic- legal.

Thus, taking into account the above statements, it can be argued that the city's transport system is a catalyst for both economic and social opportunities that stimulate the growth of cities' efficiency and productivity. Through its complementary nature, as well as links with the social and economic environment, it is an integrating factor, coordinating the urban economy,



becoming a universal and irreplaceable element of economic processes and manifestations of social life occurring in urban agglomerations (Ejdys, 2014).

Urban transport as a subsystem of the transport system is essential for the development of modern cities. In the past, urban transport was mainly focused on the internal service of the city. In addition, it contributed to the organization of the spatial structure of cities and enabled their further development (Ejdys, 2014).

Each transport system operating in a given urban area has a significant impact on its quality of life. It is an integral part of the urbanized city area, which influences its development (Banak et al., 2014).

**The essence and importance of public transport.** The concept of public transport is widely known in society. Many authors, however, attribute different scopes and areas of activity to it. Often and not quite correctly, public transport is equated with urban transport. This issue was raised by O. Wyszomirski (Wyszokomirski, 2008) who pointed out that replacing the term public transport with the term urban transport is intended to facilitate translation into foreign languages. The author points out, however, that in Poland the concept of public transport is still correct and correctly identified with "local collective transport performed as a commune's own task".

A seemingly similar approach is represented by W. Rydzkowski and K. Wojewódzka-Król (Rydzkowski, Wojewódzka-Król, 1997), who also compared urban transport to public transport, writing that "the term urban transport is most often identified with passenger transport and is used interchangeably with the term public transport". The authors explain this by the fact that the basis for separating urban transport from other types of transport is not its spatial range of operation, but the operational and economic specificity resulting from the nature of passenger transport needs and the way they are met. It is worth noting, however, that a few pages later, the authors included a functional division of means of transport used in urban transport.

E. Gołębska (Gołębska, 2010) treats public transport as an important element of the urban transport system. This is the final confirmation that public transport is not synonymous with urban transport, but only one of its components.

Summarizing the considerations related to the meaning of the concept of public transport, it can finally be stated that, in accordance with the Act on public road transport, public transport is generally accessible, performed regularly at certain intervals and along designated routes, public passenger transport operating in the area of one or several cities or neighboring communes with each other, which have concluded an agreement on the joint implementation of public collective transport in their area. Urban transport understood in this way will be the subject of consideration in the further part of this work.

After a thorough exploration of terminological issues and clarification of inaccuracies related to the concept of public transport, one can proceed to examining the role that public transport plays in the functioning of cities. Urban public collective transport basically meets the same transport needs as any other passenger transport within the city, i.e. it allows people to

travel long distances, meeting their transport needs. Theoretically, individual or group transport, such as (private car or taxi), could completely replace public transport in the form of, for example, bus or tram transport, because they offer better comfort, travel time and flexibility.

### 3. Methodology

A wide range of logistic indicators are used to measure and evaluate the activities of a public transport company. Using some of them, you can obtain the necessary information about the level of transport processes, including urban public transport, notice deviations from the assumed plans, and introduce the necessary improvements, thanks to which the company will increase its competitiveness. Therefore, they are the basis for evaluating the decisions already taken and at the same time show the directions of solutions in the future.

Ratio analysis is a relatively simple method of examining the processes carried out in the company. It is based on constructing and evaluating relations between different quantities. At the same time, it is very important to properly select and estimate the size of the tested parameters and correctly interpret the obtained results, which is made on the basis of a comparison with the adopted reference bases (Dmuchowski, 2019).

The notions of measure and indicator are related to ratio analysis. A gauge is a number characterizing a certain phenomenon, expressed in an appropriate unit of measurement that allows to compare it with other phenomena. Meters in logistics perform an informative function and do not have evaluative properties in themselves. The measured values, expressed in absolute units, determined on the basis of conducted research, make it possible to quantify the actual state. Indicators can also be created on the basis of measures (Twaróg, 2003). On the other hand, logistic indicators are used to measure the effectiveness of logistic systems, to define goals formulated in a quantitative way, to check the level of achievement of company goals and the degree of satisfaction of customer needs. Properly formulated logistic indicators enable early recognition of negative and positive trends in the process (early recognition function), and also contribute to ensuring proper control of logistic processes (steering function) (Twaróg, 2003).

Thanks to the analysis of transport process indicators, it is possible to obtain information on the transport processes in progress and to notice deviations from the assumed plans, and thus the need to introduce improvements to the process (Gaschi-Uciecha, 2018).

Indicators provide a basis for evaluating decisions taken previously and also facilitate the selection of the direction of future actions.

Quantitative indicators and measures were used for the quantitative assessment, such as:

- transport performance indicator,
- bus size meter,

- utilisation rate of fleet
- failure and defect rate of fleet

The qualitative assessment was carried out using measures and indicators such as:

- vehicle equipment malfunction meter,
- fleet age indicator,
- measure of lack of bus stop,
- passenger satisfaction index,
- punctuality index.

### 3. Results

Based on the data received from the research subject, an analysis of the current state of the enterprise and the degree of reliability of the services offered was carried out, and the trend of changes was assessed by comparing current data with historical data using quantitative and qualitative indicators and measures.

The measures and quantitative indicators selected for the analysis of the research subject are presented in table 1.

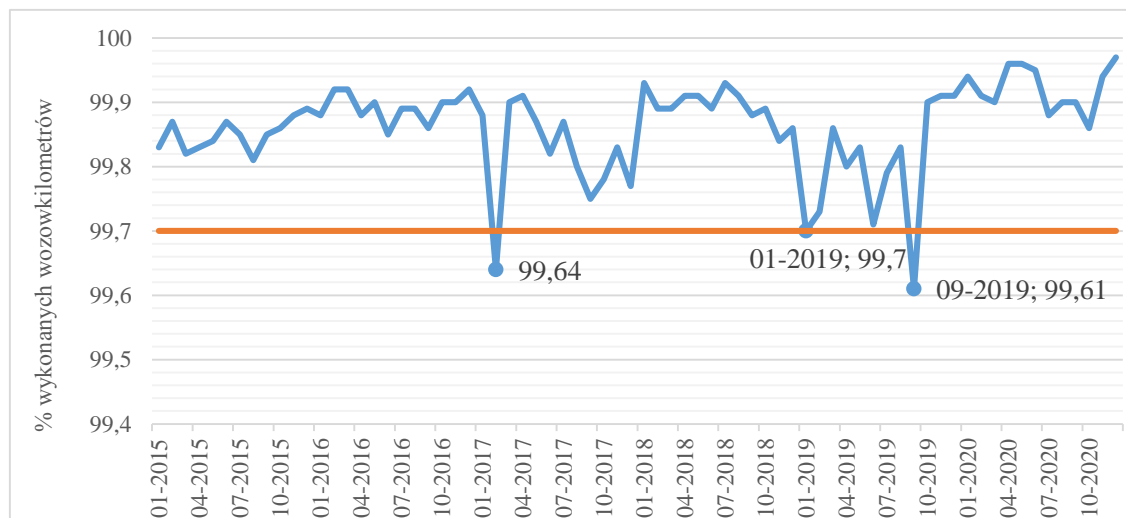
**Table 1.**  
*Selected quantitative indicators*

Name	Method of calculation	Description
<b>Transport performance indicator</b>	$\frac{\text{Completed transport work}}{\text{Planned transport work}} * 100\%$	Indicates the extent to which the planned transport work has been achieved.
<b>Bus size meter</b>	Number of buses of a given type	Indicates the number of Type A, B and C buses owned.
<b>Utilisation rate of fleet</b>	$\frac{\text{Running vehicles of a given type}}{\text{Owned vehicles of a given type}} * 100\%$	Shows the ratio of actively running to all owned vehicles of a given type
<b>Failure and defect rate of fleet</b>	$\frac{\text{Number of forced departures to depots due to technical reasons}}{\text{Number of completed services}} * 100\%$	Shows the ratio of the number of forced departures to depots to the total number of services

Source: Own study based on literature.

**The transport performance indicator** expresses the ratio of the number of vehicle-kilometres carried out to the number assumed in the route charters. The most frequent reasons for missing or incomplete journeys are fortuitous events (e.g. road closures due to accidents) and line congestion on transport routes. Missed journeys also include sections of journeys carried out with too much delay, e.g. when the vehicle of the next journey serving the same line served the stop faster than the vehicle of the previous journey.

The company's aim is to keep the indicator above 99.7%. The indicator values for the period 2015-2020 are shown in Figure 1.

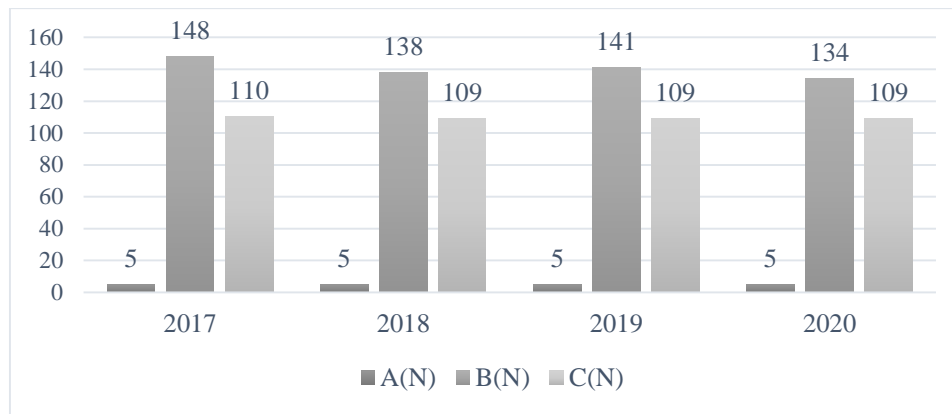


**Figure 1.** Wartości wskaźnika realizacji przewozów w latach 2015-2020.

Source: Own study based on research results.

From an analysis of the data presented in the figure above, it can be seen that during the period in question, the company only missed its target twice (99.7% of transport operations). The periods in which the target was not met are highlighted in the graph and described. This happened in February 2017 and September 2019. In addition, it is worth noting that in January 2019 the company was on the verge of meeting its target. Overall, however, the level of the indicator can be assessed positively, as in the vast majority of periods the target level of transport fulfilment was met, often even with a large margin. It is also important to note the recorded improvement in the value of the indicator in 2020, in which as many as 6 months (January, April, May, June, November, December) recorded record-breaking high results of the analysed indicator, which could be influenced by reduced traffic related to the Covid-19 pandemic.

The bus **size meter** reports the number of A(N), B(N) and C(N) buses owned by the company. Type A buses correspond to the midi class, are about 10 metres long and accommodate about 60 passengers. Type B buses correspond to the maxi class, are approximately 12 metres long and accommodate approximately 90 passengers. Type C buses correspond to the mega class, accommodate approximately 140 passengers and measure over 13 metres in length. Most C-class buses are articulated buses measuring approximately 18 metres. The bus size measure values for 2017-2020 are shown in Figure 2.

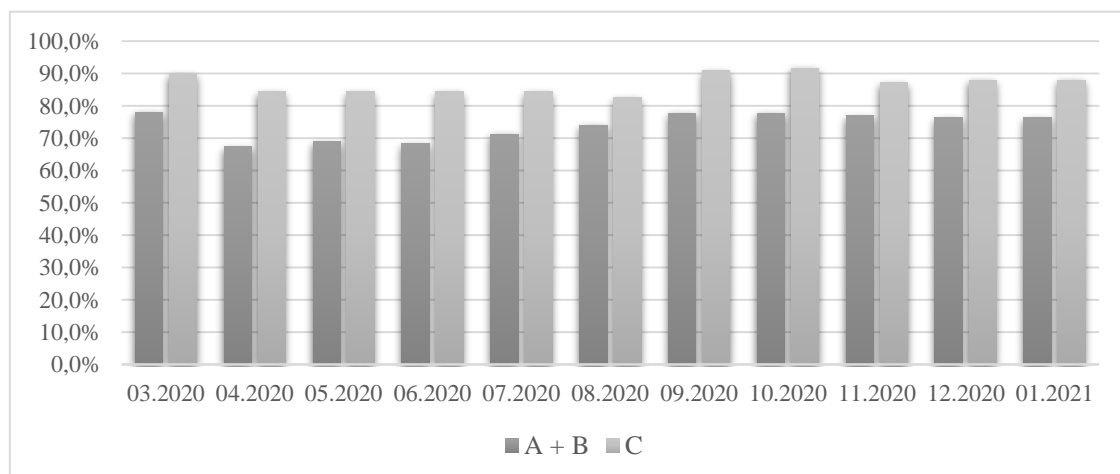


**Figure 2.** Bus size measure values for 2017-2020.

Source: Own study based on research results.

Analysis of the measure indicates that despite the high turnover of buses in the fleet, the company maintains a relatively constant proportion between the different types of bus. The fleet is still dominated by B(N) buses, with slightly fewer C(N) buses and A(N) buses making up a very small part of the fleet. The only change in the period under study that can be seen in the graph is a gradual decrease in the total number of buses of type B(N) with an almost constant number of buses of the other types.

**The fleet utilisation indicator** shows the ratio of buses of a given type actively in line use to the total number of buses. It makes it possible to determine the utilisation rate of the existing fleet, but also to assess the size of the reserve. Due to the very small size of the A(N) fleet, the company does not keep separate utilisation records for these vehicles, instead they are combined with B(N) vehicles. The results of the fleet utilisation rate for most of 2020 and the first month of 2021 are shown in Figure 3.



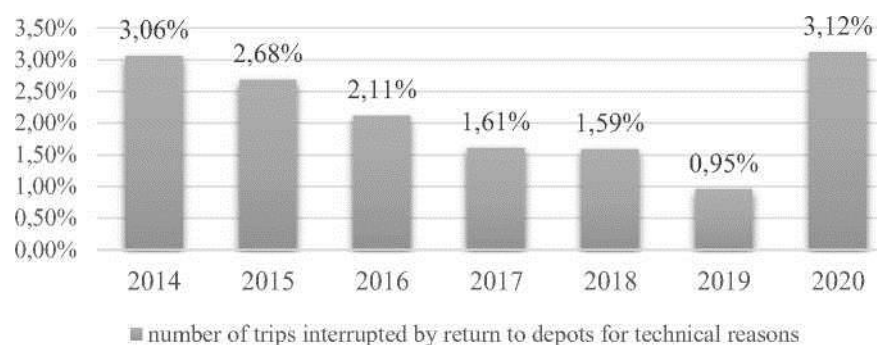
**Figure 3.** Utilisation rate of fleet.

Source: Own study based on research results.

The analysis of the value of the indicator shows that the research entity makes optimal use of its fleet. Most of the vehicles are used linearly for the services, so that the company does not incur large losses due to underutilisation of its transport potential. On the other hand,

it maintains a more or less constant proportion of reserve vehicles, ready to replace line vehicles in the event of a breakdown or road incident; for the A(N)+B(N) fleet it is around 25% and for the C(N) fleet around 10%. Having a reserve allows the company to maintain a high level of readiness and gives it the ability to respond quickly to incidents by allowing the immediate replacement of a bus if necessary. In the graph, it is noticeable that there is a periodic decrease in the value of the measure during the months of April to August. During this period, a smaller proportion of the owned fleet was used, in the case of B(N) vehicles in the months from April to June the utilisation dropped below 70% which is already a relatively low value. Utilisation of C(N) fleet fell to around 85%, which is correct. However, there is a reason for this periodic drop in the measure. It was the limited number of courses in the first months of the Covid-19 pandemic due to the transition of schools and some workplaces to remote study/working mode. After the summer holidays of 2020, the values of the measure returned to their standard levels. It is worth noting that throughout the period under study the utilisation of the C(N) fleet has been higher than that of the A(N) and B(N) types, this is probably due to the greater number of B(N) buses owned, which are dominant in the fleet of the company under study, although their predominance over the larger fleet is gradually decreasing as indicated by the data in Figure 2.

**The fleet failure and defect rate** shows the ratio of the number of courses interrupted by the need to return to the depot for technical reasons. It takes into account major vehicle failures that prevent them from continuing with their courses. Examples of dysfunctions include door, driveline, suspension, tyre (tyre burst) and other failures. In the event of a vehicle going down at the depot, it must be replaced by another bus from the reserve to continue the service. The cause of a technical failure can also be a road traffic collision, even if the consequences are not serious and only end in a scratch on the paint, it is necessary to clarify the matter, determine the guilty party, sign the documents and sometimes (in case of doubt about the fault) wait for the police. The dispatcher, in order to reduce delays in such cases, sends a replacement bus to pick up passengers and continue the journey (similar procedure to a failure). Another factor that is not a failure, but which also makes it necessary to return the vehicle to the depot included in this indicator, is the discharge of the traction batteries of electric buses. When the battery level falls below a predetermined level (about 30%), the driver must return to the depot to load the bus if possible. The failure and defect rate values are shown in Figure 4.



**Figure 4.** Values of failure rate and defects in fleet for 2014 - 2020

Source: Own study based on research results.

As can be seen from the figure, there was a continuous decrease in the number of bus defects and failures between 2014 and 2019, but 2020 turned out to be a record year in terms of forced departures to the depot for technical reasons. The gradual decrease in failure rates between 2014 and 2019 can be explained by the replacement of the older more defective fleet with new one. What is puzzling, however, is the sharp increase in the index value in 2020. There may be several reasons for this. Firstly, the Covid-19 pandemic that broke out in Poland in March 2020 may have had an impact. Depot returns may have resulted from the need to disinfect buses after incidents involving passengers. Another reason for this increase could be the adoption of electric buses for regular service in 2020. Admittedly, the first electrobus already started running in 2019, but it was only one. In 2020, nine more electric buses were taken into service. For most drivers, but also for planners, this was a new situation. Employees may have been initially surprised by the significantly lower range offered by the electrobuses compared to the proven conventionally powered buses. On top of this, it is much more difficult to set the courses for electric buses, as their range on batteries is highly variable and depends on many factors such as air-conditioning running, terrain, as well as the temperature outside (buses at lower temperatures have less range than on normal days, and they are also less effective in hot weather). Conventionally powered buses do not have such problems. Drivers and planners who are not used to the different characteristics of electrically powered vehicles may not have been able to cope with the new type of vehicle at first.

However, without data from 2021, it is impossible to determine definitively what caused this increase and whether it was just a one-off spike or the start of a new trend. Either way, a value in excess of 3% is relatively high, and unless it is just a one-off spike, related to the temporary reasons mentioned above, the company should take steps to reduce the value of this indicator.

**The qualitative indicators and measures** selected for the research subject's analysis are shown in Table 2.

**Table 2.**  
*Selected quantitative indicators*

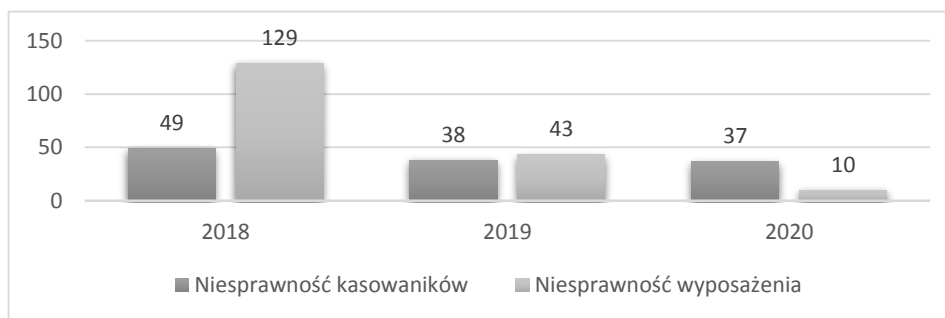
Name	Method of calculation	Description
Vehicle equipment malfunction meter	Number of bus equipment faults detected that do not result in a forced descent to the depot.	It reports on the number of minor bus faults mainly affecting the comfort of the journey.
Fleet age indicator	$\frac{\text{Number of age group}}{\text{Number of all buses}} * 100\%$	Shows the shares of specific age groups of buses.
Measure of lack of bus stop service	Number of stops not served	Informs about the number of missed stops.

Cont. table 2.

Passenger satisfaction index	$1 - \frac{\text{Number of complaints} - \text{number of praises}}{\text{Number of completed services}} * 100\%$	The ratio of all odds to the number of complaints minus the number of praises. In fact, it reports the number of customers extremely dissatisfied with the service.
Punctuality index	$\frac{\text{number of delayed courses} + \text{number of courses before time}}{\text{Number of all courses}} * 100\%$	It shows the ratio of the journeys on which delays or accelerations occurred to the total journeys made.

Source: Own study based on literature.

**The Vehicle Equipment Malfunction Measure** indicates the number of occurrences of minor equipment faults on buses that do not necessitate an immediate return to the depot and thus interrupt the service or provide a new vehicle to continue it. These are faults that do not pose a threat to passengers and traffic, and most often only reduce the comfort of the journey. Examples of faults include: faulty passenger information systems, faulty air conditioning, faulty information boards and the like. The company keeps separate records of faults of ticket punchers and the rest of the equipment. This is due to the fact that an external service is responsible for servicing the ticket punchers, and the malfunction of this element alone, although it does not pose a threat to passengers, is associated with a reduction in profits (the passengers will not punch their tickets). The values of the measure for the period 2018-2020 are shown in Figure 5.



**Figure 5.** Values of the vehicle equipment malfunction measure between 2018 and 2020.

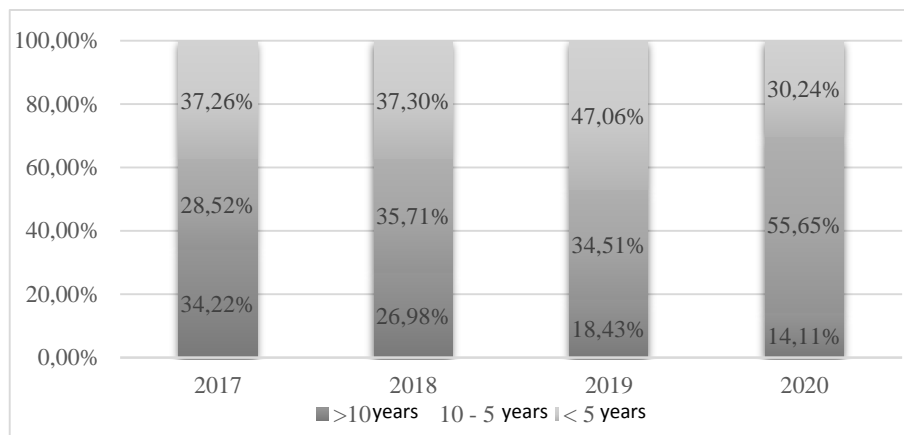
Source: Own study based on research results.

Analysing the data presented in Figure 4, it is possible to see a clear decrease in the number of minor faults occurring on buses in the company under study. This is a result of the intensive replacement of the company's fleet, where many old vehicles being taken out of line service and replaced with new ones. It is worth noting that the number of faults is also decreasing gradually for ticket punchers, but at a much slower rate than for buses. The current number of faults on buses is very low (only 10 such cases have been recorded throughout 2020), in the case of ticket punchers the number is slightly higher, but in their case the company cannot do anything about it anyway, because the SKUP system (Śląska Karta Usług Publicznych -



Silesian Public Services Card) was imposed by PTA and it is it who is responsible for signing service contracts for ticket punchers.

The **fleet age** indicator shows the shares of the different age groups of buses in the surveyed company's fleet. In order to carry out the analysis, the fleet was divided into three age groups: buses older than 10 years, buses between 5 and 10 years old and buses newer than 5 years old. The age of a bus was counted from its date of manufacture, not the start of line service with the company. In order to show the trend of change, data from the last 4 years were analysed. The results of the analysis of the age of the fleet by index are presented in Figure 6.

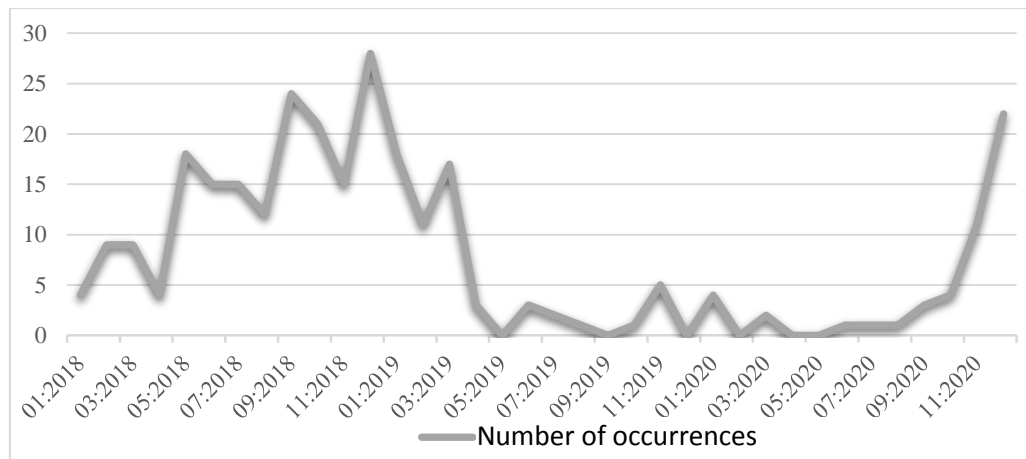


**Figure 6.** Values of the vehicle equipment malfunction measure from 2018 to 2020.

Source: Own study based on <http://phototrans.pl/>, 31.05.2021.

From the analysis of the indicator values, it can be concluded that the subject of the study is consistently upgrading its fleet by replacing old buses with new ones. The best evidence of this is the steadily decreasing number of buses older than 10 years, which decreased by about 20 percentage points in the period under study (from 34.22% to 14.11%). At the end of 2020, the fleet of the company surveyed was dominated by buses in the age range of 5 to 10 years, older buses constituted only just over 14% of the fleet, which considering the size of the fleet can be considered a good result.

The **measure of lack of bus stop service** is a very important measure affecting the reliability of public transport, and therefore one of the most important transport demands. Lack of service at a stop means that passengers are not able to start or finish their journey at the desired location. The reasons for a stop not being served can be, among others, that the stopping place is blocked by another vehicle or that the driver has made a mistake. Mistakes can occur, for example, when a driver leaves on an unfamiliar line (e.g. as a substitute) which has a variety of route options. In such situations, the new driver may inadvertently operate the wrong variant of the route, which in turn will result in some stops not being served. Such situations are very rare, as they are eliminated by dispatchers who have a full overview of the vehicle and its route, including GPS monitoring, so they can warn the driver in time that he or she is taking the wrong route. The measure results for 2018- 020 are shown in Figure 7.

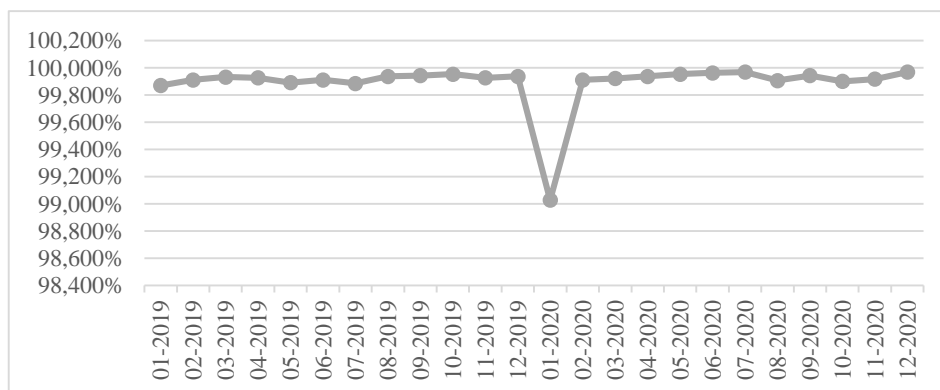


**Figure 7.** Measure of lack of bus stop service between 2018 and 2020.

Source: Own study based on research results.

From the analysis of the graph, it can be concluded that, although skipping stops is not a frequent phenomenon, it does occur consistently. The least amount of deviation was recorded from April 2019 to October 2020, with the number of skipped stops not exceeding five in a single month during this period. At the end of 2020, however, the measure again reached higher values, so it is difficult to say clearly whether there is a downward or upward trend. However, the number of occurrences of missed bus stop services over the entire study period is not high, as it should be borne in mind that, in addition to driver errors (which occur relatively rarely), factors beyond the control of the subject of the study also affect the lack of bus stop service, such as lack of access to the bus stop as a result of another vehicle blocking the bus stop bay, e.g. due to a breakdown or traffic incident.

The Customer Satisfaction Index allows us to determine what proportion of journeys were extremely unsatisfactory for passengers (so much so that they decided to write a complaint). Passenger complaints most often relate to lack of bus stop service (a person standing at the bus stop was not able to board the bus because it did not stop), faulty equipment (no air conditioning in 30 degree heat), faulty passenger information system, long delays or rude behaviour of the driver. The indicator values are shown in Figure 8.

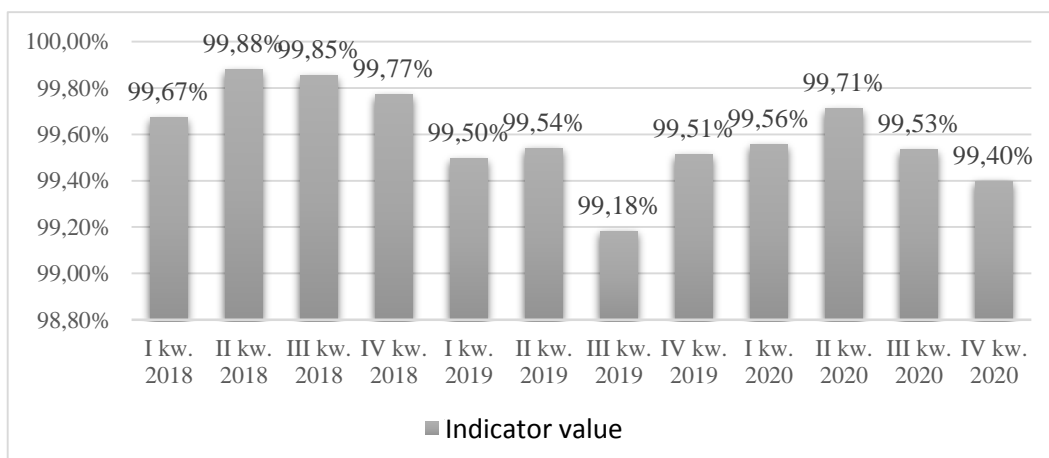


**Figure 8.** Customer satisfaction measure.

Source: Own study based on research results.

An analysis of the graph shows that the satisfaction index has remained at a consistently very high level over the period studied. The only significant drop was recorded in January 2020, but even then the index did not fall below a value of 99, which is a very good result. On the other hand, it should also be realised that there is probably a large group of dissatisfied passengers who simply did not make their dissatisfaction known by writing complaints. Nevertheless, an indicator that oscillates almost consistently between 99.8 and 100% can be considered a very good result.

The punctuality index shows the ratio of the number of total journeys made to those on which delays or accelerations (departures from a stop ahead of schedule) occurred. A tolerance of < 7 minutes is expected for delays. This means that only trips with a delay of 7 minutes or more are counted in the indicator. For accelerations, on the other hand, no tolerance is applied, all journeys on which at least one stop was missed before the scheduled time to the nearest 1 minute are counted. The main cause of delays is congestion. Traffic congestion prevents the smooth passage of the means of transport and thus the punctual service to the stops. The causes of congestion are usually high traffic volumes, traffic incidents and road repairs and narrowings. Not without significance is also the continuous increase in priority for pedestrians and cyclists manifested in extreme cases even by narrowing of lanes and speed limitation of motor vehicles and construction of infrastructure facilities aimed at "traffic calming" consisting in artificial speed limitation of means of transport. This unfavourable trend harms not only individual transport, but also public mass transport by lowering travel speeds, increasing travel times, reducing the capacity of vehicular roads and thus making them more prone to congestion and ultimately reducing the quality of service. Other causes can be breakdowns or traffic incidents involving the bus (ending up with the need to send a reserve vehicle, which generates delays) or extreme weather conditions combined with the lack of a proper response from the city authorities, as metropolitan residents experienced at the beginning of February 2021, when, as a result of heavy snowfall and the late response of the city's cleaning services, buses were running with delays of up to an hour, but these are extreme situations, occurring very rarely in practice. The values of the punctuality index are shown in Figure 9.



**Figure 9.** Punctuality index

Source: Own study based on research results.

An analysis of the values of the indicator leads to the conclusion that the number of delays and accelerations remained at a good level during the study period. The punctuality index never once fell below 99%, which is a very good result, but it should be borne in mind that a fairly large tolerance for delays of up to 7 minutes was applied. In any case, the performance of the indicator can be considered very good, analysis of the graph does not identify any repeatability other than a slight increase in punctuality in the second quarter of each year. The indicator reached its lowest value (99.18%) in the third quarter of 2019. However, this is not a large deviation, as less than 1% of courses were not on time. What is worrying, however, is the observed trend of change, showing that punctuality is on a downward trend over the period under review. Objectively speaking, however, the company has relatively little influence on the values of this measure, as traffic fluidity and the quality of the road infrastructure are dependent on authorities beyond the control of the research subject. Taking this into account, as well as the fact that the company operates traffic lines in very densely populated areas, it can be concluded that the values of the indicator are at a good level.

On the basis of the metrics and quality indicators shown above, an assessment of the reliability of the passenger transport services provided by the research subject was carried out. Each measure/indicator was given a weight corresponding to the importance that passengers attach to the parameter in question and a score according to the scale adopted below:

1. insufficient, immediate action is required to improve the parameter,
2. unsatisfactory, the company should take measures to improve the performance of the parameter in question,
3. satisfactory - the value of the indicator/measure is at an acceptable but still low level,
4. good, the value of the measure is satisfactory,
5. very good, value of the measure at a very good level, no need for any improvement actions, the company should focus on maintaining the current state.

The sum of all weighting coefficients is equal to one, and ratings were assigned according to the value of the respective measure. Based on the weights and ratings of the individual measures and indicators, a process reliability rating was calculated. It should be borne in mind that this is an assessment of indicators/measures created on the basis of data obtained from the research subject, which cover only the selected aspects of reliability and may be incomplete, i.e. not every dissatisfied passenger writes a complaint, while a relatively high tolerance for delays is used in the punctuality measure. The ratings of the adopted indicators and quality measures are summarised in Table 3.

**Table 3.**  
*Selected quantitative indicators*

Name of the measure/indicator	Weight	Rating	Assessment indicator
Vehicle equipment malfunction measure	0.1	4	0.4
Fleet age indicator	0.05	4	0.2
Measure of lack of bus stop service	0.3	4	1.2
Passenger satisfaction index	0.25	5	1.25
Punctuality index	0.3	4	1.2
<b>TOTAL</b>	1	-	4.25

Source: Own study based on research results.

According to the ratio analysis, the overall reliability of the services of the surveyed company can be assessed as good (score 4.25). The indicators with the greatest impact on the final rating include: the passenger satisfaction indicator, the indicator of the lack of service at stops (linked directly to the postulate of certainty) and the indicator of punctuality (linked directly to the second very important transport requirement, which is punctuality).

However, it should be remembered that the indicator analysis was based on data received from the enterprise and it does not have to coincide with how these parameters are assessed by residents traveling by public transport. The indicators do not allow to analyze all the aspects that passengers may pay attention to (for example, air conditioning, travel time, etc.) and which, due to the lack of historical data, cannot be included in the indicator analysis.

Other indicators may be incomplete due to imperfections in the data collection process, such as the Passenger Satisfaction Index, which assumes that dissatisfied passengers will write complaints, which is relatively rare in practice.

## 4. Conclusion

Based on the ratio analysis, based on the data received from the company, it can be concluded that the public transport passenger transport services provided by the research subject are characterized by a good level of reliability. This is indicated by the high values of individual monitored measures and indicators, as well as the weighted assessment of individual criteria calculated at the end. However, it should be borne in mind that the values of the measures do not have to coincide with the passengers' opinion on the analyzed criteria, as well as the fact that there are many factors influencing the reliability, which were not included in the conducted ratio analysis due to the lack of necessary data.

Indicator analysis makes it possible to identify, those factors whose performance should be improved. However, it should be borne in mind that the indicator system does not determine the success of the enterprise, but makes it possible to improve the management of operations.

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## SAFETY OF TRANSPORTATION OF PALLET SHIPMENTS BY A SELECTED LOGISTICS OPERATOR

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**Purpose:** A key issue in the transportation of pallets is their proper preparation. The selection of an appropriate pallet, the stacking of goods and the proper securing of the pallet with the cargo is intended to minimize the risk of damage to the goods. Transporting goods on a pallet allows for additional protection of fragile items, as well as transporting heavy or oversized cargo. Unfortunately, damage to transport shipments is a common problem for many companies, for the sake of the damage to the goods being transported and the costs they entail. That's why it's so important to be safe when transporting pallet shipments to reduce its negative effects. This article addresses the problem of a logistics operator that serves its customers by first placing products on pallets and then loading the pallets onto trucks. In addition to the standard geometric constraints of keeping products from overlapping and exceeding the dimensions of pallets and trucks, there are many other constraints in this real-world problem, related to the total weight of the load or the distribution of the load inside the truck, as well as transportation safety. By analyzing the transportation process and shipment damage data, it was possible to propose measures to implement to reduce or eliminate the occurrence of damage to pallet shipments.

**Design/methodology/approach:** The article briefly reviews the literature in the area of the concept of pallet. A map of the processes of execution of the transport order of pallet shipments was used, as well as FMEA analysis, which is an effective tool for identifying potential risks, causes of damage and their impact on the process of transporting pallet shipments.

**Findings:** The purpose of the article was to analyze the current state of transportation management in the studied company using process mapping and to detect the causes of the appearance of damage to pallet shipments using FMEA analysis.

**Originality/value:** As the selection of an appropriate pallet, the stacking of goods and the proper securing of the pallet with the cargo is aimed at minimizing the risk of damage to the goods, the topic addressed is relevant to the business of the logistics operator under review.

**Keywords:** logistics provider, transport process, pallet, pallet shipment, security of shipment transportation.

**Category of the paper:** case study.

## 1. Introduction

Security of transportation of pallet shipments by the selected logistics operator is a key element of effective and efficient supply chain management (Kołdys, 2015; Silva, 2023). Companies are increasingly relying on logistics operators to focus on their core business activities, delegating the area of transportation to specialists<sup>1</sup>. Pallet transportation, on the other hand, is an indispensable part of modern logistics and supply chains (Bieniek, 2019; Quiter, 2023). It involves the use of pallets to efficiently and safely transport goods from one point to another, whether it's shipping products overseas or delivering orders at home. With the increasing demands of global trade, pallet shipping has become a key aspect for companies to ensure that their products reach customers in accordance with the 7W principle. Therefore, one of the most important areas is packaging. It is the packaging that determines whether the product will reach the customer in proper condition. Packaging that will provide the transportation company with the information needed to move the product to the correct customer location (Witos, 2021; Herzau 2021). Whether transporting a single commodity or a larger quantity of goods, it requires proper planning and a lot of steps to make sure that everything runs smoothly and without unnecessary complications, so that the transport is safe (Smolnik, 2018; Wasiak, 2016). Pallet shipments are an integral part of all transportation, and failure to use pallets could very negatively affect all logistics processes. The task of pallets is not only to facilitate transportation, but also to ensure the safety of both goods and the environment and people involved in the transportation process. Pallet shipping is a key logistics process for many companies. It is a safe and easy way to move cargo. It can, however, also be complicated and require the organization of many activities to secure the goods. It is also worth noting that pallets are one of the most widely used returnable transportation items and are a key resource for the supply chain, as they have a significant environmental and economic impact throughout their life cycle (Masis, 2022). Unlike other packaging products, pallets are specifically designed to be reused. This, in turn, is good for the environment as it reduces waste. Pallets play a key role in handling and transporting products at all levels of the supply chain. Pallets are used to handle unit loads of raw materials that are shipped from suppliers to manufacturers; in turn, manufacturers ship finished products on pallets to distributors; and finally, distributors fill orders to retailers on pallets (Debjit, 2016). As the structural basis of unit load, pallets provide efficient and standardized material handling and logistics around the world. An estimated 80% of trade in the United States (US) is conducted on pallets (Carrano, 2018), and pallets are undoubtedly the most widely used unit load platform in the world (Kończak, 2023; Martin, 2021). Approximately 450-500 million new pallets are produced annually, joining the approximately 2 billion pallets in circulation in the US (Buehlmann, 2009). In the European Union, about 280 million pallets are in circulation each year (Debjit, 2016). In view of the specific relevance of the topic and its importance for the conduct of effective operations of

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<sup>1</sup> Trends and perspectives for pallets and wooden packaging (2016) United Nations ECE/TIM/2016/6.



a logistics operator, the research question posed is: the application of FMEA analysis and obtaining information on the causes of disruption to the safety of pallet shipments will improve their safety and that of people who are in the vicinity of the shipments and the loading area.

## 2. Specificity of pallet shipment

The pallet is an indispensable item to discuss in order to move forward with your work, and the importance of the pallet and the role it plays has a significant impact at every stage of the movement of goods. The pallet is the basis for storing items, allowing them to be transported by forklifts without the need for reloading. Pallets are the basic loading platform that connects packaging with handling equipment, transportation means and storage equipment (Hassa, 2013). A pallet can also be defined as a package that can act as a bulk package, i.e. a direct packaging of units of goods, or a transport package, i.e. one whose purpose is to provide additional protection for materials and bulk packaging, during such maneuvers as transportation or storage. A pallet is a logistic unit that has a kind of dimensional system. At the moment, in the era of outsourcing, the pallet is also counted as a returnable packaging unit in the supply chain (Bendkowski, 2011). Their recycling is as possible given that they are made of wood, which is easily recycled (Szołtysek, 2009). Goods are placed on pallets for easy storage, warehousing, or transportation between different points. Such activities are among the basic logistics activities, so that the place, time and quantity of goods can be changed, all of which is greatly facilitated by the pallet (Bendkowski, 2013). It is an auxiliary device for storage and manipulation, as it is a platform for moving and storing inventory (Kij, 2019).

The following palettes are distinguished (Bril, 2012, Dudziński, 2002):

- Flat – these are devices with one or two plates, they can be reversible or irreversible, and the entrance to them can be on one or four sides. There are models with or without wings. Typically made of wood, metal, plastic, mixed materials. These types of pallets contain goods that are resistant to mechanical damage during transport and stacking.
- Post-type – reusable devices, they have posts that make it possible to stack pallet units without burdening the load placed on them. They are usually made of metal and their posts are made of wood.
- Box pallets – these pallets are suitable for repeated use, they are characterized by the fact that they have walls thanks to which it is possible to stack and store loads of unusual shapes. The walls protect the products inside against pressure when stacking them, as well as damage during transport.
- Specialized – these are devices whose shape and dimensions are prepared depending on the products stored with them, taking into account transport, storage and retrieval of materials from there. Pallets also allow goods to be stacked.

Pallet shipping is used when the weight of the package is greater than that specified for a standard or non-standard shipment without a pallet. A pallet makes it very easy to transport heavy and large goods. The most popular pallets are flat EUR pallets, whose features, physical properties and functionality are strictly defined. Their dimensions are precisely defined. The most commonly used pallets are 1200 mm x 800 mm x 144 mm. The EURO pallet has dimensions of 120 x 80 centimeters at the base, and its maximum height after placing the load is approximately 200 centimeters. It is usually used to send parcels over 50 kilograms, and the highest pallet weight is 700 or even 1000 kilograms. The pallet performs many tasks depending on the method and purpose for which it is used. We can distinguish such tasks as (Litewka, 2018; Coyle, 2002; Toruń, 2016):

- Fulfilling the function of packaging, which includes protection for the goods, facilitates storage, transport and other manipulation activities, contains basic information about the products, how to handle the cargo, and how they can be disposed of.
- A means of facilitating unloading, loading and transport of goods over long distances.
- The use of pallets forms units of specific dimensions that can be picked up by robots and other devices, facilitating the work of people.
- In the case of disposal and its final use, it can be used as compost (after grinding), bedding for pigs, or can be used as a packaging material.
- Material for making furniture, flower stands, tool chests and much more.

The large size of shipments makes them difficult to manipulate when loading or unloading onto means of transport. The same problem occurs when there are a large number of shipments. Pallet shipments are used to facilitate shipment handling operations. These are shipments that use pallets on which the goods to be sent are placed and sent as one parcel. This method is used especially when shipments weigh more than 30 kg. When their weight reaches such a limit, they must be susceptible to mechanical overloading, i.e. using mechanical reloading equipment, e.g. a forklift. A pallet shipment makes this task easier because it is a carrier that is easy to pick up by a forklift. The goods on it are safe, and manipulation activities will not damage the goods or pose a threat to the surroundings. The pallet shipment must be properly secured to prevent it from deforming during transport, storage or warehousing. For this purpose, special foil or plastic or metal strips are most often used. When such a shipment is to be unpacked, it should first be carefully unwrapped to make it easier to retrieve the goods later (Odlanicka, 2014). Pallet shipments, which are one of the most common ones, are pallets with food goods and they are particularly exposed to damage during numerous operations in various distribution centers where they are located along their route (Grabowska, 2020). Therefore, they must be packed extremely carefully to ensure that each transported item is safe at every stage of the pallet shipment route.

Safety is a key task that should be a priority during every job. This should also be the case with the transport of pallet shipments and all related activities. You should always act prudently and take care not only not to damage the goods, but also not to pose a threat to people participating in any maneuvers related to its transport. Ignoring safety rules and failing to follow

them may cause damage to human health and irreversible damage to transported shipments. In order to avoid or minimize the possibility of a threat occurring, legal provisions and generally established rules by companies must be followed (Wołczański, 2014). The literature on the subject provides the basic principles that should be followed when securing pallet shipments (Bomba, 2018):

- Suitable pallet goods.
- Proper arrangement of goods on the pallet - so that they do not move or slide.
- Arranging enough layers of goods so that none of them is crushed, remembering that the maximum height of the shipment should not exceed 180 cm.
- Remember to take into account the weight of the entire pallet shipment and its even distribution.
- Ensuring that the goods do not protrude beyond their dimensions.
- Protection with an appropriately selected tool: heat-shrinkable foil, tapes, cardboard or wooden tops, corner boxes.

Placing the bill of lading in a visible place on the shipment, because this is where all the information about the goods and how to handle them is located. Additionally, you can place stickers with information on how to handle the goods. They will visually show what to do, which in turn will better inform the pallet operator ([https://opaksystem.pl/...](https://opaksystem.pl/)).

Ensuring safety in the transport of pallet shipments is a basic element of organizing loading activities. Thanks to the appropriate formation of loads, it is possible to move goods efficiently and in an intact condition. Good security protects the transported goods against damage and negative impact of the goods on the environment (Grzelak, 2018).

A significant factor in the safety of transported pallet shipments is their proper packaging and correct shaping. Packaging must properly protect the product against unexpected damage and protect the surroundings from the harmful effects of the product. A properly formed shipment allows for the effective use of the means used during transport and movement throughout the entire logistics chain (Galińska, 2016).

### **3. Actions of the logistics operator to secure the transport of a pallet shipment**

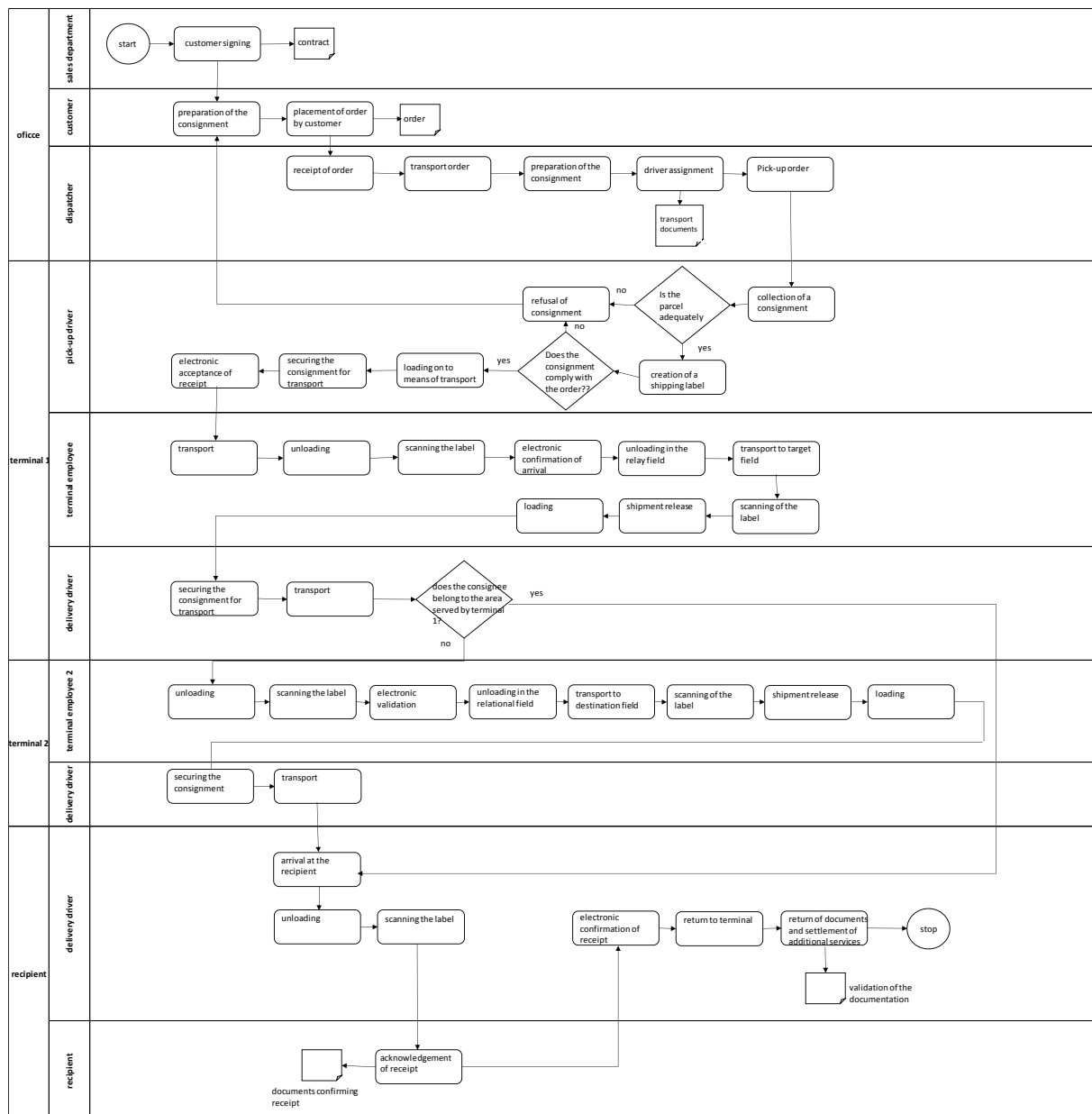
The security of pallet units at the analyzed enterprise is crucial to ensure the integrity and safety of goods during transportation, storage and handling. The entity under study, due to the numerous manipulations of shipments and their rapid movement by road, must use many different types of security features to ensure that the transported goods arrive without damage from the place of shipment to their final destination. There are many types of security features for pallet shipments used both at the loading terminal and on the transport vehicle. Among the safeguards used by the surveyed entity are:

- Lashing straps - used on means of transport to prevent shifting of pallet shipments. Lashings usually made of special strong canvas stabilize the shipment, but be sure to use them according to the instructions and fasten them at the right angle to be most efficient and not damage the goods.
- Locking beams - are used to prevent the shipment from moving. In particular, they are fixed after the last shipment is loaded, when the means of transport is not fully loaded. Such protection blocks shipments from moving and pushing against the door, so that when the door is opened, shipments do not fall out on their own and contribute to causing hazardous events.
- Blankets - are used most often during extreme temperatures, i.e. severe cold in winter and hot days in summer. Shipments are then covered with a special thermal blanket to prevent large temperature fluctuations and keep the temperature relatively constant for shipments. They are used during the transportation of products at which such temperatures could adversely affect them.
- Stretch film - a flexible and durable film that is wound onto a pallet unit to protect goods from dust, moisture and mechanical damage. It is flexible, allowing it to conform securely to the shape of the cargo.
- Clamping straps - are used to hold pallet units securely in place. They can be placed around the pallet to prevent the cargo from shifting during transport.
- Protective corners - made of plastic or foam, they are placed on the corners of pallet units to protect them from damage during handling. They also help stabilize the load.
- Heat-shrinkable pallets - are a type of packaging that, when placed on a pallet unit, is subjected to heat, causing it to shrink and fit the load perfectly. This protection is especially applicable to one-time shipments.
- Temperature control systems - for shipments that need to maintain a certain temperature, temperature control systems such as refrigerated or heat-insulated packaging are used.
- Seals - are applied to both shipments and vehicles, in which full truckload shipments are most often transported. They must have an appropriate number and be documented so that it is known that the shipment has arrived safely from its starting point to its destination.
- Markings - It is important to properly mark shipments for their contents, transport conditions and movement. If a shipment were not marked it could be improperly picked up and subject to damage. There are ADR shipments that are hazardous shipments and they must be transported in a special way for them in order not to pose a danger. Therefore, it is very important to have proper labeling before such events.

It should be noted, however, that not every security is in the interest of the entity under study, as it only provides transportation services and that is the focus. On the other hand, such safeguards as, for example, packaging or securing a pallet unit in the first place is up to the shipper. The carrier has the right not to accept a shipment if it is poorly packed and secured. Then the shipper of such a shipment must properly secure it. All the safeguards used

significantly protect not only the goods, but also the environment from danger, injury, damage or financial loss. However, this is not always enough and, despite everything, damage does happen, which is something to pay attention to and then try to prevent.

The analysis of the transport process of the studied logistics operator and the analysis of data on the number of pallet units transported each day over a period of 6 months and the number of damaged shipments also occurring on each day of the month contributed to proposing measures whose implementation will reduce or eliminate the risk of damage to pallet shipments. The analysis of the transportation process was performed using a process map. This map is shown in Figure 1.



**Figure 1.** Map of the process of execution of the transport order of pallet shipments.

Source: Own elaboration based on information of logistics operator.

The order fulfillment process includes all activities that occur during the transportation of a particular cargo shipment. The process begins when the sales department acquires a customer. The customer packs the shipment and secures it properly and generates an order in the system. The order automatically appears in the company's system and the employees of the department dealing with a given customer and region proceed to execute it. Dispatchers create shipping documents and send a driver to the pickup site, the driver must scan each pallet being taken up, and check it against the documents. When the shipment matches, the driver visually inspects it for proper security, and when everything matches, he can load it onto the truck. Otherwise, he has the right to refuse the shipment or ask for additional security or repacking. On the means of transport, the driver is also required to secure the shipment with the appropriate equipment so that it is not damaged during the journey. Once the shipment arrives at the terminal, it is unloaded, everything is scanned once again, so that the message about the shipment's stay at the terminal is sent to the company's system. The goods are located on a relay field at the unloading dock, after which terminal personnel transport them to the appropriate relay field, from where they are picked up by a driver to be digested to the terminal serving the specified region where the shipment is to ultimately arrive. The same loading procedures are repeated, i.e. scanning the labels, loading and securing for transport, and the transport itself. At this terminal, unloading, scanning, deployment to relational fields takes place, until finally transport to the shipment's final destination. There, the driver unloads the pallet units, gives the documents to the person authorized to receive them to sign, then approves everything on a mobile device or phone. Once back at the terminal, he gives the documents back to the appropriate department so they can be accounted for.

Of course, from the analysis of the process itself, the number and type of damage to pallet shipments is not clear, so data analysis of the number of pallet units transported each day over 6 months and the number of damaged shipments was carried out. These data are presented in Table 1.

The collected data shows that all shipments involved in the transportation process in 6 months are 912686 of which 1014 shipments were damaged. The highest percentage of damaged shipments occurred in the area - terminal, as it is, as many as 745 of all damaged shipments, which is 73.5%. The smallest number of shipments that were damaged originated through the driver, and this is 46 shipments, or 4.5%. After analyzing the data, one can proceed with further analysis, and the first step is to select the appropriate scale and ratings to suggest when conducting the FMEA analysis. Table 2 defines the probability of failure (P). The probability with which a given defect can occur, its characteristics, the P rating on a scale of 1-10, and the estimation of the ascension of a defect are specified.

**Table 1.**  
Data analysis of the number of pallet units transported over 6 months

YEAR		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER						
2023	DAY	number of pj	number of pj damaged	DAY	number of pj	number of pj damaged	DAY	number of pj	number of pj damaged	DAY	number of pj	number of pj damaged	DAY	number of pj	number of pj damaged			
	01.05.2023	7389	3	01.06.2023	4569	5	03.07.2023	5169	8	01.08.2023	5632	1	01.09.2023	5632	12	02.10.2023	8563	15
	02.05.2023	7521	1	02.06.2023	7896	12	04.07.2023	7523	9	02.08.2023	5236	2	04.09.2023	5236	9	03.10.2023	7456	9
	03.05.2023	6987	1	05.06.2023	7896	8	05.07.2023	6452	10	03.08.2023	5478	5	05.09.2023	5478	8	04.10.2023	5627	8
	04.05.2023	6589	5	06.06.2023	7820	9	06.07.2023	6410	7	04.08.2023	8651	8	06.09.2023	8651	7	05.10.2023	6890	1
	05.05.2023	5698	8	07.06.2023	5890	5	07.07.2023	6520	6	07.08.2023	4523	9	07.09.2023	4523	5	06.10.2023	8700	1
	08.05.2023	4569	6	08.06.2023	4789	8	10.07.2023	6325	14	08.08.2023	7896	15	08.09.2023	7896	8	09.10.2023	5890	5
	09.05.2023	7896	14	09.06.2023	7600	9	11.07.2023	5632	12	09.08.2023	5879	14	11.09.2023	5879	11	10.10.2023	4789	4
	10.05.2023	7896	7	12.06.2023	5210	6	12.07.2023	5236	8	10.08.2023	6987	18	12.09.2023	6987	19	11.10.2023	7600	125
	11.05.2023	7820	6	13.06.2023	8765	11	13.07.2023	5478	1	11.08.2023	5687	9	13.09.2023	5687	2	12.10.2023	5210	19
	12.05.2023	5890	5	14.06.2023	7856	5	14.07.2023	8651	2	14.08.2023	5478	8	14.09.2023	5478	8	13.10.2023	8765	36
	15.05.2023	4789	5	15.06.2023	8563	2	17.07.2023	4523	6	15.08.2023	5784	1	15.09.2023	7856	10	16.10.2023	7856	5
	16.05.2023	7600	5	16.06.2023	7456	1	18.07.2023	7896	3	16.08.2023	8547	2	18.09.2023	8563	9	17.10.2023	4569	1
	17.05.2023	5210	2	19.06.2023	5627	1	19.07.2023	5879	5	17.08.2023	6547	3	19.09.2023	7456	15	18.10.2023	7896	4
	18.05.2023	8765	1	20.06.2023	6890	1	20.07.2023	6987	3	18.08.2023	4569	4	20.09.2023	5627	4	19.10.2023	7896	7
	19.05.2023	7856	1	21.06.2023	8700	1	21.07.2023	5687	6	21.08.2023	7896	1	21.09.2023	6890	8	20.10.2023	7820	8
	22.05.2023	8563	1	22.06.2023	6800	7	24.07.2023	5478	4	22.08.2023	7896	5	22.09.2023	8700	9	23.10.2023	5890	9
	23.05.2023	7456	3	23.06.2023	6984	8	25.07.2023	5784	5	23.08.2023	7820	8	25.09.2023	9874	1	24.10.2023	4789	6
	24.05.2023	5627	8	26.06.2023	6547	14	26.07.2023	8547	1	24.08.2023	5890	8	26.09.2023	8965	9	25.10.2023	9870	9
	25.05.2023	6890	7	27.06.2023	6987	15	27.07.2023	6547	1	25.08.2023	4789	5	27.09.2023	8521	8	26.10.2023	9600	16
	26.05.2023	6800	9	28.06.2023	7896	6	28.07.2023	5647	8	28.08.2023	7600	2	28.09.2023	8540	16	27.10.2023	8960	18
	29.05.2023	6984	4	29.06.2023	6999	8	31.07.2023	6325	9	29.08.2023	5210	1	29.09.2023	8740	7	30.10.2023	8942	1
	30.05.2023	6547	7	30.06.2023	8796	7				30.08.2023	8765	4				31.10.2023	9752	1
	31.05.2023	6987	1							31.08.2023	7856	1						
	total	158329	110	total	156536	149	total	132696	128	total	150616	134	total	151179	185	total	163330	308
	Damage passage			Damage passage			Damage passage			Damage passage			Damage passage			Damage passage		
	way	driver	Terminal	way	driver	Terminal	way	driver	Terminal	way	driver	Terminal	way	driver	Terminal	way	driver	Terminal
	25	2	83	39	12	98	22	9	97	34	8	92	31	9	145	72	6	230

Source: own compilation based on data received from the operator.

**Table 2.**  
*Probability of damage*

probability of occurrence of the event	characteristics	points	estimation
almost unlikely	damage is almost impossible	1	less than 1/100000
very rare	several small defects	2	1/2000
rare	minor defects	3	1/4000
average	medium damage (quantity and quality)	4-6	1/1000, 1/400, 1/80
frequent	repetitive damage	7-8	1/40, 1/20
very frequent	unavoidable	9-10	1/8, 1/2

Source: own elaboration (after consulting the company).

Table 3 shows the significance of the damage also rated on a scale of 1-10 (S) respectively for damage ranging from very small and insignificant to very large, which generates further problems. Table 4, meanwhile, shows the probability of detecting damage. Table 5 shows the problem analyzed using the FMEA questionnaire, which is related to the impact of security features on pallet shipments.

**Table 3.**  
*Significance of the damage*

Significance of the threat		S
very small	minimal impact on the process, with no impact on other consignments or persons involved	1
small	slight inconvenience, other consignments may flow correctly	2-3
medium	other processes may be disrupted further	4-6
large	major problems, with the result that other processes are more likely to be disrupted downstream	7-8
very large	major problems, other processes are disrupted further downstream generating damage repair costs	9
	a major constraint on the realisation of the logistical (transport) process, its stoppage, its violation	10

Source: own elaboration (after consulting the company).

**Table 4.**  
*Probability of detecting damage*

level of detection	probability of damage detection	D
very high	very high shipment and process security	1-2
high	low probability of undetected damage	3-4
medium	little difficulty in detecting damage	5-6
low	low ability (possibility) of damage detection	7-8
very small	high possibility of damage detection	9-10

Source: own elaboration.



**Table 5.**  
*The analyzed problem with the help of the FMEA questionnaire*

	Problem	Cause of the problem	Consequences of the problem	Current state				Improvement activities	Revised condition			
				P	S	D	C		P	S	D	C
1	Damage to palletised shipments - through poor security	No safety beams	Shipment shifting while in transit, crushing, falling out of the means of transport. Damage or destruction of goods. Possible damage to the health of those involved and other consignments.	5	9	1	45	Introduce the use of beams irrespective of vehicle loading.	2	9	1	18
2		No tie-down straps	Shipment shifting while in transit, crushing, overturning, falling out of the means of transport. Damage to or destruction of goods. Possible damage to the health of those involved and other consignments.	4	8	1	32	Training of employees and drivers in relation to the use of security features.	3	8	1	24
3		Lack of control by the driver	Occurrence of damage that went unnoticed causing further problems and costs.	5	7	5	175	Introducing a function on the mobile device about the need to confirm the security check as a reminder.	1	7	2	14
4		Lack of control by a terminal employee	The occurrence of damage that went unnoticed causing further problems and costs for the company.	4	7	5	140	Introducing a function on the mobile device about the need to confirm the security check as a reminder.	1	7	2	14
5		Wrong packaging	Poorly secured goods, hardly susceptible to transport and handling.	3	10	7	210	Penalties for shippers for poorly packaged shipments and their thorough training.	2	10	5	100
6		Incorrectly selected protection	Poor securing of goods or failing to secure them and exposing them to multiple damages and unfitness for transport.	7	10	6	420	Introducing a function on the mobile device about the need to confirm the security check as a reminder.	4	10	2	80
7		Defective packaging	Damage to the goods through defects in packaging or insufficient protection from damage.	3	5	5	75	Penalties for shippers for poorly packaged shipments and their thorough training.	2	5	4	40
8		Defective security	Poor securing of goods or failing to secure them and exposing them to multiple damages and unfitness for transport.	4	6	6	144	Introduce systematic security checks on company consignments to reduce unusable ones.	3	6	5	90
9		Too few safeguards	Poor securing of goods or failing to secure them and exposing them to multiple damages and unfitness for transport.	7	4	6	168	Training of employees and drivers in the types of security features of the consignments concerned.	4	4	4	64
10		Irresponsible handling of a consignment	Damage to the consignment and its security features, causing further damage and costs.	7	3	7	147	Greater emphasis on incurring criminal consequences for employees who do not comply with parcel handling rules.	2	3	5	30
11		Improper labelling of the consignment	Damage to the consignment and its security features, causing further damage and costs.	7	3	4	84	Penalties for shippers for poorly packaged shipments and their thorough training.	3	3	4	36
12		External factors (e.g. weather conditions, traffic accidents)	Damage to the consignment and its security features, causing further damage and costs. Damage or destruction of the goods.	2	7	9	126	Lack of	2	7	9	126

Source: own elaboration.

FMEA (Failure Mode and Effects Analysis) is an effective tool for identifying potential hazards, causes of damage and their impact on the pallet shipment process. The following are steps that can be taken to conduct an FMEA analysis in the context of the causes of damage to pallet shipments:

**Step 1. Define the Process**

The transportation process was analyzed. Data was collected on the number of pallet units transported each day over 6 months and the number of damaged shipments also occurring on each day of the month. Days on which the company does not work, i.e. weekend days and non-working holidays, were omitted. The process described was considered in view of the realization of transports when maximum loading of the vehicle occurs, not just parts of it, as such transports are a rarer phenomenon.

**Step 2. Identification of Components**

In this step, a map of the transportation process was made.

**Step 3. Identify Possible Damages.**

Potential damages that may occur were identified.

**Step 4. Identify Causes**

Possible causes were identified for each potential damage.

**Step 5. Identify Effects**

The effects of the potential damage were identified.

**Step 6: Determine Probability of Occurrence**

Assign. each potential damage a probability of occurrence.

**Step 7. Determine Ease of Detection.**

Evaluate how easy it is to detect each potential damage before it affects the process.

**Step 8. Calculate Priorities**

For each potential damage, an FMEA priority was calculated, which is the product of an assessment of probability, impact and ease of detection. This priority will help identify the riskiest areas.

**Step 9. Implement Corrections and Monitoring**

Based on the results of the FMEA analysis, action plans were developed to minimize the identified risks.

After conducting the FMEA and analyzing the results, it can be deduced that the root cause of the problem that received the highest risk rating is misplaced security. The rating it received is, as high as 420, and it differs significantly in scale from the other causes of shipment damage. Only this one number exceeds the threshold of 300, and to such a high degree, which suggests that the problem is quite serious and should be looked at even more closely and, as a first step, proceed to reduce it as soon as possible to avoid further problems and their subsequent consequences, including financial ones. When performing the analysis, the solution that was proposed to lower the risk threshold was to introduce a function on the mobile device about the need to confirm the security check as a reminder. This means that the employee who was

loading and securing the goods at the time would have to dutifully confirm an automatically displayed query during scanning whether the security features had been correctly applied and checked in sequence. This proposal would not only help reduce the risk, down to level 80 for the biggest problem, but also reduce other problems such as the driver's failure to check and the terminal employee's failure to check.

This would have the effect of eliminating the occurrence of damage, since it would have been noticed earlier during the inspection and would not have had the chance to cause further problems, as well as costs. As a result, their risk would also be reduced almost to non-existent. There are also other damage-causing risks, and these were also examined during the performance of the analysis, but none of them cause such a "jump" as the one discussed above, but for them, too, proposals have been made to lower them, which in turn results in lowering the risk assessment of their occurrence. In the problems that occur and have been studied, there are also those that will not be affected by any improvement measures that could be proposed. Such problems are caused by fortuitous events beyond anyone's control, such as weather conditions or traffic accidents with accidental participation. These are fortuitous events beyond the company's control and cannot be predicted, and unfortunately the effects are usually very noticeable.

The difficulty of securely securing a shipment is caused by poorly selected security, which is inadequate not only in terms of the strength and alignment of its physical characteristics, but can also be detrimental to the shipment itself. This problem mainly involves the terminal, and this is where preventive measures should be implemented. Certainly, control by drivers should be increased by introducing a function on the mobile device about the need to confirm security checks. Next, it is necessary to get the security features right for the goods through instructions and the introduction of a function on the mobile device about the need to confirm security checks. It will also be necessary to train employees and drivers on the types of security features for given shipments. There should also be greater emphasis on incurring criminal consequences for shippers and employees who do not comply with shipment labeling. It is also advisable to introduce systematic security checks of shipments at the company to reduce those unfit for use, and better quality packaging should be used and more emphasis should be placed on proper packaging and securing of shipments.

In conclusion, it can be said that the analysis of the transportation process was presented using the process mapping method, in which the individual steps that are taken to get the shipment from the starting points to the destination point were determined, taking into account the many activities on its way. During observations at the company, data was collected, and their analysis made it possible to note that the greatest number of all damages are caused within the terminal, this represents, as much as about 73.5% of all damages. Therefore, all actions should start in this area and focus their attention on it. Subsequently, an FMEA analysis was carried out, which made it possible to detect and analyze problems related to damage to shipments. From here it emerged that the biggest problem faced by the company is

misplaced security, caused by incorrectly securing the goods or not securing them, and thus exposing them to numerous damages and even unfitness for transport. Its assessment differs significantly in outcome from the other risks, which means that it should be focused on first. The FMEA analysis introduced in the study influenced the detection of the main causes of the occurrence of hazards in the loading and transportation of goods and people in this loading space.

#### **4. Conclusive remarks**

The safe transportation of pallet shipments is a key element in the logistics process. Whether you are a manufacturer, distributor or consignee, you need to ensure that your shipments arrive at their destination in perfect condition. The study shows that:

- most of all damage occurs within the terminal, it accounts for, as much as about 73.5% of all damage,
- the biggest problem faced by the company is erroneous security, caused by incorrectly securing the goods or not securing them, and thus exposing them to numerous damages and even unfitness for transport.

Preventive measures that can help avoid damage that occurs during the execution of pallet shipment shipments can be modifications to mobile devices and the introduction of a new function there - confirmation of security checks, to remind people to perform this action.

To ensure the safe transportation of palletized shipments, there are several important factors to consider. The first step in securing the transportation of pallet shipments is to choose the right logistics provider. It is important to find a company that has experience in transporting this type of shipment. The second aspect is securing the shipment during transport. There are many ways to secure pallet shipments during transport. These can include safety straps, safety tapes, anti-slip pads or other specialized devices. These items prevent shipments from shifting or being damaged during transport. To ensure the safety of pallet shipments being transported, the logistics operator should follow proper handling procedures. Shipments should be moved using specialized equipment, such as forklifts, which minimize the risk of damage. It is also important that personnel are properly trained in handling pallet shipments.

When choosing a logistics provider, it is worth checking whether it offers insurance for pallet shipments. A good logistics company should have adequate insurance to protect shipments in case of possible damage or loss. This type of insurance gives the customer a sense of security and protection in case of unpredictable events. Another aspect of pallet shipment security is access to a tracking system. The logistics operator should provide the customer with an online system to monitor the location of shipments and check their status in real time. This allows you to react quickly to any problems, such as delays or lost shipments. Security of

pallet shipments is an extremely important part of the logistics process. Choosing the right operator, using the right safeguards during transport, proper handling procedures, insuring shipments and having access to a tracking system are key elements to consider. Attention to these aspects ensures the safe transportation of pallet shipments and guarantees that they will arrive at their destination in perfect condition.

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## KNOWLEDGE MANAGEMENT CHALLENGES IN PROJECTS IN BUILDING AND CONSTRUCTION SECTOR

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**Purpose:** The objectives of the article are focused on identifying and evaluating mainly the information technologies that are currently used to manage knowledge in the building and construction industry, highlighting the strengths and weaknesses of particular IT tools for KM, and analyzing how to combine different information technologies together to support knowledge transferring process between construction professionals.

**Design/methodology/approach:** The objectives of the research were achieved by a questionnaire survey. The respondents were professionals, mainly project managers in projects executed in a building and construction sector. An on-line questionnaire was elaborated to get the information on knowledge management in building and construction projects.

**Findings:** It was found that knowledge management is an increasing challenge in projects in a building and construction sector. Barriers of applying knowledge management in construction industry have been identified. As project teams in construction projects are often disbanded at the end of a project, the knowledge generated in a project is difficult to track after the project is accomplished. The knowledge generated in the project should be stored and coded within the project.

**Practical implications:** The research proved that knowledge management processes are of great importance and the use of IT tools is crucial for effective knowledge management in building and construction projects.

**Originality/value:** The value of the research is the deep analysis of tools and technologies applied in selected building and construction projects. The respondents, professionals in project management, assessed what is important in the area of knowledge management in building and construction sector. The paper is dedicated to managers participating in construction and building projects.

**Keywords:** knowledge management, IT tools, building and construction sector.

**Category of the paper:** research paper, case study.

## 1. Introduction

The building and construction industry needs information and knowledge input to be effective. The products of the construction industry are larger than others, and the project execution takes more time and resources. Knowledge is treated as a vital organizational resource that results in competitive advantages. Managing knowledge assets is a sophisticated process, especially in the building and construction industry, as it is a project-based business which creates one-of-a-kind product and highly fragmented working environment (Egbu, Botterill, 2002). As teams in construction projects are often disbanded at the end of the project, the knowledge generated in the project should be stored and coded within the project. The reason is that projects do not have any organizational memory, as they are temporary in nature (Fong, 2005). Knowledge, when you compared it with non-project organizations that are supported both by the organizational structure and knowledge-absorbing routines, becomes reutilized and socialized into the organization, Project-based organizations generally do not have support mechanisms that enable knowledge transfer to occur.

Although the construction industry is featured by many small and medium enterprises (SMEs), which make up over 90% of construction organizations (Egbu, Robinson, 2005), knowledge management efforts have been focused predominantly on large companies. This is because large organizations generally have more resources and higher employee turnover, and are more geographically spread, which urges them to develop efficient ways for knowledge retaining and sharing. On the contrary, to some extent, SMEs need knowledge management even more. SMEs cannot compete with large companies in terms of tangible resources such as capital, labour, equipment, and physical commodities, but the intangible knowledge assets can provide them a leverage to survive the fierce competitive market (Boyd, Xiao, 2006).

This research is addressing knowledge management facilities for small and medium sized construction organizations. Knowledge Management technologies used for SMEs may be smaller in scale and cheaper in cost but can be advanced in functionality to support its usability in order to encourage knowledge sharing. Many construction projects involve team members from distributed sites and organizations, and this requires ways to support team members to work across distance to adapt project tasks to changes in the environment. However, research on the knowledge sharing-support software only started very recently (Wang, 2004). Functional software with high-level ability of data analyzing, knowledge sharing, and collaborative process is rare in the construction industry.



The present article approaches the analysis and case study of knowledge management in projects in the building and construction industry. The objective of the article focuses on identifying and evaluating the information technologies that are currently used to manage knowledge in the building and construction industry, highlighting the strengths and weaknesses of particular IT tools for KM, and analysing how to combine different information technologies together to support knowledge transferring process between construction professionals.

## **2. The literature review on knowledge management in building and construction projects**

Research on knowledge management, organizational memory, and organizational learning is focused on the development of models and mechanism for the capturing, storage, and delivery of knowledge in organizations (Lee et al., 1992). Organizational knowledge management is a social process, involving interactions among many individuals leading to well-informed decision making. Thus, a culture that learns and adapts as part of everyday working practices is essential. Reuse must equal or exceed reinvent as a desirable behavior. Adapting an idea must be rewarded along with its initial creation. Sharing to empower the organization must supersede controlling to empower an individual. Knowledge can either be generated within organization or accessed externally that is knowledge flows may view as intra-organization or inter-organization.

Projects exist in almost every organization as of today. Sahlin-Anderson et al., (2002) gave a definition of project: "A project is an organization unit dedicated to the attainment of a goal - generally the successful completion of development product on time, within budget, and in conformance with predetermined performance specifications". Within the project-based industry, the need for innovation and improved business performance requires the effective deployment and utilization of the intellectual assets of project team members. Hall J. et al., (2000) pointed out that knowledge capturing, and transferring can be regarded as strategic issues, in that they benefit the organization as a whole. However, the process of accumulating and documenting "lessons learned", is more tactical in nature, as it involves costs, may be on conflict with the pressure of a specific project, such as completion on time within budget. If there are inappropriate or non-existing incentive structure to address this inherent conflict, knowledge management policies will be inadequate.

For a project-based organization, its main activities happen within every individual project they carried on; its goal is to successfully complete the next project on time and within budget. Lessons learned from past project or best practice collected from past project is project knowledge, but to share this knowledge with all the employees in the organization and encourage employees to apply it in their next projects are the process of transforming project

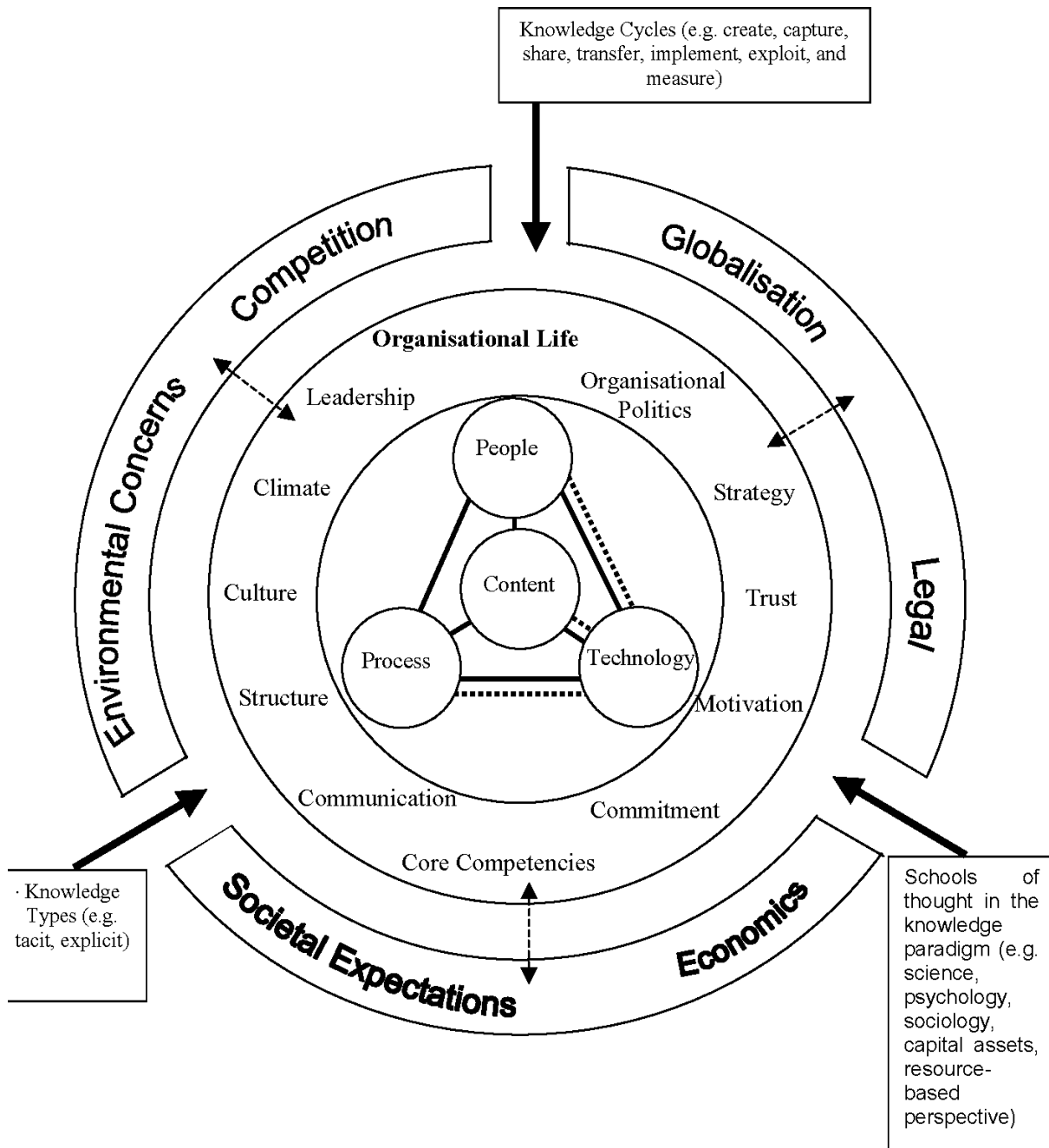
knowledge to organizational knowledge. Francisco (Francisco, 2001) examined how web technologies may support knowledge management in construction organizations. Some early web technologies such as email, HTML, XML and EDI were discussed in his paper; however, tacit knowledge was not supported by the system. To support both explicit and tacit knowledge, a knowledge management system needs to be built with content and collaboration technologies. As Duffy (2001) pointed out, technologies to support tacit knowledge sharing are more likely to require human interaction than those to support data and information sharing. Romaldi (2002) also stressed the value of using "technologies with hyper-linking and hyper-media capabilities" to effectively capture experts' tacit knowledge and make it explicit.

Based on the fact that researchers generally agree that tacit knowledge management needs human intervention and can be enhanced by advanced IT technology. There are some attempts to build computer systems to support tacit knowledge sharing. Woo et al. (2004) presented a Dynamic Knowledge Map which showed us an approach that can assist in the reuse of experts' tacit knowledge. Dynamic Knowledge Map is a Web-based knowledge navigator that searches for experts and facilitates communications with the experts by using Internet technology. Tserng and Lin (2004) proposed a concept of activity-based knowledge management and presented a system which uses a knowledge sharing platform for construction projects.

### **3. IT role in knowledge management in building and construction projects**

The role of technology, especially IT in knowledge management, is still valid (Mohamed et al., 2006; Dohn et al., 2013). The identification perspective views knowledge management as mainly a re-naming of computer-based technology's various monikers and variants. Dent & Montague (2004) asserted that the primary role of technology within a knowledge management strategy is not as a driver but as an enabler. Davenport and Prusak (1998) described knowledge management as involving organizational, human, and technical issues, with the advice that the technical should be treated as the least important of the three. Similar idea on organizational knowledge model was proposed by Egbu & Botterill (2002) and is given in Figure 1.

IT offers unique opportunities to overcome barriers of space and time, but it has also been criticized that it offers only limited opportunities for truly "social" communication (Kiesler et al., 1984). But others argue that lack of social cues and absences of status differences have potential benefit for knowledge sharing, as status differences are frequently considered to be significant barriers for knowledge sharing.



**Figure 1.** Organization knowledge network.

Source: Egbu, Botterill, 2002.

IT has also been challenged for failing to adequately address the problems of managing tacit knowledge. Tacit knowledge by definition is at best, difficult or, at worst, impossible to articulate. Nonaka and Takeuchi (1995) suggested that tacit knowledge becomes explicit knowledge through the process of externalization, i.e., by sharing metaphors and analogies during social interaction. Some researchers also argue that to abstract tacit knowledge from its context of application is to lose much of its intrinsic meaning and value, i.e., "knowledge dilution" (Swan, Newell, 2000; Mohamed et al., 2006). Current technology may not offer the entire cognitive dimension, because the cognitive process involves socio-cultural perspectives which were built and sustained by social activities (Mohamed et al., 2006). A successful

KM practice requires both an effective organizational KM strategy and an appropriate IT infrastructure to support it (Dent, Montague, 2004).

A variety of IT has been used as knowledge management enablers. They can be classified in the following categories (Tsui, 2002):

- Communication Tools,
- Information Repository,
- Groupware/Collaborative Tools/Social Network,
- Expert System,
- Case-Based Reasoning,
- Taxonomy/Ontology,
- Knowledge Maps,
- Data Mining/Knowledge Discovery System.

Below, there are a few examples of applying the above-mentioned technologies in the building and construction industry:

- CBR-CURE is a CBR system for building construction duration and cost estimation (Yau, Yang, 1998),
- CACP (Computer-aided construction planning) a project-based planning software, also employs a CBR tool which is designed to capture and reuse planning knowledge and the application of this knowledge to computer-assisted planning. (Rankin, Froese, 2002),
- iKonnnect, an organizational knowledge management system, implemented by BLL (Bovis Lend Lease) is mainly based on telephone connection (Zou, 2003),
- LCPL a major subsidiary company of Leighton Holdings Limited set up their KM infrastructure namely EDMS (Electronic Document Management System) to capture information in digital format and to share them online throughout the project (Zou, 2003),
- bxXML is a construction taxonomy which was designed to support the eBusiness communication needed between clients, architects and engineers, suppliers, and contractors for the procurement of products, components, and services (Lima et al., 2003),
- ConABKM (Construction Activity-Based Knowledge Management) is an example of web-based, on-line organizational knowledge repository (Tserng, Lin, 2004).

A technology integration which links several information technologies together is considered as a possible solution. Ontology and collaborative tools, along with some newly emerged technologies such as semantic web and blogging showed their potential in KM and have drawn researchers' attention (Cayzer, 2004). Knowledge management is a very complex issue in general. When knowledge management is researched in the sub-domain of the construction industry, some features of this industry should be considered, and they are presented as follows.

- The industry is dominated by small and medium enterprises (SMEs), which make up over 90% of all organizations, with a relatively small number of large companies (Egbu, Robinson, 2005). In Australia especially, 94% of business in this sector employs fewer than five people and only 800 firms among 158,000 – or less than 1 % - employ more than 20 people (Love, Irani, 2004). Compared to large organizations, these SMEs usually are technologically weak, cannot invest heavily in innovation and development, and take a less-formal strategy in management with an emphasis on survival and cash flow. The knowledge in SMEs tends to be local, oral, tacit, and contextual. Therefore, some of the KM concepts and methods dedicated developed for large company may not apply to SMEs (Boyd, Xiao, 2006).
- Construction projects are often unique in their design, location, end-user, supply chain, budget, and partner (Fong, 2005). Knowledge generated in a project is embedded within its unique contexts. Therefore, how to express its context while codifying knowledge, how to identify contexts while retrieving knowledge, and how to recontextualize while applying knowledge become important considerations when applying KM in construction industry.
- The construction sector consists of a huge number of disparate companies of all sizes and representing very wide-ranging expertise and activities. In one project several very different companies often work together, communication between project participants and between organization employees becomes very important issue to share common understanding and eliminate misinterpretation (BSI, 2003).
- The construction industry is characterized as project-based business and delivers one-of-a-kind product. As project teams in construction projects are often disbanded at the end of a project, the knowledge generated in the project is difficult to be tracked after the project is completed unless there is an organizational KM system that maintains historical project knowledge. The reason for lack of keeping knowledge within the organization and effectively sharing between projects is that no organizational memory is kept for future retrieval as projects are temporary in nature.
- Lack of time has been identified as another significant barrier to recording and sharing knowledge. With the core project team is likely to be dispersed at the end of the project, little time or resources are generally devoted to capturing 'what people know'. Effort is often focused on immediate deliverables (e.g., drawings, reports, calculations, the building, or facilities itself), with no emphasis on what could be done now to help future projects (Fong, 2005).
- The industry still relies on conventional techniques for KM process. Egbu and Botterill (2002) investigated the role of IT for KM in the construction industry. They found that perceptions about more conventional techniques for KM process seem unchanged. Telephone and face-to-face meeting still are the most common means to acquire and transfer knowledge.

In summary, keeping knowledge context and historical knowledge, providing social communication, and making an easy-to-use system are the main challenges that to be faced by knowledge management practitioner in the construction industry.

## **4. The research analysis on knowledge management in building and construction sector**

### **4.1. Research methodology**

The data collection was done through a survey with a questionnaire that was sent to the research participants. The sample population is composed of 32 professionals holding various roles in the construction industry. In this sample, different professionals from project managers, architect or design engineers, site engineers, quality controllers, foremen, land valuation officers, counterpart engineers contributed as they gave their feedback on the survey. The responded time of the participants was on an average of ten minutes per one survey and overall, the questions were applicable to the professional areas of the target population.

The questionnaire is composed of over 100 questions, that are subdivided into sections that provide information about the respondent's details, the knowledge at the business level, the level of knowledge and the tool processes applied in project management and of used and planned IT applications.

### **4.2. Results and discussion**

It turned out that 32 respondents answered questions, 12 (37.5%) worked in small companies (less than 50 employees), 11 (34.4%) worked in large companies (more than 250 employees) and the rest - 9 respondents (28.1%) worked for medium companies (not less than 50 employees but not more than 250 employees).

One of the questions is related to the role of the respondent in a company. 45.2% of respondents held the position of project manager, 29% of respondents held the position of architect or design engineer, 12,9% of respondents held the position of site engineer. The rest held various positions like quality controller, foreman, land valuation officer and counterpart engineer.

**Table 1.***General questions concerning knowledge management system in projects*

Ld.	Question	Realized	Planned in a longer term	Not planned at all
1.	the development of a knowledge management strategy	56,2%	31,3%	12,5%
2.	formal knowledge management procedures	42,0%	40,0%	18,0%
3.	the existence of trainings, workshops in the field of knowledge management	22,0%	63,0%	15,0%
4.	the existence and development of "communities of practice"	31,0%	38%	31,0%

Source: own elaboration.

The next question concerned the type of projects in which respondents participated. 31 respondents answered the question and the majority, 71% of respondents mainly conduct non-residential (commercial and institutional, heavy industrial) projects. 45,2% of respondents executed residential (houses, multi-unit apartments, townhouses) projects. 25,8% of respondents executed transport projects. The rest were involved in infrastructure and heavy construction projects.

The respondents' answers for general questions concerning knowledge management systems in analysed projects are given in the Table 1.

Likert's scale was used to get the feedback from respondents on knowledge processes. In table 2 the rate 5 means the highest level, the rate 1 means the lowest level and the rate 0 means the respondent didn't decide on any level.

**Table 2.***Questions concerning the process of acquiring knowledge*

Ld.	Question	Rate 0	Rate 1	Rate 2	Rate 3	Rate 4	Rate 5
1.	the acquiring knowledge from suppliers	9,7%	12,9%	9,7%	25,8%	29,0%	12,9%
2.	the acquiring knowledge from customers	9,9%	16,7%	6,7%	26,7%	26,7%	13,3%
3.	the acquiring knowledge from competitors	6,1%	19,4%	29,3%	19,4%	12,9%	12,9%
4.	the acquiring knowledge from business partners	10,0%	10,0%	13,3%	16,7%	30,0%	20,0%

Source: own elaboration.

When analyzing the usage of knowledge, it has been necessary to take a close look at the effectiveness and non-effectiveness of different technologies used in terms of management and communication of enterprise information resource. The technologies have been given to respondents in order to figure out how and to which level they were used. It is given in Table 3.

**Table 3.**

*Questions concerning different technologies/methods used in terms of management and communication in projects*

Ld.	Question	Hard to say	Definitely ineffective	Rather ineffective	Rather effective	Definitely effective
1.	Internet	3,2%	9,7%	0,0%	6,5%	80,6%
2.	Intranet	41,9%	3,2%	0,0%	32,3%	22,6%
3.	Extranet	41,9%	9,7%	6,4%	22,6%	19,4%
4.	Portals	19,4%	16,1%	12,9%	25,8%	25,8%
5.	Videoconferencing	10,0%	10,0%	10,0%	20,0%	50,0%
6.	Newsletters	25%	23,3%	12,5%	26,7%	12,5%
7.	Meetings	12,9%	3,2%	6,5%	22,6%	61,3%
8.	Data warehouses	12,9%	6,5%	9,7%	32,2%	38,7%
9.	Document management systems	9,7%	6,5%	9,7%	15,7%	58,4%
10.	Decision support systems	10,0%	3,3%	13,3%	36,7%	36,7%
11.	Group work support systems	10,0%	0,0%	10,0%	36,7%	43,3%
12.	Customer Relationship Management	40,0%	3,3%	20,0%	16,7%	20,0%
13.	ERP/MRE systems	41,4%	3,5%	6,9%	24,1%	24,1%
14.	E-learning	16,7%	6,7%	10,0%	26,6%	40,0%
15.	Content management systems	6,9%	6,9%	6,9%	31,0%	48,3%
16.	Knowledge expert localization systems	10,0%	16,7%	3,3%	33,3%	36,7%
17.	Artificial intelligence systems	10,0%	10,0%	13,3%	36,7%	30,0%
18.	Knowledge management systems	3,4%	13,3%	10,0%	40,0%	33,3%

Source: own elaboration.

The most considerable technologies in the processes of knowledge is still Internet – respondents find it effective (totally 87,1%) which delivers a wide spectrum of possible tools and solutions to implement. Highly recommended technologies (as effective) are: meetings (totally 83,9%), group work support systems (totally 80,0%), and content management systems (totally 79,3%). On the other hand, Customer Relationship Management (36,7%) and newsletters (39,2%) are treated as ineffective.

Recommendations dedicated to building and construction sector companies are as follows:

1. For companies in the building and construction industry, the adoption of an organizational-based system structure rather than project-based structure can facilitate knowledge transfer beyond the project scope and duration.
2. “Collaboration in construction” simply means that teams are working together towards one project goal. Everyone can access the main plans and goals of a project at any time, without having to rely on gatekeepers or slog to faraway offices to get the information they need.
3. Transmitting information between contractors, designers, suppliers, and stakeholders is risky business. It also results in gaps in understanding and data loss. To reduce those gaps and foster collaboration in construction, it’s important to take measured steps towards that goal, which requires usage of the right tools.
4. By using collaborative software in construction industry, construction professionals may not only benefit from the advantages of working effectively without geographic and time restriction, but also enjoy the virtual collaboration that enables them to



simulate a real social environment and promotes tacit knowledge transfer. A collaborative software could help to extract tacit knowledge, and to encourage and support people to share their tacit knowledge in construction organizations.

Knowledge management is challenging in the analyzed sector. The knowledge is crucial to avoid some pitfalls in the future executed project. What is more, collaborative tools make project processes more effective and more resistant to disturbances.

## 5. Conclusions

1. Barriers of applying knowledge management in construction industry have been identified in the research. As project teams in construction projects are often disbanded at the end of a project, the knowledge generated in a project is difficult to track after the project is accomplished.
2. Irrespective of the type of projects implemented, results show that the majority of companies have invested or are planning to invest into knowledge management tools and solutions which are important for the effective knowledge sharing and using.
3. Sources of knowledge identified for construction and building projects mainly include knowledge from suppliers, customers, and business partners.
4. The tools for acquiring tacit knowledge are mainly based on collaboration with other organizations, work placements and internships in other domestic enterprises, taking part in conferences, customer knowledge acquisition, hiring new employees with appropriate knowledge and competences training workshops teaching specific skills are highly used.
5. Results of the research have proven that in the building and construction industry the main knowledge development tools are creation of research and development initiatives, connecting different departments or people leading to the creation of new knowledge systems and new solutions, building a community of practitioners and professional networks.
6. IT applications are widely used for customer management operations (storing customer records and supporting market research), human resources management (employee's data storage, budgeting purpose and managing employees working time), management of fixed assets, logistics, orders, and service. Knowledge management processes are present, and it has been proven that the use of ICT tools is crucial for effective knowledge management in the construction and building projects.

The undertaken research was limited to projects in the construction and building sector. The respondents' answers gave important information how knowledge management is realized in analyzed sector. The future study should be deepened and focused on precisely chosen decisive factors. The research should be undertaken in a quantitative way.

However, the achieved results could be observed in other sectors with similar structure of executed projects e.g. in the logistics sector. Recommendations should be considered to emphasize the significance of team collaboration in project teams.

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## THE ANALYSIS OF ACCESSIBILITY OF TOURISM INFRASTRUCTURE IN THE CONTEXT OF X-MINUTES CITIES: A CASE STUDY OF THE CITY OF ZABRZE

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**Purpose:** The aim of the study is to examine the accessibility of selected attractions and tourist services in Zabrze, in the context of the transformed concept of a x-minute city, and to orient it towards the tourist perspective.

**Design/methodology/approach:** The goal was achieved through the analysis of urban infrastructure, publicly available maps, and software used to study the range of pedestrian traffic.

**Findings:** The potential of Zabrze to become an x-minute tourist city was identified. All necessary services are within a 15-minute reach, similar to half of the identified tourist attractions.

**Research limitations/implications:** From the perspective of tourism managers, it would be interesting to conduct an analysis of the surroundings of tourist attractions. This would allow for the identification of what tourist services are available within the x-minute radius of the facility. Research on the walkability of the area can also play a significant role.

**Originality/value:** Looking at the idea of an x-minute city from a tourist's perspective is interesting. This viewpoint can be a starting point for creating and developing tourist-friendly cities.

**Keywords:** Tourist attractions, Guido mine, Tourist infrastructure.

**Category of the paper:** Case study.

### 1. Introduction

In recent literature, increasing attention is given to the concept of x-minute cities as an approach to spatial planning (Lu, Diab, 2023). This is because cities worldwide have undergone significant transformations in recent decades, becoming more complex and dynamic places where people live, work, and spend their leisure time. In public discourse, considerable focus is placed on sustainable urban development, particularly in terms of environmental protection, the necessity of limiting human impact on the environment, expanding public

transportation, urban modernization, and energy efficiency (Augustyn, 2023). The need for an integrated approach to urban planning has also been a topic of political discussion, as seen in the informal ministerial meeting in Leipzig in the early 21st century, resulting in the Leipzig Charter on Sustainable European Cities (2007).

One theory associated with sustainable urban development proposes restricting car access to city centers in favor of pedestrian traffic (Abdelfattah et al., 2022). This is manifested in the concept of "clean air zones", where restrictions may include technical aspects of vehicles and the establishment of intermodal hubs to promote public transportation.

Implementing comprehensive environmental protection measures and thoughtful policies for sustainable development, along with a cautious approach to limiting car traffic, holds particular significance in tourist cities. Nowacki (2015) demonstrated in his research that 23.05% of individuals choose not to visit museums and paramuseal institutions due to inconvenient (difficult) access (a structural barrier). Therefore, it is important to monitor the accessibility of key services not only for residents but also for tourists. This is especially relevant for those who, being aware of the changing world and the need to care for the natural environment, opt for public transportation and walking.

This paper attempts to adapt the concept of the 15-minute city, originally focused on residents, to tourists visiting the city. The study area was the city of Zabrze, with a specific emphasis on tourist attractions, particularly those related to industrial heritage. The article aims to explore the accessibility of selected tourist attractions and services in Zabrze, within the context of the transformed concept of the 15-minute city, with a focus on the tourist perspective. To achieve this goal, the study addressed the following research questions:

1. Are the key industrial heritage tourism sites accessible on foot for a tourist arriving in the city using public transportation?
2. What tourist infrastructure is available within the x-minute radius for a tourist arriving in the city using public transportation.

The achievement of the goal began with a literature review, considering the concept of the x-minute city and identifying services crucial from the tourist's perspective.

## **2. Theoretical background**

The concept of the 15-minute city is not new (Pozoukidou, Chatziyiannaki, 2021). It is an idea based on chrono-urbanism as the foundation for a city creation model (Murgante et al., 2023). Essentially, it posits that residents should have access to urban functions (housing, healthcare, education, entertainment) crucial for improving their quality of life through active means of transportation, such as walking or cycling (Moreno et al., 2021). In its fundamental premise, it pertains to designing urban spaces in a way that essential services, amenities,

and intentional places are within a 15-minute walk or bike ride from people's residences. This concept implies a compact and well-connected urban structure where residents have easy access to their daily needs without the necessity for long commutes (Abdelfattah et al., 2022). According to Murgante et al. (2023), the 15-minute city model is based on four criteria: density, diversity, proximity, and digitization. The density criterion pertains to the optimal number of residents aimed at reducing pollution and providing services in a given area. Providing services is also associated with the proximity criterion, which involves the decentralization of services and their distribution at the neighborhood level. This especially applies to fundamental aspects of life such as housing, employment, healthcare, education, entertainment, and commerce. Digitization, on the other hand, is linked to the use of ICT (Information and Communication Technology) to optimize service delivery.

In addition to the availability of specific services, researchers emphasize the importance of the location of services (Ferrer-Ortiz et al., 2022). This is related to the concept of "Walkability", which comprises features of a place that determine whether a person is willing to engage in pedestrian activities (Southworth, 1997).

In the literature, numerous examples of services that should be considered when assessing the level and attractiveness of a city in the context of the 15-minute concept can be found. Literature analysis has identified fifteen different categories of services. These include attractions, commerce, culture, education, employment, entertainment, finance, gastronomy, healthcare, post office, public administration, public transport, recreation and sports (Graells-Garrido et al., 2021; Gaxiola-Beltrán et al., 2021; Pozoukidou, Chatziyiannaki, 2021; Weng et al., 2019; Knap et al., 2023).

The mentioned service categories focus on the needs of city residents and may not always align with the needs of tourists. Meeting the needs of tourists requires essential tourist infrastructure, considered crucial for tourism growth and destination competitiveness (Wall, 2022). A similar analysis was conducted to identify service categories necessary to meet the needs of tourists. The recognized categories include attractions, car services, commerce, culture, finance, gastronomy, healthcare, petrol stations, public transport, recreation, sports, and tourist information (Jasion, 2023, Szpilko, Ziółkowski, 2010; Widz, 2019; Wiktorówna et al., 2019; Smith, 1994; Crouch, Ritchie, 2000).

Taking into account significant services in the context of the 15-minute city and tourist needs, numerous common features have been observed, which can be used to assess the accessibility of tourist infrastructure (Fig. 1.)

Category of services to satisfy tourist needs	Category of services for both categories	Category of services in the 15-minute city concept
Accommodation	Commerce	Attractions
Car services	Culture	Education
Petrol stations	Finance	Employment
Tourist information	Gastronomy	Entertainment
	Healthcare	Post office
	Public transport	Public administration
	Recreation	
	Sports	

**Figure 1.** Category of services to satisfy tourist needs and in the 15-minute city concept.

Source: own work.

Due to the focus on pedestrian movement, identified services related to car servicing and petrol stations were excluded from further analysis.

In the literature, it is also noted that the concept of the 15-minute city is merely a starting point for analyzing urban spaces. This is confirmed by Jasion (2023), who approached the concept of the 15-minute city by using a fan (tourist) visiting a stadium as a reference point for assessing the accessibility of key tourist infrastructure.

More commonly, cities are referred to as x-minute cities (Logan et al., 2022), where x is a variable calculated based on selected criteria (Duany, Steuteville, 2021). Examples include 20-minute neighborhoods in Melbourne and Portland, the 15-minute city in Paris, or Utrecht's ambition to become a 10-minute city. Therefore, the analysis did not focus solely on the 15-minute range but also considered other time frames.

### 3. Methods

The subject of the analysis was the city of Zabrze. The research process began with identifying managed tourist attractions related to the industrial heritage of Zabrze. For this purpose, a geospatial analysis was conducted, taking into account Google Maps, the website of the Zabrze City Office, the website of the Technical Monuments of the Silesian Voivodeship, the TripAdvisor application, and the Google search engine. The identified attractions included Maciej Shaft, Guido Mine, City Museum, Water Tower, Coal Mine Museum, and three locations of Queen Luise Adit. Unmanaged monuments, such as Steel House or the Zandka and Borsigwerk post-industrial settlements, were not included in the analysis.



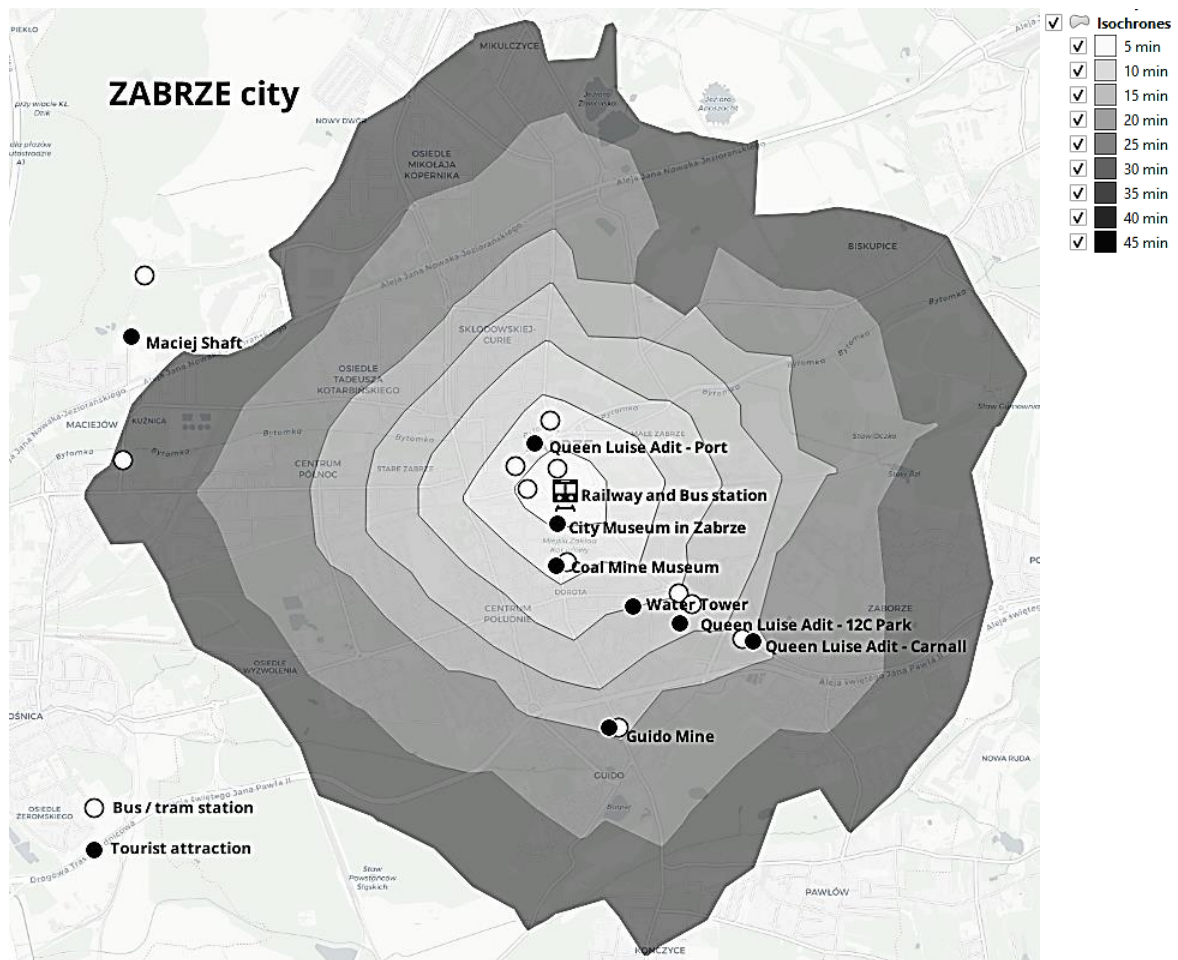
In the next stage of the research, a literature analysis was conducted to establish the essential 10 categories of services affecting residents and tourists. Subsequently, the locations of selected services and attractions were mapped. For this purpose, the QGIS application with the installed QuickMapServices and ORS Tools plugins was utilized. The railway and bus stations were then marked as the starting points to generate isochrones with a range of 5 to 45 minutes for a person traveling on foot. This allowed for addressing the research questions and achieving the research goal, which was to examine the accessibility of selected tourist attractions and services in Zabrze, within the context of the transformed concept of the 15-minute city, oriented towards the perspective of tourists.

#### 4. Results

Firstly, the industrial heritage tourist attractions were plotted on the map, and isochrones with a range from 5 to 45 minutes were delineated from the main railway and bus station. In the studied area, it can be observed that out of eight objects, seven are within the 45-minute range. The only inaccessible object is Maciej Shaft. Within a 5-minute range, the City Museum is accessible. In the 10-minute range, there are two industrial heritage tourism objects, namely Queen Luise Adit – Port and Coal Mine Museum. In the 20-minute range, there are Water Tower and Queen Luise Adit – Park, and within the 25-minute range, there are Guido Mine and Queen Luise Adit – Carnall. The map is presented in Fig. 2.

The analysis of the surroundings of attractions revealed that most objects are located along the main arteries of the city. Tourist attractions are also well-connected. The furthest distance from a public transportation stop to an attraction is in the case of Maciej Shaft, where one would need to walk approximately 680 meters, estimated to take about 7 minutes. Additional analysis showed that a tourist traveling from the railway station (PKP) to Maciej Shaft by public transport would need at least 29 minutes (source: <https://rj.metropoliaaztm.pl/>). These observations prompted the author to limit the analysis area to a 25-minute radius from the station.

During the conducted research, an analysis of the accessibility of basic tourist infrastructure for a tourist visiting the city using public transportation was also carried out. The subject of the study was the identified categories of services.



**Figure 2.** Tourist attractions of Zabrze's industrial heritage and pedestrian reach displayed using isochrones, measured from the central City Station.

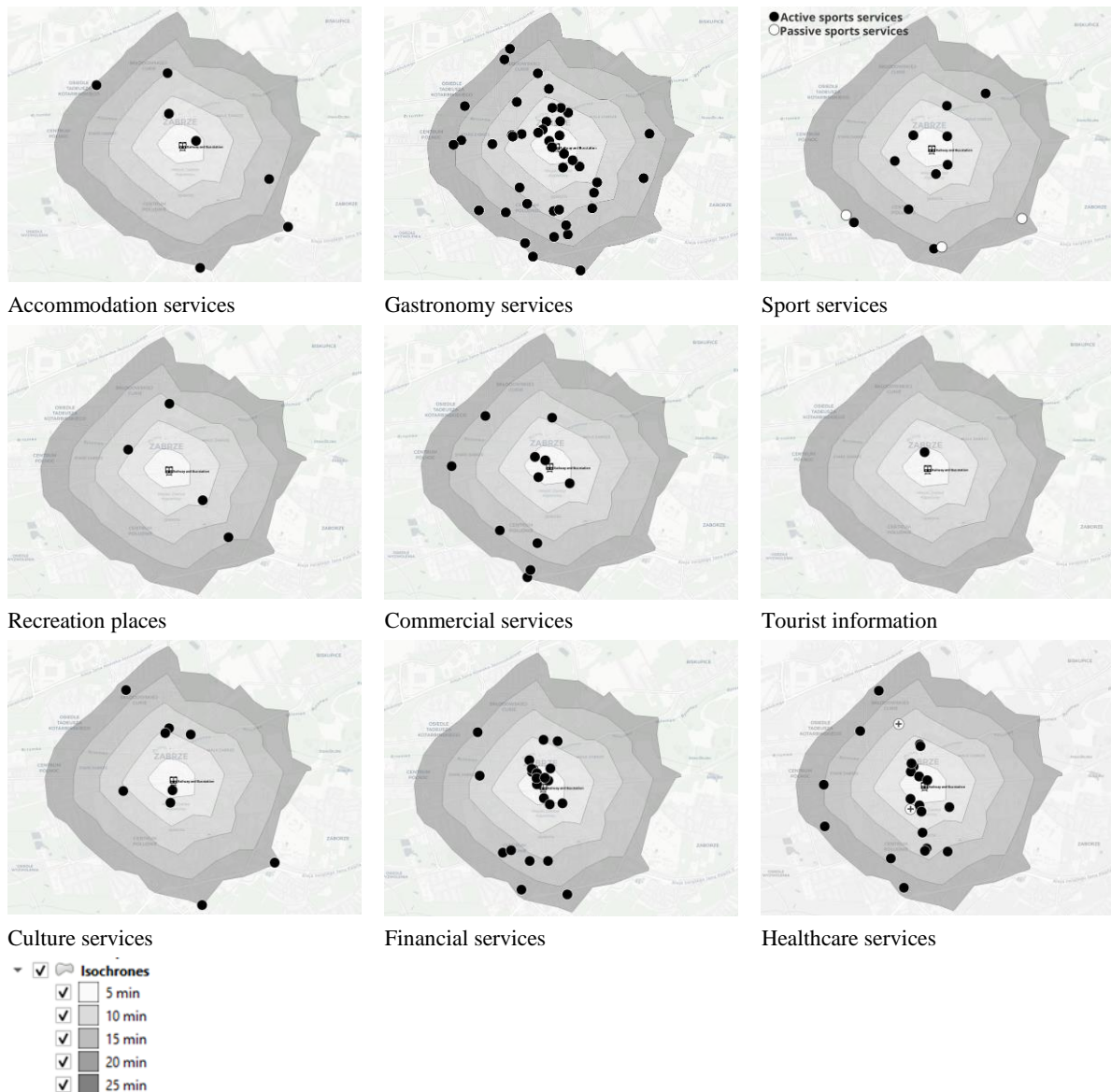
Source: own work.

In the accommodation category, the analysis revealed that there are 7 standardized accommodation facilities in the studied area. Additionally, there are also private accommodation facilities that were not considered. For the gastronomy category, 43 places were identified. A significant diversity of gastronomic facilities was observed. In the studied area, there are both restaurants and fast-food bars. It is worth noting the relatively high concentration of establishments in the eastern part of the surveyed area, which may be attributed to the lower level of industrialization in that part of the city.

In the category of sports-related services, the decision was made to divide the infrastructure into facilities offering services related to providing spaces for sports activities and services related to watching sports competitions. In the 25-minute area, 10 services for active tourists and 3 for passive tourists were identified.

Regarding recreation available in the studied area, there are four zones. These include city parks and one managed facility that is part of an industrial heritage attraction – Park 12C. A significant portion of the infrastructure consists of commercial establishments. It should be noted that, apart from shops near tourist attractions, there are no shops exclusively for visitors.

The entire offer is primarily oriented towards residents. The analysis was limited to large retail stores for map clarity, and 11 such stores were identified.



**Figure 3.** Identified services categorized.

Source: own work.

In the analyzed area, there is only one tourist information point. However, it is good practice for all tourist facilities to provide support to tourists as much as possible. Another aspect examined was cultural facilities. Among the 9 identified facilities are a theater, cinemas, music venues, and cultural centers. As many as 7 of them are accessible within a 15-minute distance from the city center. Regarding financial services, both banking institutions and ATMs were taken into account. 23 units were identified, with most of them located in the city center.

The last examined aspect was access to healthcare services. A total of 23 healthcare facilities were identified, including 21 pharmacies and two hospitals.

The conducted analysis allowed answering the research questions. It was observed that although the main industrial heritage tourist attractions are concentrated in the central part of the city, only four out of eight attractions are accessible within 15 minutes from the central station. The next 3 are within the 25-minute range, and one is beyond the 45-minute range.

Examining the accessibility of infrastructure beyond recreational aspects, all identified services are available within a 5-minute range. As the isochrone range expands, there is an increasing variety of services.

These observations indicate a significant potential for the city of Zabrze to become an x-minute tourist city. However, determining the extent to which it is one requires further, more detailed research.

## 5. Discussion and summary

While the concept of the 15-minute city has been recognized as a fundamental tool in designing healthier and more sustainable urban spaces (Allam et al., 2022), it is seldom applied to existing cities. More often, though not always consciously, the ideas embedded in this concept are utilized to redesign already existing cities, especially through the revitalization of public spaces. An example is the demolition of a road to expose the Cheonggyecheon River in Seoul (Kim, Jung, 2019). This intervention, primarily aimed at improving environmental quality, also enhanced the public space, making it more appealing to residents. Similar actions are taken by the authorities in Utrecht, transforming a road in the city center into a canal (Stolk, 2022), simultaneously restoring the historical character of the area.

Simply examining whether services are available for residents or, as in the case of this analysis, for tourists, is not sufficient to classify a city as a 15-minute city. The crucial factor is whether a tourist decides to cover the required distance on foot. In this context, the concept of walkability is also significant. Although this term is primarily associated with city planning and the public health field, it can have considerable importance in other research areas as well. According to Spoon (2005), walkability at its basic level simply means an area that promotes walking.

There are numerous variables that determine whether a given area is pedestrian-friendly (Southworth, 1997; Shriver, 1997), as well as methods and approaches for measuring pedestrian-friendliness (Manzoli et al., 2021; Taleai, Amiri, 2017). Distefano et al. (2023), in their research, list 25 factors conducive to walkability. These include, among others, the quality of pedestrian pathways, the sense of safety, travel comfort, and aesthetic perception of the surroundings. Generally, the criteria for assessing pedestrian-friendliness encompass usability, safety, comfort, and attractiveness (Abdelfattah et al., 2022).

In conclusion, despite the research indicating that essential services for tourists are available within a 15-minute radius, the decision of whether a tourist will choose pedestrian activities requires further investigation into walkability. Undoubtedly, the local government plays a significant role in shaping the city's image. Whether the city will strive to be recognized as an x-minute city or not depends on its capabilities and willingness.

Looking at the concept of the x-minute city from a tourist's perspective and their needs can serve as a starting point for creating and developing tourist cities, especially considering that significant service infrastructure related to tourism largely overlaps with the essential infrastructure associated with the concept of 15-minute cities. Actions taken to improve the accessibility of services in one group would contribute to improving the accessibility of services in the other group.

Based on the conducted analysis, new research areas have also been identified. Undoubtedly, managers in the tourism industry would find it interesting to conduct an analysis of the surroundings of tourist attractions and examine what tourist services are available within the x-minute range from the object. Research on the walkability of the area could also play a significant role. As mentioned earlier, the availability of a service within walking distance does not guarantee that pedestrians will choose to walk. Identifying weaknesses and opportunities could certainly influence the improvement of walkability and bring the city closer to the principles of x-minute cities.

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## CSR ACTIVITIES CONSISTENT WITH CLUSTER MANAGEMENT STANDARDS

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**Purpose:** The utilitarian purpose of this article is to identify the links between cluster management standards and CSR areas and verification of compliance with CSR standards and areas based on quantitative data. The cluster management standards developed by PARP<sup>1</sup> and the CSR areas identified in ISO 26000 were used to achieve this goal.

**Design/methodology/approach:** Taking into account the description of the fulfillment of cluster management standards and the essence of each area of social responsibility, the mapping method arbitrarily assigned the fulfillment of a given cluster management standard to CSR areas.

**Findings:** The study reveals a notably high level of compliance among surveyed clusters with social responsibility standards, averaging 90% across seven CSR areas. Labor practices and community involvement and development received the highest scores at 96%, followed by consumer issues at 92%. Human rights and the environment each achieved commendable scores of 89%. Organizational governance and fair organizational practices scored 88% and 83%, respectively. These findings indicate that the surveyed clusters are actively engaged in socially responsible activities, as scores exceeded 80% in each CSR area. Additionally, the verification of PARP cluster management standards demonstrated a positive assessment for standard 3.5.1 (Corporate Social Responsibility) in 89% of clusters, affirming a growing commitment to CSR-related initiatives.

**Originality/value:** The primary value of this text lies in addressing a significant research gap concerning the intersection of CSR and economic clusters. The authors emphasize the limited attention given to the concept of CSR within the context of clusters in the existing literature. The originality of the text is evident in its focus on the emerging field of CSR within clusters, identifying critical aspects such as trust, cooperation, competitiveness, sustainability, eco-innovation, openness, knowledge, and new value creation. The text positions itself as a pioneering effort to bridge this gap by proposing a quantitative analysis of CSR activities aligned with cluster management standards. This approach not only contributes to the understanding of CSR in a unique context but also offers a practical framework for assessing compliance with CSR standards within clusters.

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<sup>1</sup> The Polish Agency for Enterprise Development (pl. PARP - Polska Agencja Rozwoju Przedsiębiorczości).

**Keywords:** cluster management standards, Corporate Social Responsibility, CSR activities, industrial cluster.

**Category of the paper:** research paper.

## 1. Introduction

With the development of the market and globalization, the approach to the role of business in society has changed. Organizations have become more aware that taking care of high quality products or services is no longer enough (Oliński, 2019). It has become a necessity to take actions related to with concern for the environment, relations with the local community or employees themselves (Knop, 2013). The creation of a new quality that takes into account the expectations of not only individuals, but all stakeholders, is becoming a requirement. Over the past few decades, the idea of corporate social responsibility (CSR) has evolved a great deal, and interest in the subject is now growing. The understanding of CSR and how it is implemented varies from country to country and from time to time, as different business environments have determined the pace of development of the concept. In fact, CSR is represented as an umbrella term covering a diverse range of issues, the importance of which for business performance at the global level continues to grow. In line with the concept of CSR, companies are changing their traditional economic goals, also focusing on environmental, social and ethical issues and aligning their mission, vision and strategy.

Today, no economic entity functions in complete isolation from other entities (Olko, 2017). The specific nature of economic processes means that they must enter into continuous formal or less formal relationships with other entities, institutions or organizations in vertical or horizontal arrangements (Skawińska, Zalewski, 2009). On the basis of these relationships it is possible to diagnose the forms of cooperation between enterprises. The degree of intensity of these relationships is particularly important when operating in specialized sector concentrations or agglomerations (Knop, Olko, 2008). In this context, particularly important in the last twenty years has become the concept of clusters. They are a form of self-organization of economic activities of independent, but interrelated, forming more or less spatially concentrated economic systems (Zaleśna, Predygier, 2021). The essence of the existence of clusters is to stimulate cooperation between entities operating within the cluster and the development of innovation processes, which is a new way of thinking of creating competitiveness of enterprises.

Cluster policy in the EU has been developing for almost 20 years. It now focuses not only on creating clusters, but also on improving those that are globally competitive and impact national economies. In 2008. The European Commission proposed the World Class Cluster concept to strengthen global competitiveness through better cluster policies, greater transnational cooperation and the integration of innovative SMEs into clusters (European



Commission, 2008). Strong clusters can develop into world-class innovation and business centers, based on high-quality R&D and education systems (Europa InterCluster, 2010) with active market and technology leaders (Ahlqvist, 2014). These clusters focus on integrating with global business, fostering new technologies and creating new industries (Büscher, Schierenbeck, 2012), which contributes to the development of regions and increases the competitiveness of companies, also bringing higher returns to investors (Meier zu Köcker et al., 2010).

Excellence in cluster management is a key element of European cluster programs. The introduction of the European Cluster Excellence Initiative (ECEI) and the quality label system further underscores this. With EU funding, quality labeling according to ECEI standards can support cluster managers in developing better cluster services, improving branding strategies and facilitating the acquisition of financing. This also improves methods of benchmarking, monitoring and impact evaluation (Christensen et al., 2012). The development of world-class clusters encompasses management across multiple levels, from policy to the actual functioning of clusters (Bialic-Davendra, 2011). The European Cluster Analysis Secretariat (ESCA) introduced cluster benchmarking as an effective tool for assessing potential and providing strategic suggestions for their development (European Secretariat for Cluster Analysis, 21.12.2023). Management quality is determined through three quality labels: bronze, silver, and gold certificates, awarded after comparative analysis of structures, processes, products, and services. Benchmarking serves the purpose of learning from better-performing clusters or entities to enhance one's own structures, processes, products, and services. This certification system is recognized throughout Europe as a credible standard for cluster management (Młodzianowski, Rostek, 2017). The benchmarking process involves a conversation with the cluster coordinator, focusing on 28 indicators divided into four main groups: structure, management and strategy, services and activities, achievements and distinctions.

The Polish Agency for Enterprise Development (PARP), which focuses on cluster development in Poland, conducted research leading to the formulation and publication of cluster management standards in 2014. These standards delineate the desired characteristics for managing and operating cluster coordinators. The aim of publishing these standards is to elevate the quality of cluster management and provide interested parties with tools for diagnosing cluster management processes, identifying shortcomings, and enabling corrective actions. These developed standards also aim to professionalize the role of cluster coordinators, enhancing their prestige and credibility within the environment (Bembenek, 2016). The research resulted in identifying five main areas: organization, resources, processes, services for cluster members, and collaboration with the environment. Within these areas, there are sub-areas (a total of 19), each assigned specific standards (36 standards in total) (Piotrowski, 2014).

The relevance of addressing the topic of social responsibility in clusters firstly stems from the research gap that exists in the literature. In the literature, researchers have been dealing with the concept of CSR in relation to clusters for a relatively short time. As the bibliometric analysis of the two areas has shown, not many works related to social responsibility in clusters have been produced so far. No publication on socially responsible activities in the context of clusters has been reported in the Web of Science and Scopus databases. The concept of CSR takes into account society's expectations of businesses in economic, legal, ethical and philanthropic aspects. CSR is also responsible for the behavior of those who cooperate with an enterprise, so it can be analyzed in relation to clusters and cluster members. In analyzing these two areas, it is important to note several aspects that, according to the authors, link the issues of clusters and CSR. These include trust, cooperation, competitiveness, sustainability, eco-innovation, openness, knowledge and new value creation. Thus, it becomes important to study CSR activities in line with cluster management standards and verification of compliance with CSR standards and areas based on quantitative data, which is the main objective of this article.

## 2. Methods

To achieve the main objective of this article, the cluster management standards developed by PARP and the CSR areas indicated in the ISO 26000 standard were used. The last verification of the cluster management standards was carried out in 2016 on a sample of 64 clusters (Buczyńska, Frączek, Kryjom, 2016). The sample for the study was selected based on criteria such as regional diversity of clusters, number of cluster entities, year of cluster formation, participation in projects, sectoral diversity of the cluster (Frączek, Kryjom, 2016). Evaluation of the degree of fulfillment of individual standards was carried out during a meeting at the cluster's headquarters, with the participation of an external expert and at least two cluster representatives, i.e. the cluster coordinator and cluster members. The assessment was conducted on the basis of the coordinator's self-evaluation tool and had a zero-one character ("meets" or "does not meet" a given standard). Depending on the stage of development of a given cluster (embryonic, development, maturity), the standards were either mandatory or optional. A positive assessment of the fulfillment of cluster management standards depended on the final assessment of all mandatory standards for a given phase of cluster development. After each completed meeting, the verification expert filled out a meeting information sheet, which served as a carrier of information about the course and results of the meeting. This card also formed the basis for the analysis on the basis of which the cluster management standards verification report was prepared. It is worth noting, that clusters that obtained the status of a KKK<sup>2</sup> did not

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<sup>2</sup> National Key Cluster – KKK (pl. KKK – Krajowy Klaster Kluczowy).



Cont. table 1.

2. Resources	2.1. Financial resources	2.1.1. Financial plan								
		2.1.2. A sustainable source of financing for the cluster								
		2.1.3. Transparency of financial operations and compliance with the financial plan					X			1
	2.2. Infrastructure	2.2.1. Permanent access to a separate office space			X					1
		2.2.2. Availability of laboratory/ research infrastructure for cluster members								
	2.3. Human resources and information	2.3.1. Human resources at the coordinator's disposal								
		2.3.2. The coordinator has an up-to-date database of identified resources and competences in the cluster	X							1
		2.3.3. The coordinator actively improves his skills and related competencies with cluster management			X					1
	3. Processes	3.1. Marketing and PR	3.1.1. Common visual identification system					X		1
3.1.2. The coordinator initiates and supports fair and exhibition activities										
3.2. Internal communication		3.2.1. Use of various tools and forms of communication								
		3.2.2. Taking actions to integrate members			X				X	2
		3.2.3. Established thematic and/or working groups								



Cont. table 1.

5. Cooperation with the surround- ings	5.1. Cooperation with local government units	5.1.1. Coordinator cooperates in a lasting way with local government units							X	1
	5.2. Cooperation with scientific units and business environment institutions	5.2.1. Coordinator cooperates in a lasting way with scientific units							X	1
	5.3. Cooperation with other cluster coordinators	5.3.1. Coordinator cooperates in a lasting way with coordinators their clusters							X	1
	5.4. Cluster recognition and achievements	5.4.1. Presence in media								
5.4.2. Recognition of the cluster by organizations creating cluster policy										
SUM			9	1	6	1	3	2	8	

Source: Own study.

According to Table 1, 22 of the 36 cluster management standards were identified, which, according to the authors, are related to the areas of social responsibility. Taking into account the 5 main areas of the analyzed standards, from the area of organization, all 6 standards were selected as related to CSR. In sub-area 1.1. organizational basis of operation, four standards were selected. Three of them, i.e. the defined responsibilities and improvements of the coordinator, the organizational structure of the cluster, and the coordinator has an up-to-date database of cluster members were assigned to the CSR organizational governance area. The fourth standard, prevention of conflicts of interest in the cluster, was assigned to organizational integrity practices. On the other hand, from the sub-area of operating strategy, two standards were indicated, i.e. the current cluster development strategy and the coordinator's activities are in line with the provisions of the cluster's founding documents and the current strategy, which were combined with the organizational governance area.

In the area of resources there are three sub-areas. The first is financial resources, of which only one standard - transparency of financial operations and compliance with the plan, which was linked to fair organizational practices. The second sub-area is infrastructure, where also only one standard - permanent access to office space - was found to be socially responsible (labor practices area). The last sub-area is human and information resources, from which two standards corresponding to CSR areas were identified. Item 2.3.2. the coordinator has an up-to-date database of identified resources and competencies in the cluster, which was linked to the area of organizational governance, and standard 2.3.3. the coordinator actively improves his skills and competencies - the area of labor practices of the field of work.

The third area is processes, which consists of five sub-areas. The first is marketing and PR, which identifies standard 3.1.1. common corporate identity system as meeting CSR area six. The second sub-area is internal communications, which also identified only one standard - taking action to integrate members. This standard was the first to qualify for two CSR areas, i.e. labor practices and community involvement and development. In sub-area three (cluster development), all standards were counted as those that correspond to the selected areas of social responsibility. Standard 3.3.1. conducting monitoring and evaluation of activities in the implementation of the strategy and 3.3.3. the coordinator has a quality management system in place were counted as an area of organizational governance, while the standard conducting activities to attract new cluster members is the seventh CSR area. No standard was identified in sub-area 3.4 R&D activities. Sub-area 3.5. principle of sustainable development, in which there is only one standard, Corporate Social Responsibility, became key in the analysis. Due to the convergence of the objectives of this standard and the analysis carried out, standard 3.5.1 was the only one assigned to all CSR areas.

In the fourth area of services to cluster members, there are 7 standards, 3 of them are assigned to two areas of social responsibility. The first 4.2.1. supporting cluster members in existing value chains (sub-area market activity) is the last CSR area, as is the standard. Standard 4.4.1. the coordinator conducts activities to develop the skills and knowledge of its members is an area of labor practices. The last standard is 4.3.1. the coordinator conducts activities in the area of networking and matchmaking, which was linked to both of the above CSR areas.

The last area assigned by PARP is cooperation with the environment, in which 3 standards were selected. All of them were assigned to the last CSR area - social engagement and community development. These standards include: 5.1.1. the coordinator Permanently cooperates with local government units, 5.2.1. coordinator sustainably cooperates with scientific units, 5.3.1. the coordinator sustainably cooperates with coordinators of other clusters.

Summarizing the data in Table 1, only 3 standards were included in more than one area of CSR. Standard 3.5.1. covers all areas of social responsibility, standard 3.2.2. taking action to integrate members - the area of labor practices and social engagement, standard 4.3.1. the coordinator conducts activities in the area of networking and matchmaking, the same two areas of CSR. On the other hand, analyzing the CSR areas, the highest number of standards concerned organizational governance (9 standards) and the area of social involvement and community development (8 standards). A minimum of one standard was assigned to each of the seven CSR areas. The areas with the least number of standards included human rights and the environment. Two standards were assigned to the area of consumer issues, and three standards to fair organizational practices. The last area is labor practices, with the number of six standards. The above analysis showed that it is possible to match cluster management standards with areas of social responsibility.

Based on the results of the survey of the fulfillment of cluster management standards developed by PARP and the links indicated in Table 1, the fulfillment of the extracted standards was compared with the CSR areas. Table 2 presents the percentage score for each standard, a score of 100% means the fulfillment of a given cluster management standard in all 64 clusters. Figure 1 presents the percentage summary results of the level of fulfillment of cluster management standards assigned to CSR area.

**Table 2.**

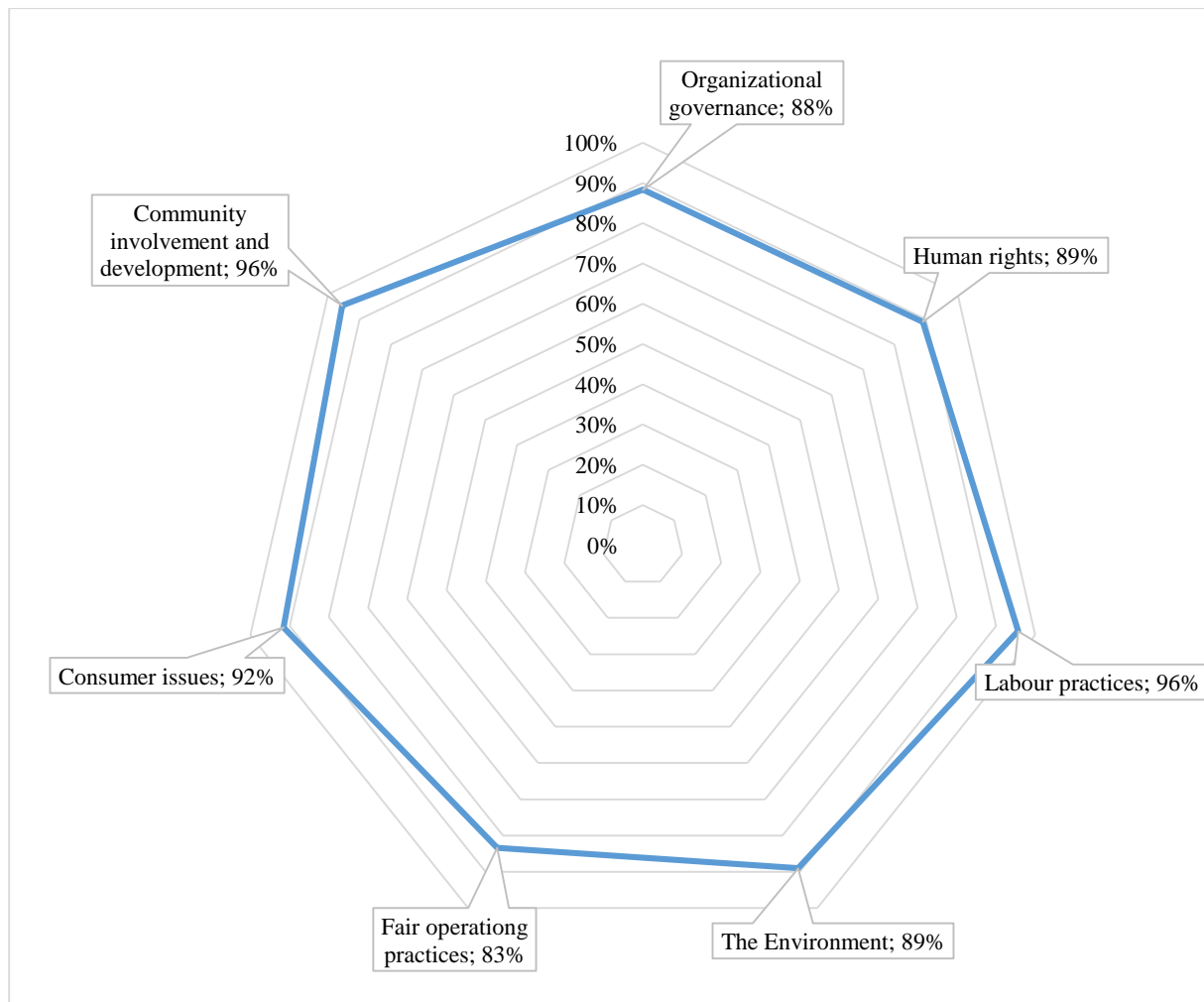
*Verification of fulfillment of CSR areas resulting from cluster management standards*

Cluster management standards			CSR areas						
			Organizational governance	Human rights	Labour practices	The Environment	Fair operating practices	Consumer issues	Community involvement and development
1. Organization	1.1. Organizational basis of operation	1.1.1. Defined scope of responsibilities and powers of the coordinator	98%						
		1.1.2. Organizational structure of the cluster	98%						
		1.1.3. The coordinator has an up-to-date database of cluster members	95%						
		1.1.4. Preventing conflicts of interest in the cluster					92%		
	1.2. Action strategy	1.2.1. Current cluster development strategy	83%						
		1.2.2. The coordinator's activity is consistent with the provisions of the documents establishing the cluster and with the current strategy	94%						
2. Resources	2.1. Financial resources	2.1.3. Transparency of financial operations and compliance with the financial plan					69%		
	2.2. Infrastructure	2.2.1. Permanent access to a separate office space			98%				
	2.3. Human resources and information	2.3.2. The coordinator has an up-to-date database of identified resources and competences in the cluster	89%						
		2.3.3. The coordinator actively improves his skills and related competencies with cluster management				95%			



Cont. table 2.

3. Processes	3.1. Marketing and PR	3.1.1. Common visual identification system						94%		
	3.2. Internal communication	3.2.2. Taking actions to integrate members			100%				100%	
	3.3. Cluster development	3.3.1. Conducting monitoring and evaluation of activities in the implementation of the strategy		75%						
		3.3.2. Conducting activities aimed at acquiring new cluster members								97%
		3.3.3. The coordinator has an implemented quality management system		73%						
3.5. The principle of sustainable development	3.5.1. Corporate Social Responsibility (CSR)		89%	89%	89%	89%	89%	89%	89%	
4. Services for cluster members	4.2. Market activity	4.2.1. Supporting cluster members in terms of existing value chains							97%	
	4.3. Exchange of experiences and networking /matchmaking	4.3.1. The coordinator conducts the activities in the area of networking and matchmaking				94%			94%	
	4.4. Human resources development	4.4.1. The coordinator conducts activities to develop the skills and knowledge of its members				98%				
5. Cooperation with the surroundings	5.1. Cooperation with local government units	5.1.1. Coordinator cooperates in a lasting way with local government units							95%	
	5.2. Cooperation with scientific units and business environment institutions	5.2.1. Coordinator cooperates in a lasting way with scientific units							97%	
	5.3. Cooperation with other cluster coordinators	5.3.1. Coordinator cooperates in a lasting way with coordinators other clusters							95%	
<b>AVERAGE</b>			<b>88%</b>	<b>89%</b>	<b>96%</b>	<b>89%</b>	<b>83%</b>	<b>92%</b>	<b>96%</b>	



**Figure 1.** Level of fulfillment of cluster management standards assigned to CSR areas

Source: Own study.

The overall level of compliance of the cluster's management standards with the areas of social responsibility is very high. The average for all seven CSR areas is 90%. The highest score of 96% was given to two areas, namely labor practices and community involvement and development. Another area with a very high score was consumer issues, with 92%. This was followed by the areas of human rights and the environment, each receiving 89%. The lowest scores were recorded for the areas of organizational governance - 88% and fair organizational practices - 83%. Thus, it can be concluded that the surveyed clusters are socially responsible. In each of the seven CSR areas, the score was above 80%, indicating that clusters are highly engaged in socially responsible activities. Moreover, verification of the fulfillment of PARP cluster management standards showed, that standard 3.5.1 Corporate Social Responsibility was positively assessed for 57 clusters, which is 89% of the surveyed clusters. This result also confirms that clusters are increasingly and willingly undertaking activities related to CSR areas. The above analysis allowed us to achieve the main objective of this article which was to identify the links between cluster management standards and CSR areas, and to verify the fulfillment of CSR standards and areas based on quantitative data.

#### 4. Conclusion and discussion

Clusters, in order to reap the benefits of cooperation, must trust their partners. This approach allows for synergies and the creation of new value. One of the benefits of clusters is the promotion of regional development and the building of a competitive advantage for businesses. Buoyant development of the business sector means increasing employment, decreasing unemployment and, consequently, higher wages for residents, which realizes the goal of regional development. On the other hand, cluster development can support the implementation of the principle of sustainable development at the regional level. Clusters also contribute to the development of local labor markets, they take care of the development of the local community which, according to the authors, coincides with the areas of CSR. Factors conducive to the implementation of CSR concepts in the cluster include building the cluster brand, gaining the trust of investors and the local community, as well as increasing the negotiating power of the cluster in the international arena. However, such activity may have negative consequences, such as skepticism of cluster coordinators, reluctance to cooperate in joint activities and invest in CSR, or prioritization of economic factors.

In conclusion, the analysis of cluster management standards in relation to Corporate Social Responsibility (CSR) areas reveals a substantial alignment between the two domains. A total of 22 out of the 36 identified cluster management standards are associated with CSR, distributed across seven key areas. Organizational governance emerges as the most prominent category, encompassing nine standards, followed closely by social involvement and community development with eight standards. Examining the distribution of standards within CSR areas, it is evident that labor practices and community involvement and development exhibit the highest fulfillment levels, both achieving an impressive 96%. Consumer issues closely follow with 92%, while human rights and the environment both score 89%. Organizational governance and fair organizational practices, though slightly lower, still maintain strong scores of 88% and 83%, respectively. The overall compliance of cluster management standards with CSR areas is remarkably high, averaging 90% across all seven categories. This suggests a pervasive commitment among the surveyed clusters to socially responsible practices. Notably, the analysis underscores the positive reception of standard 3.5.1 (Corporate Social Responsibility) across 89% of the surveyed clusters, indicating a growing inclination toward CSR-related activities.

In the presented cluster management standards in the paper, CSR is present as a basis outlined in strategic documents and as an applied operational practice. Also, the assessment criteria for KKK partly refer to the cluster's social actions, cooperation, and relations with the environment. It is assumed that engaging in CSR activities not only increases the cluster's recognition but also indicates its significant commitment to the issues of the local community,

that is, the environment in which the cluster operates. The conducted research allowed for determining the level of compliance with cluster management standards assigned to CSR areas.

In essence, the study successfully achieves its primary objective of establishing links between cluster management standards and CSR areas. The robust quantitative data presented in Tables 1 and 2 and Figure 1 not only highlight the convergence between these two domains but also validate the clusters' proactive engagement in socially responsible initiatives. This result confirms that Polish clusters that have met cluster management standards are increasingly and more willing to undertake activities related to CSR areas. This insight contributes to a broader understanding of the integration of CSR principles within cluster management practices, emphasizing the increasingly vital role that clusters play in fostering sustainable and socially responsible development.

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## CONDITIONS FOR THE APPLICATION OF A GENETIC ALGORITHM IN SCHEDULING PRODUCTION ORDERS IN AN INDUSTRY 4.0 ENVIRONMENT

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**Purpose:** The article is based on the premises of the R&D project "Research and Development Work on the Development and Application of a Genetic Algorithm for the Optimization of Production Management." The primary goal was to determine the conditions for the application of genetic algorithms in the scheduling of production orders in the Industry 4.0 environment.

**Design/methodology/approach:** The objectives are achieved through a comprehensive analysis of current challenges in production management, particularly in the context of Industry 4.0. The main method used is a theoretical examination of the potential applications of genetic algorithms (GAs) in optimizing production scheduling. The approach is interdisciplinary, combining insights from artificial intelligence, operations management, and industrial engineering. The paper explores both the theoretical framework and practical aspects of GAs in the production environment.

**Findings:** The paper finds that genetic algorithms can significantly enhance production scheduling in the dynamic and complex environment of Industry 4.0. GAs offer solutions for optimizing production processes, maintenance prediction, and supply chain management. It was also found that while the practical applications of GAs are still developing, they hold great potential for addressing the multifaceted challenges of modern production systems.

**Research limitations/implications:** The research is primarily theoretical, suggesting a need for empirical studies to validate the proposed applications of genetic algorithms in real-world industrial settings. Future research should focus on case studies and simulations to demonstrate the effectiveness of GAs in production scheduling.

**Practical implications:** This research highlights the potential of genetic algorithms to revolutionize production scheduling in Industry 4.0, leading to increased efficiency, reduced costs, and enhanced production flexibility. Businesses could implement GAs to optimize various aspects of production, leading to significant economic benefits.

**Social implications:** The implementation of genetic algorithms in production can influence society by potentially leading to more sustainable production practices, efficient use of resources, and reduced environmental impact. It could also set new industry standards in production management, influencing public attitudes towards technological innovation in manufacturing.

**Originality/value:** The originality of the paper lies in its comprehensive analysis of the application of genetic algorithms in the context of Industry 4.0, a relatively new and unexplored area. The paper's value is in providing a theoretical foundation for future empirical research and practical implementation, and it is addressed to academics, industry professionals, and policymakers in the field of production management.

**Keywords:** Genetic Algorithms, Industry 4.0, Production Scheduling, Optimization, Manufacturing Management.

**Category of the paper:** Theoretical Research, Applied Research.

## Introduction

The manufacturing industry has undergone dynamic changes in recent years. On one hand, the consumer market encourages manufacturers to expand their product range by introducing a growing number of small differentiators or product variables, and to seek and introduce innovative products. On the other hand, market globalization brings local companies to international markets while introducing global products and brands that compete for customers not only with product appeal but also with price. This leads to numerous changes in the management of manufacturing companies. Producers, fighting for the best material supply prices, often have to choose between quality and delivery punctuality. At the same time, all management trends are moving towards reducing inventory and associated costs. On the other side, we have the customer who expects quick turnaround times at competitive prices and immediate responses about planned delivery dates. Balancing customer interests with receiver expectations is increasingly challenging within the framework of traditional production planning due to the growing number of variables affecting production plans. The wide variety of products is associated with the need to arrange many variants of production batches, considering setup times, which in combination with logistical deadlines and production capabilities (availability of machines and personnel) expands the possibilities of arranging the production plan into countless combinations. Traditional software is unable to cope with a large number of variables and determinants in a satisfactory time. The tools used in the market for arranging production plans are so complicated or time-consuming that in case of any disturbances such as delayed material delivery, machine breakdown, or the impact of a priority order, most companies rely on the intuition of planners or production managers.



The main objective of this study is to present the concept of the use of genetic algorithms in the problems of Industry 4.0, and in particular in the processes of production planning and scheduling. Industry 4.0 encompasses technologies such as cyber-physical systems, IoT, Big Data analytics, artificial intelligence, as well as issues related to production planning and scheduling systems, including simulation, adaptive structure of the production process, and vertical and horizontal integration. Therefore, the above-mentioned issues should be taken into account in the considerations, and this in turn requires their adaptation and flexibility both in planning and in the approach to production scheduling, taking into account dynamic changes in the production process and the increased level of uncertainty.

The main research method was bibliometric analysis of scientific documents (scholarly works) related to the keywords "genetic algorithm", carried out using the lens.org service.

The considerations have led to the development of assumptions for preparing a project application titled "Research and development work concerning the development and application of a genetic algorithm to optimize production management".

## **Genetic Algorithms**

Genetic algorithms (GA) are a type of optimization algorithms inspired by the process of natural selection. They are widely used in the field of artificial intelligence, particularly in machine learning and robotics, and have gained significant attention in the context of Industry 4.0. This article discusses the applications of genetic algorithms in Industry 4.0 production and how they can be used to optimize industrial processes. One of the main applications of genetic algorithms in Industry 4.0, as mentioned earlier, is the optimization of production processes. GAs can be used to find optimal parameters for a given process, such as temperature or pressure, by evaluating a set of potential solutions. This allows for more efficient and economical production, as the process can be adjusted to reduce waste and increase efficiency. Additionally, GAs can be used for product or component design optimization, leading to more efficient and economical production. Another application of genetic algorithms in Industry 4.0 is predictive maintenance. GAs can be used to analyze historical data and predict when a machine or component is most likely to fail. This allows for proactive maintenance, reducing downtime and increasing efficiency. GAs can also be used to optimize maintenance schedules, ensuring that resources are allocated in the most effective way. Additionally, GAs can be used to optimize supply chain management. By analyzing historical data and current market conditions, GAs can be used to optimize inventory levels, transportation routes, and production schedules. This can lead to significant cost savings and more efficient product delivery to customers (Hu, Feng, 2018; Hwa, Yan, Chao, 2020; Sun, Chen, Zhou, 2020). Genetic algorithms have many applications in Industry 4.0, including optimizing production

processes, predictive maintenance, and supply chain management. They offer a powerful tool for optimizing industrial processes and improving efficiency, leading to cost savings and increased productivity.

## Genetic Algorithms in Literature

A bibliometric analysis of scholarly works related to the keywords "genetic algorithm", conducted using the lens.org service, indicates that the first publications on this topic appeared in the 1970s. A total of over 320,000 publications on this topic have been indexed on lens.org since 1966. A significant increase in the number of publications, and thus in the interest of researchers in the topic of genetic algorithms, occurred in the 1990s, with a peak in 2015, in which nearly 25,000 publications on genetic algorithms were published. The analysis of patents for the keywords "genetic algorithm" conducted using lens.org indicates a steady and dynamic increase in patent activity in this field. However, it should be noted that the patenting of computer programs is only possible in American jurisdiction. Of the over 46,000 documents (patent applications and patents), more than half (27,000) are American documents. The systematic increase in the number of patents compared to the stable situation related to scholarly publications means that genetic algorithms are currently in the phase of implementing practical solutions in various fields of activity. The applied solution will essentially be a hybrid genetic algorithm (HGA), i.e., one that uses local search procedures within the obtained generation of solutions. The literature describes various problems with the application of hybrid genetic algorithms, e.g.: flow shop scheduling problem, job shop scheduling problem, the problem of assigning limited work resources to task implementation, project implementation problems under limited resource conditions (Vallsa et al., 2008), problems in medical diagnostics of diseases (e.g., markers and other methods of searching large sets of medical data). The total number of scholarly publications for the keywords "hybrid genetic algorithm" indexed on lens.org is 5,671. In terms of patents, lens.org for the keywords "hybrid genetic algorithm" indicates only 7 documents (5 applications and 2 obtained patents):

1. Application of Cost Constraints in Event Scheduling (application).
2. Genetic Severity Markers in Multiple Sclerosis (USPTO application).
3. Genetic Severity Markers in Multiple Sclerosis (WIPO application).
4. Systems and Methods for Predicting Repair Outcomes in Genetic Engineering (WIPO application).
5. Application of Cost Constraints in Event Scheduling (USPTO granted rights).
6. Genetic Severity Markers in Multiple Sclerosis (Australian application).
7. Genetic Severity Markers in Multiple Sclerosis (EPC granted rights).

The above summary indicates a limited (so far) nature of practical applications. Noteworthy is the only patent in the above set related to the problem of event scheduling.

## **Division of Basic Production Scheduling Problems**

Production planning in systems: The job shop problem, flow shop problem, and open shop problem are examples of optimization problems in industry and production. These problems involve determining the order and timing of tasks or operations, aiming to minimize production time, reduce costs, and increase efficiency.

In the job shop scheduling problem, a set of tasks must be processed on a set of machines, with each task requiring a specific sequence of operations on different machines. The goal is to minimize the total time, i.e., the time needed to complete all tasks. This problem is NP-hard, meaning that finding an optimal solution requires exponential time. Various algorithms have been proposed to solve this problem, including genetic algorithms, simulated annealing, and ant colony optimization (Baker, 1974; Das, Mohapatra, 2001).

In the flow shop scheduling problem, a set of tasks must be processed on a set of machines in a fixed order, with each task requiring the same sequence of operations on all machines. The goal is to minimize the total time, similar to the job shop scheduling problem. This problem is also NP-hard, and various algorithms have been proposed for its solution, including dynamic programming, genetic algorithms, and simulated annealing (Elmaghraby, 1975; Panwalkar, Sarin, 1984).

In the open shop scheduling problem, a set of tasks must be processed on a set of machines, with each task requiring a specific sequence of operations on any machine. Unlike the job shop and flow shop scheduling problems, the sequence of operations for each task can be different on each machine. The goal is again to minimize the total time. This problem is also NP-hard, and various algorithms have been proposed for its solution, including branch and bound, simulated annealing, and genetic algorithms (Adams, Balas, 1984; Pinedo, 2012).

Among the mentioned problems, the flow shop (flow-shop) is one of the basic problems in production scheduling. As mentioned, this problem is related to the order of jobs ( $n$ ) on machines ( $m$ ). Searching for solutions to this issue can be divided into permutation problems with a solution space of  $n!$  and non-permutation flow-shop problems with a solution space of  $n!(m-1)$ . In both cases, solving this problem is classified as an NP-hard task as mentioned earlier. The space of possible solutions from which any could be the optimal solution dramatically increases with the size of the task. Beyond a certain configuration, searching all permutations becomes utilitarianly inefficient.

## **Industry 4.0 and Challenges in Planning and Scheduling Production**

Industry 4.0 can be understood as the comprehensive digitalization and interconnection of production and logistical processes covering the entire product life cycle, from product and service design, customer order handling, product manufacturing, delivery to the point of consumption, to post-sales service, including activities within reverse logistics (Stawiarska et al., 2021). In such a case, Industry 4.0 is based on three main pillars: digitalization of the product offering (including service offerings), introduction of innovative digital business models, and digitalization and increased vertical and horizontal integration of value chains (Matussek, 2021).

### **Cyber-Physical Systems (CPS)**

CPS is defined as the integration of physical elements of the production process (such as machines, robots, people), capable of collaboration (including machine-to-machine and human-robot collaboration), along with integrated sensors and monitoring instrumentation, which collect data about the state and processes generated during task processing (Frank et al., 2019). The use of data collection systems or monitoring technologies goes hand in hand with the need for a system capable of processing a large number of events and capable of efficient analysis of large amounts of data (Friedemann et al., 2016). As the effectiveness of environmental monitoring increases, so does the number of sensors in the production process, and thus the requirements related to the ability to process collected data increase. From a scheduling perspective, this creates conditions for their development towards real-time and reactive scheduling (Lai et al., 2018; Zhang et al., 2018). At the same time, some authors (e.g., Nahhas et al., 2018) emphasize the need to consider decision-making at the tactical and strategic levels, which should also be included in the real-time scheduling process. In such cases, they encompass a wide range of decisions from automatic planning of maintenance activities to reactive adjustment of the schedule in response to unforeseen events (e.g., sudden, urgent customer orders or unpredictable delays in material deliveries, machine breakdowns). As a result, increased flexibility in a greater number of organizational dimensions is expected, strengthening the vertical integration of machines and production processes. The need for flexibility is not only a result of a broader scope and newly available information. It also arises from the "proactive" feature of devices, which involves their autonomous decisions concerning, for example, the order of operations to be included in schedules based on data collected from other devices and the environment (Uhlemann et al., 2017). Current machines, in most cases, can only receive commands and react to them, while CPS should be able to actively suggest task distribution and adjust operation parameters to maximize productivity, task completion time, etc. (Lee et al., 2013).

However, already known applications of intelligent algorithms capable of learning show some limitations in handling unexpected events, preventing their widespread implementation in industry (Bagheri et al., 2015). This translates to another, already evolving direction in scheduling methods, referring to the fact that a large amount of significant information, combined with new interactions between machines and people, generates a series of new constraints that must be taken into account during the scheduling process (Lödding et al., 2010). In other words, task and resource management will need to consider various trade-offs, taking into account these new interactions of collaborating units (i.e., people and machines) (Klement et al., 2017; Benkamoun et al., 2015). This imposes the necessity to consider new objective functions and/or appropriate constraints to ensure the smooth flow of orders in the production process. One of the important constraints arises from the technological limitations of intelligent sensors and monitoring technologies (sometimes the reliable functionality of these systems is disturbed in many cases due to environmental conditions, such as the presence of water or large quantities of metal devices (Huang et al., 2011).

In such a situation, planning under uncertainty and dealing with missing data will most likely become a key issue in schedule building (Fu et al., 2018; Guendouz et al., 2017; Huang et al., 2011). While many scheduling methods are effective in the case of known parameters of the production system, in practice it is not always possible to definitively determine its state. Since even humans have difficulty making decisions with incomplete information, scheduling should include mechanisms/rules capable of considering such situations, which will ultimately contribute to improved decision-maker support (Azman et al., 2020).

### **Internet of Things (IoT)**

The Internet of Things (IoT) is understood as physical objects (or groups of such objects) equipped with sensors, capable of processing information, software, and other technologies, which connect and exchange data with other devices and systems via the Internet or other communication networks (Stawiarska et al., 2021). It is noteworthy that devices do not have to be connected to the public Internet, it is sufficient that they are connected to a network and are uniquely (individually) identified. In this sense, IoT not only connects partners, competitors, and customers, but also production process units (e.g., machines and employees) and decision-makers. IoT enables the functioning of so-called product-service systems (Matusek, 2023), in which customers are in constant contact with manufacturers and suppliers through networks (e.g., the Internet), placing orders and providing feedback, which ultimately facilitates mass customization of products (Matusek, 2023; Kerin, Pham, 2019). For this reason, product-service systems have been included in the scope of IoT, thus renamed the Internet of Things and Services (IoT&S). Mass customization requires flexible scheduling capabilities. Hence, it is necessary to enable the adaptation of schedules to different product portfolios, as well as enabling continuous reactive corrections to adapt to sudden changes in demand or urgent orders. Considering the complexity of these requirements, research related to

decentralization, and in particular to autonomous decision-making, is considered a key means to solve scheduling problems, providing decision-makers and production process units with information that allows them to autonomously make their own decisions (Rüßmann et al., 2015; Brettel et al., 2017). In such an environment, it is natural that scheduling concepts guaranteeing the greatest flexibility will gain an advantage over others, i.e., conventional or predictive ones (Hsu et al., 2011).

### **Vertical and Horizontal Integration**

Vertical integration of partners and suppliers in the supply chain means that scheduling is also directly related to the increase in significant and immediately available information, but this time concerning products, demand, payment terms, or availability/delays in resource availability. Mass customization intensifies these phenomena (Erol, Sihni, 2017). This can prevent problems associated with traditional, centralized scheduling, which is rarely up-to-date after considering occurring deviations. Such a situation usually results in high inventory levels or carrying out non-value-adding activities, as components and raw materials are delivered too early or too late (Brettel et al., 2017). Additionally, this large amount of information and data, which becomes available as a result of vertical integration, creates opportunities for the application of big data technologies (Matusek, 2023; Lee et al., 2013). Big data collected from production processes, exploration of such data, and then transforming it into useful knowledge can be useful in supporting the adaptability of plans and schedules.

On the other hand, horizontal integration refers to the connectivity between all elements that make up the product life cycle in an organization through the close inclusion of activities in marketing, design, engineering, production, and sales, along with the activities of other companies in a horizontal arrangement. Ultimately, this transforms the production process into a dynamic market of customers, where resources are combined between companies and configured to execute various product variants. Consequently, this translates into dynamic scheduling (Karnik et al., 2022). Both horizontal and vertical integration involves collecting as much available information as possible, which can be used to improve the quality of schedules. In this case, this information can be targeted at increasing the accuracy and reliability of schedules, as they also consider issues such as delivery delays (i.e., of raw materials, components) or variability in supply and demand.

### **Adaptive Production Process Structure and Simulations**

The dimension of "simulation", as proposed by Rüßmann et al. (2015) in the context of Industry 4.0, can be incorporated into a broader concept, i.e., Adaptive Manufacturing. Along with the digitalization process (digital twin), it can be used for analyzing various scenarios and the impact of events on the production process and for decentralized decision-making. While CPS primarily concerns the physical elements of the production process and the

associated sensors and monitoring instrumentation, Adaptive Manufacturing pertains to the virtual counterpart of these physical resources, whose behavior is modeled using simulation systems based on data collected from the process monitoring system (Nahhas et al., 2018).

A major identified limitation of the adaptive structure of the production process is the difficulty in optimizing in environments of such high complexity while considering a large amount of available data. This is related to the challenges of expanding the optimization system to include the ability to decompose scheduling problems. The success of optimization, in this case, largely depends on the ability to decompose a large problem into subproblems while achieving a solution close to the global optimum (Mönch et al., 2011). This idea leads to adopting a decentralized approach to decision-making, both at the strategic and operational levels. A decentralized approach would provide an environment for autonomous decision-making, directly controlled by elements of the production process instead of a centralized controlling unit. This increases the flexibility and agility of production. The level of decentralization can vary, starting from partial processing of collected data by sensor-equipped machines. In this case, only a small portion of pre-processed data remains accessible to the central controlling unit and/or other devices (a solution known as Fog or Edge Computing). Ending with the full processing and interpretation of all collected data by the local devices themselves (Mo et al., 2019). Such an approach allows for the use of decision rules that require less computing power and data processing time. Thus, optimal decisions are limited to the local scope of the device's actions, increasing the schedule's resilience to disturbances (Rawat et al., 2017). However, the evolution of scheduling towards decentralized and autonomous decision-making leads to a situation where global optimization solutions become a complex issue (Zhang et al., 2019). If each resource makes its own decisions based on local data, increased effort is required for their coordination, as each tries to achieve its own goals, which may not necessarily be aimed at the global optimization of the system. Therefore, for a decentralized scheduling system to be effective, it is necessary to align the goals of individual units, allowing them to collectively achieve the goal of the production system.

In summary, to fully utilize the potential of Industry 4.0 technologies, production planning and scheduling software must utilize the vast amount of data generated in the production process, easily integrate, leverage new technologies supported by Industry 4.0, and automatically adapt to the continuous changes occurring in the production process. The complexity of production systems continues to grow with the pace of implementing new technologies and the new possibilities they bring for manufacturers (e.g., mass customization of products, change in business models). This requires the construction of schedules with a high degree of adaptability, flexibility, reconfigurability, and resilience to an increased level of uncertainty.

## **Key Considerations for Implementing Genetic Algorithms in Industry 4.0 Production**

The application of genetic algorithms for scheduling production orders in an Industry 4.0 environment involves various considerations that need to be taken into account to effectively utilize the potential of this technology. Among the key considerations highlighted in this article are:

- Complexity of the production environment, indicating that Industry 4.0 is characterized by complexity stemming from the integration of cyber-physical systems, IoT, Big Data, AI, and other technologies. Therefore, genetic algorithms must be capable of processing and analyzing large amounts of data for effective management of complex production processes.
- Flexibility and scalability of algorithms, suggesting that GAs should be adaptable to dynamic changes in production, enabling quick reconfigurations in response to changing market conditions, consumer demand, and resource availability.
- Integration with existing production and IT systems, requiring compatibility and the ability to cooperate with various technological platforms.
- Data management and privacy, meaning that in the context of Industry 4.0, where huge amounts of data are collected, it is essential to ensure data security and protection, as well as proper data management for the effective use of genetic algorithms.
- Consideration of human and organizational factors, as besides technological aspects, it is important that the implementation of genetic algorithms takes into account factors such as employee training, technology acceptance by staff, and changes in organizational structure.
- Resilience to disruptions, indicating that systems using genetic algorithms should be properly designed to be resistant to hardware failures, delivery delays, or sudden changes in orders.

Furthermore, other important considerations for implementing genetic algorithms for scheduling production orders in an Industry 4.0 environment include:

1. Before full implementation, genetic algorithms require detailed testing and optimization to ensure they are effective and efficient in solving real-world production problems.
2. Genetic algorithms should support decision-making processes at various management levels, providing decision-makers with necessary information for making informed and efficient operational and strategic decisions.
3. Implementing genetic algorithms requires an innovative approach and readiness to adapt new technologies, which may necessitate a change in organizational culture and approach to innovation.



4. The Industry 4.0 production environment is dynamic and continuously evolving, so genetic algorithms must be regularly evaluated and improved to keep up with changing needs and trends.

Considering these conditions, the implementation of GAs requires addressing the following issues:

- Whether the implemented solution complies with regulations, referring to the specificities of industrial sectors, which have various regulations regarding quality, safety, and environmental protection that must be considered in the planning process?
- Whether employees in the enterprise have the necessary skills to work with advanced IT tools, as well as the ability to interpret results generated by the algorithm?
- Whether employees and management are open to implementing new technologies and the changes these technologies bring to production processes?
- How to ensure data security and privacy, meaning that robust security measures must be implemented to protect production and personal data from unauthorized access and cyber attacks?
- How to consider ethical and social aspects of using GAs, as the implementation of advanced technologies like genetic algorithms can raise concerns about the impact on employment and the role of workers in an automated environment?

## Summary

The article presents the complex conditions for the application of genetic algorithms in scheduling manufacturing orders in the context of Industry 4.0. The changing dynamics of the manufacturing industry, characterized by an increasing assortment diversity, require manufacturers to adapt to rapid changes, maintain flexibility, and be efficient in production. In such an environment, traditional production planning methods are not sufficiently effective, especially in the face of an increased number of variables affecting the production process.

Genetic algorithms, inspired by natural selection processes, have the potential to optimize production processes in the context of Industry 4.0. These algorithms are used to solve optimization problems in industry, especially in production scheduling, which is related to the aim of minimizing production time and costs while increasing efficiency.

The steadily growing number of patents related to genetic algorithms, particularly in the American jurisdiction, indicates their practical applications and commercial significance. However, despite the increasing interest in genetic algorithms, the number of patents concerning hybrid genetic algorithms is relatively small, which may indicate some limitations in their practical application.

A bibliometric analysis conducted using the lens.org service showed that various forms of genetic algorithm applications are considered in the literature, including hybrid genetic algorithms that integrate local search procedures for more effective problem-solving in production. These applications can cover a wide range of issues, from optimizing production processes to more complex issues such as task and resource management in the context of new interactions between machines and people.

The context of Industry 4.0, encompassing technologies such as cyber-physical systems, IoT, Big Data analytics, artificial intelligence, and others, sets new requirements for scheduling systems. This requires adaptation and flexibility both in planning and in the approach to production scheduling, taking into account dynamic changes in the production process and increased levels of uncertainty.

Genetic algorithms, with their ability to work efficiently in complex and dynamically changing environments, seem to be an effective tool in developing new scheduling methods in Industry 4.0. Their application can help address challenges associated with mass product personalization, vertical and horizontal integration of supply chains, and the need to quickly respond to changing market and production conditions.

In conclusion, genetic algorithms have great potential in contributing to more effective and flexible management of production processes in the era of Industry 4.0, which can lead to better efficiency, reduced costs, and increased productivity. However, there is still a need for further research and development to fully utilize their potential in practice. Therefore, the considerations presented in this article served to develop the assumptions of a project application titled "Research and development work on the development and application of a genetic algorithm to optimize production management". This application has been approved for implementation in the years 2021-2023.

Nevertheless, it is worth pointing out the numerous conditions for the application of the genetic algorithm to schedule manufacturing orders in the Industry 4.0 environment to effectively utilize the potential of this technology. The article highlights the complexity of the production environment, the flexibility and scalability of algorithms, integration with existing production and IT systems, data and privacy management, consideration of human and organizational factors, and resilience to disruptions.

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## MODERN METHODS OF PRODUCT DELIVERY – ACCEPTANCE OF INNOVATIONS AMONG KEP INDUSTRY CUSTOMERS

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**Purpose:** The primary aim of this investigation is to scrutinize the level of acceptance of novel parcel delivery methods, inclusive of parcel machines, drones, autonomous cars, and delivery robots, within the specific socio-economic context of Poland. This inquiry is specifically directed toward individuals actively involved in online retail transactions and the utilization of online food ordering applications.

**Design/methodology/approach:** A survey was conducted among people actively using online stores regarding modern methods of delivery of purchased products, 140 respondents were surveyed in two main age groups: young consumers up to 35 years of age and a group of older consumers over 35 years of age.

**Findings:** The pivotal findings from the surveys underscore that the reluctance to embrace new delivery solutions primarily affects respondents aged 35 and above. Additionally, this demographic highlighted numerous inconveniences and concerns associated with the delivery process. A proper communication scheme is advisable for that group to embrace the innovations.

**Research limitations/implications:** A conspicuous imperative arises for the extension of research endeavors to encompass the entirety of the Polish population. Heretofore, the conducted research has predominantly focused on diverse nations, encompassing various European countries. Presented in the paper analysis, conducted on a selectively chosen cohort expressly for this investigation, thereby underscores the inapplicability of its findings to the broader societal milieu.

**Practical implications:** The conducted research holds the potential to influence the breadth and preparedness of consumers for the introduction of innovative methods in product delivery. A comprehensive comprehension of concerns and limitations stands to facilitate the formulation of pertinent information campaigns tailored to address these aspects effectively.

**Originality/value:** Until now, there has been limited research in Poland regarding the acceptance of modern methods in product delivery.

**Keywords:** consumer acceptance, technological innovation acceptance, parcel machine, delivery robots.

**Category of the paper:** research paper.

## 1. Introduction

The Courier, Express, and Parcel industries are undergoing continuous development, marked by not only escalating volumes and market expansion but also technological advancements. A growing interest is observed in the extensive adoption of automation and robotization within the realm of parcel delivery. Mechanization, automation, and robotization are manifesting not only in the transportation of parcels but also in their accurate identification (utilizing barcodes, multi-dimensional QR codes, or RFID) and sorting processes employing automated systems in parcel sorting centers of courier companies or post offices. In recent years, systems facilitating the automatic delivery of parcels through the use of parcel machines have been developed.

Companies serving the courier industry are testing or already using robots to deliver orders to customers. They do this mainly to automate the final part of the delivery process or reduce last-mile costs. It may also result from the desire to stand out from the competition. Companies showing interest in delivery robots include Amazon, Postmates, FedEx, and Starship Technologies. Drones are a special case of testing and very preliminary use. Amazon plans to equip courier cars with drones that would deliver parcels by taking off from the courier's car. Thanks to this, it could reduce the number of kilometers to be covered during the last mile stage. After delivering the order, the drone would return to the car (Tarkowska, Bolisęga, 2020). The drone could carry a parcel weighing up to 2.5 kilograms over a distance of 16 kilometers (Remiszewska, Czubaszek, 2021).

The objective of this paper is to investigate the degree of acceptance for innovative parcel delivery methods, encompassing parcel machines, drones, autonomous cars, and delivery robots, within the context of Poland. This examination is targeted at individuals actively engaged in online shopping and utilizing online food ordering applications. Specifically, the research seeks to gain insights into consumer opinions regarding the perceived advantages, disadvantages, and challenges associated with these emerging delivery modalities.

## 2. Consumer attitude towards modern forms of delivery

Consumers'/end-users attitudes towards forms of delivery are important to consider while introducing to the market new solutions in last-mile logistics. Their acceptance is crucial in innovation development.

The shift in acceptance of contemporary solutions has become evident in the post-COVID-19 era, particularly in recommendations advocating reduced interpersonal contact and the maintenance of physical distance. This extends to the domain of contactless parcel



deliveries. Studies by Pani et al. (2020), Yuen et al. (2022), and Buldeo Rai et al. (2022) have highlighted that the unique circumstances of the pandemic have significantly impacted consumers' perceptions. It has increased their awareness of the associated risks with traditional parcel deliveries involving direct contact with couriers. This elevated awareness has further reinforced attitudes toward prioritizing health and safety, consequently fostering an increased acceptance of deliveries in an impersonal format.

Extensive scholarly investigations have scrutinized contemporary delivery methodologies, with a notable emphasis on the meticulous examination of parcel lockers. Numerous studies have investigated models of operating those solutions by Orenstein et al. (2019) usability by Lemke et al. (2016), costs and location by van Duin et al. (2020) consumers intentions were analyzed by Yuen et al. (2019). Sustainability and environmental issues concerning last-mile were raised by Liu et al. (2017), and Ramirez-Villamil et al. (2022), that topic was mentioned in most of the previously mentioned above.

Autonomous delivery systems like robots and cars are challenging issues in city logistics Bachofner et al. (2022), accessibility in cities was studied by Plank et al. (2022), acceptance was investigated by Romanjuk (2020), Yuen et al. (2022), acceptance in public space by Rasouli and Tsotsos (2020). The literature review revealed a small share of research on the acceptance of innovative solutions in the field of last-mile logistics, especially in different age groups.

### **3. Research method and respondents characteristics**

This research, conducted in September 2023, employed a survey methodology to assess the attitudes and preferences of e-commerce users towards delivery robots and parcel machines. The questionnaire titled "Acceptance of innovative forms of goods delivery among e-shop users" was distributed to respondents through online platforms. The deliberate selection of participants yielded two distinct age groups: 70 individuals aged 18-35 and 70 individuals aged above 35. All participants were identified as active users of online retail platforms or food ordering applications, having utilized courier services for the delivery of purchased goods or parcel machines. The characteristics of the respondents are presented in table 1.

The questionnaire, comprising 20 inquiries of varied nature, focused on exploring diverse facets of respondents' perspectives. In the subsequent analysis presented herein, emphasis is placed on four specific questions of the acceptance of delivery robots, drones, autonomous cars, and parcel machines, elucidation of associated advantages and disadvantages/obstacles of these delivery modalities.

**Table 1.**  
*Characteristics of the respondents*

Category	Description of the characteristics	Number of indications	Percentage
Gendre	Woman	89	63.6%
	Man	50	35.7%
	Other	1	0.7%
Age	18-25	40	28.6%
	26-35	30	21.4%
	35-50	42	30.0%
	51-69	25	17.9%
	70 and more	3	2.1%
Dwelling-place	Village	29	20.7%
	City up to 200 thousand residents thirty	35	25.0%
	City with over 200,000 inhabitants residents	76	54.3%

Source: Own study.

The majority of women participated in the study, the share of men was approximately 36%. Respondents were stratified based on their age, and subsequent analyses were conducted concerning two distinct age cohorts: individuals aged up to 35 years and those surpassing this age threshold. Delving into the specifics of the age distribution, the preeminent demographic comprised respondents within the 35 to 50 years age bracket, constituting 30% of the participant pool. Following closely, individuals aged between 18 and 25 years represented a substantial proportion, amounting to nearly 29%. An effort was made to ensure respondent diversity, as evidenced by the inclusion of participants aged over 70, albeit constituting a modest 2% of the overall population surveyed.

The purchasing behaviors of the deliberately selected respondents, identified as patrons of online retail establishments and food delivery applications, are delineated in Table 2. The utilization patterns of courier services and parcel machines by the respondents are also expounded upon. The dataset is stratified into two distinct cohorts, namely those below 35 years of age and those aged 35 years and above.

**Table 2.**  
*Characteristics of the respondents*

Category	Description of the characteristics	Number of total indications	Percentage	Number of indications in the group under 35 years	Percentage share in the group up to 35 years old	Number of indications in the group over 35 years of age	Percentage share in the group over 35 years old
Online shopping	E-shops and e-commerce platforms	140	100.0%	70	100.0%	70	100.0%
	Food ordering applications	85	60.7%	47	67.1%	38	54.3%
Delivery options	Courier services	105	75.0%	54	77.1%	51	72.9%
	Parcel machines	116	82.8%	69	98.6%	47	67.1%

Source: Own study.

The table presents a comprehensive overview of respondents' characteristics categorized by age, particularly emphasizing their engagement with online shopping and delivery options. The data reveals that, in the group where every respondent is involved in online shopping, the younger group is more engaged in food delivery via applications. Analyzing the used delivery options, courier services are less popular than parcel machines. In the younger group, only one respondent did not use them. In the older group, courier services were more popular than parcel machines.

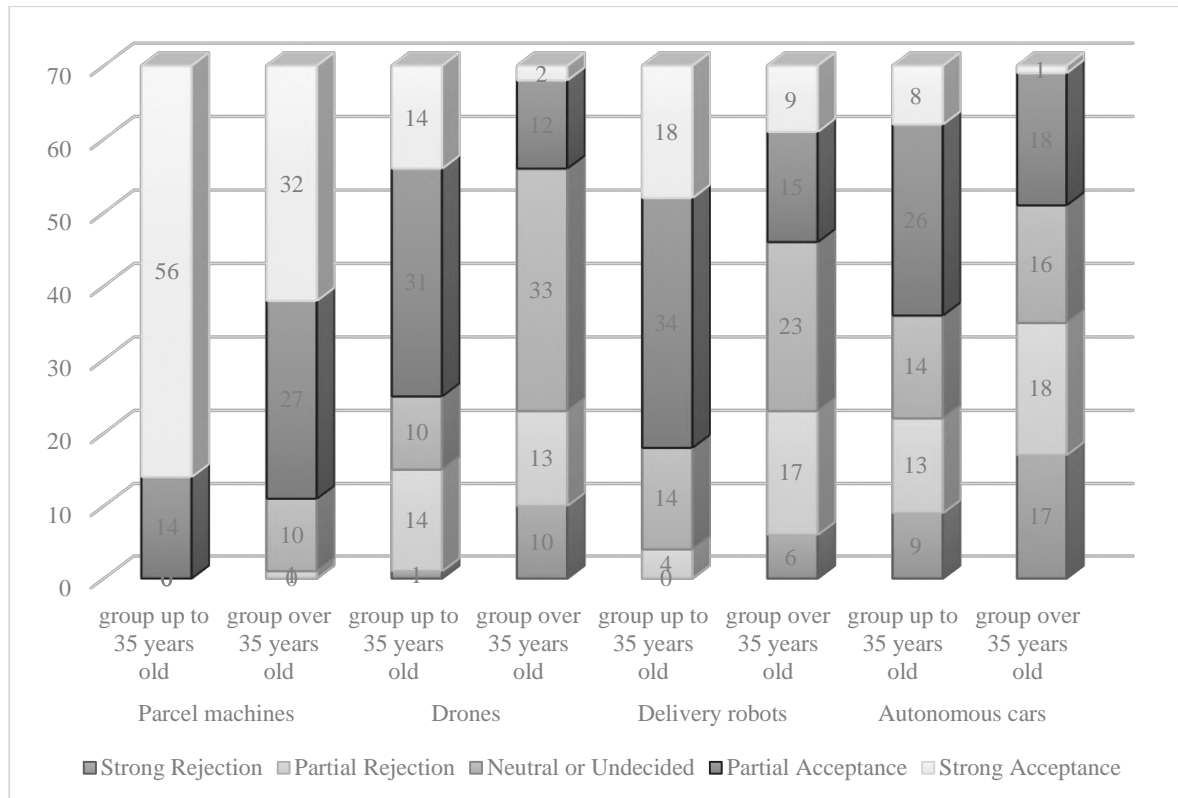
The specific selection of the group was necessitated by the imperative to investigate individuals engaged in online shopping to assess their acceptance of innovative solutions in the realm of parcel delivery, encompassing food services. One of the primary research objectives was to ascertain the willingness of respondents to utilize parcel machines, drones, autonomous cars, and delivery robots. In particular, the study sought to address the following inquiries:

1. Does the older research group exhibit significant differences in acceptance of parcel lockers, drones, autonomous cars, and delivery robots compared to the younger research group?
2. What advantages do respondents observe in employing delivery services through innovative forms of goods delivery?
3. What disadvantages and impediments do respondents identify in the proposed delivery methods?
4. Do respondents harbor the belief that delivery robots, drones, or autonomous cars can potentially supplant traditional couriers in the future?

The answers to these research questions were sought in the analysis of data obtained from respondents and the use of statistical inference.

#### **4. Respondents' attitudes towards modern methods of goods delivery**

The initial analytical inquiry pertained to the respondents' willingness to embrace specified modes of delivery. On a nominal scale, their task was to indicate to what extent they accepted the above-mentioned delivery solutions. The results divided into two age groups are presented in Fig. 1. The data presented in the figure shows responses regarding the acceptance of parcel machines, drones, delivery robots, and autonomous cars. Respondents could indicate the following answers: strong rejection, partial rejection, neutral or undecided, partial acceptance, and strong acceptance.



**Figure 1.** Innovative forms of goods delivery acceptance.

Source: Own study.

Parcel lockers, a well-known solution, were predominantly accepted by the majority of respondents, with only one person in the older group rejecting the possibility of goods delivery through this means. On the other hand, drones proved to be a less acceptable solution, with 45 individuals in the younger group and 14 individuals in the older group supporting this delivery form. Delivery robots garnered acceptance from the majority of younger individuals, while in the older group, 24 individuals expressed a willingness to use this service. Autonomous cars had 34 supporters in the younger group, with only 19 individuals in the older group accepting this solution.

To investigate whether the rejection and acceptance is independent of age, Table 3 was prepared, wherein the sums of strong rejections and partial rejection indications were combined, as well as strong agreement and partial agreement,  $\chi^2$  test value was analyzed. The results constituted an analysis of independence, testing the hypothesis regarding the relationship between the age of respondents and their response to the rejection of delivery methods. A test value less than 0.05 indicated that the answer was independent of age. The statistical analysis revealed that the rejection of the solutions was dependent on age. Acceptance was independent of age.

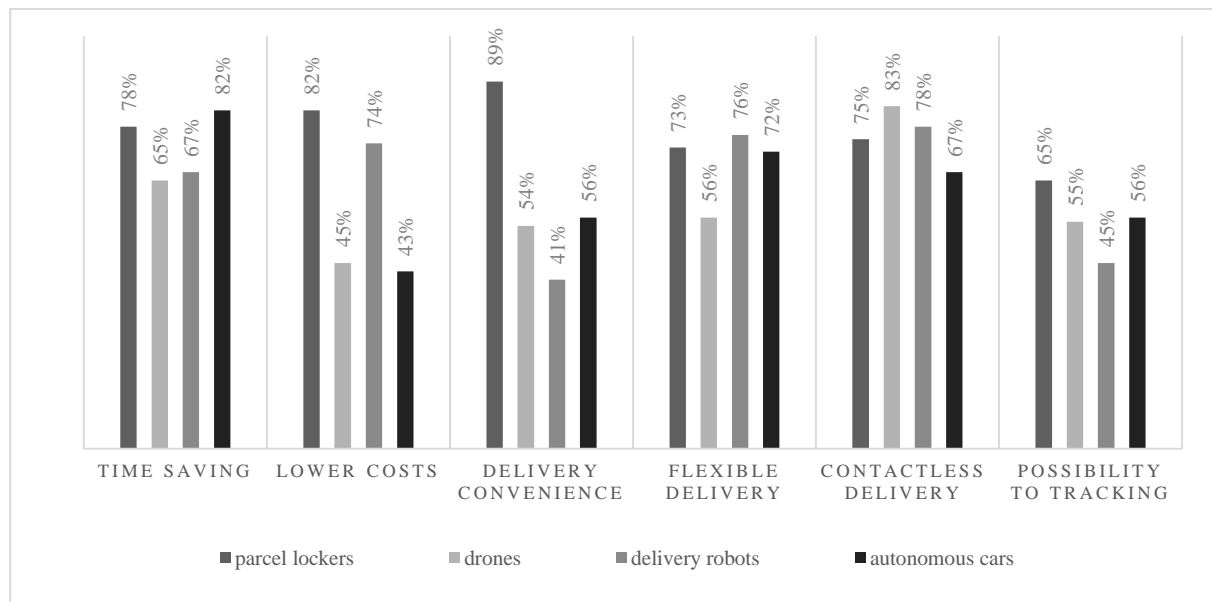
**Table 3.**

*Rejection and acceptance numbers concerning services through innovative forms of goods delivery in age groups*

Age category	Parcel lockers	Drones	Delivery robots	Autonomous cars	$\chi^2$ test value
<b>Rejection numbers</b>					
Group up to 35	0	15	4	24	0.086
Group over 35	1	23	23	35	
<b>Acceptance numbers</b>					
Group up to 35	70	45	52	34	0,021
Group over 35	59	14	24	19	

Source: Own study.

An important element of the study was the respondents' indication of the benefits they noticed from the use of modern forms of delivery. Multiple choice semi-open questions with a proposed cafeteria of answers and the option to add respondents' responses. The results are shown in Fig. 2.



**Figure 2.** Advantages identified by participants in the utilization of modern delivery methods.

Source: Own study.

Time-saving was indicated as merit most frequently for autonomous cars (82% of respondents) and parcel machines (78%). Drones and delivery robots got 65% and 67% respectively. Lower costs of delivery were indicated in parcel machines and delivery robots methods. The flexibility of delivery was indicated by 76% of respondents in robot delivery very close results also parcel locker (73%) and autonomous cars (72%). Contactless delivery (no need for interaction with other person) was prized in the result of drones (83% of respondents indicated that answer). The possibility of tracking was indicated less frequently concerning other answers but still was indicated as an advantage by 65% of analyzed persons in the opinion about parcel machines. The high percentage of responses indicates that respondents notice many benefits resulting from the use of modern delivery methods.

The next part of the study was the identification of disadvantages and impediments of novelty delivery solutions, data was collected in two age groups separately, and are presented in table 4.

Research results have revealed that the most commonly indicated disadvantage was the problem of accessibility for all locations, even in cities. This issue concerned both younger and older groups of respondents. Other noticeable inconveniences included unreliability, problems with another application necessary for operation, as well as safety concerns, and dangers to animals. There is a significant difference between the number of disadvantages indicated by younger and older respondents is statistically confirmed.

**Table 4.**

*Disadvantages and impediments of goods delivery innovative methods indicated by respondents in different age groups*

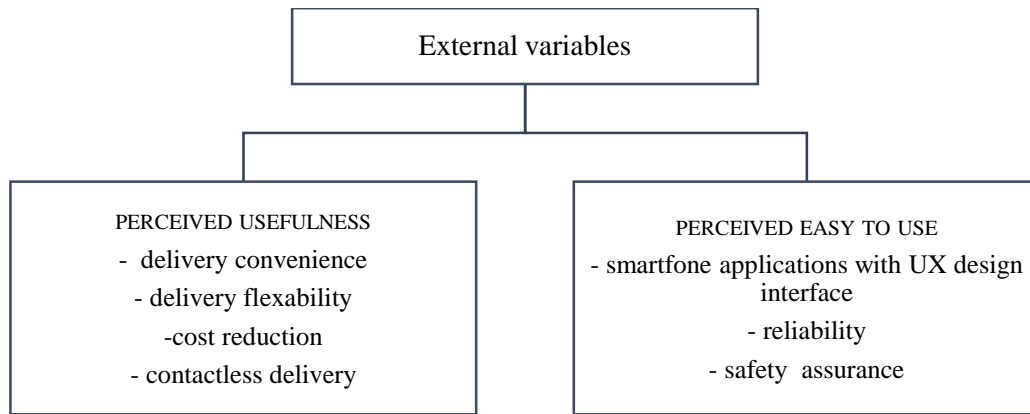
Disadvantages and impediments	Group up to 35 years old	Group over 35 years old	All participants
Unable to reach all locations	35	56	91
Unreliability, possible failures	21	52	73
The need to install the application on the smartphone	20	42	62
Safety hazards on roads and sidewalks	18	39	57
Danger to domestic and wild animals	19	28	47
Longer delivery time	12	34	46
Limiting jobs	9	33	42
Sum of indications	134	284	418
$\chi^2$ test value	0,009226		

Source: Own study.

## 5. Findings and discussion

The research results indicated a much higher percentage of young people interested in and accepting modern delivery solutions. The most important results of the surveys are the demonstration that the lack of acceptance of new delivery solutions applies mainly to respondents over 35 years of age., this group also pointed out many inconveniences and concerns related to the correct delivery process.

In research on the acceptance of technological innovation Technology Acceptance Model delivered by Davis, (1989) is useful. In that model external variables are categories in perceived usefulness and perceived ease of use, those two categories influence behavioral intention partly through attitude. Behavioral intention translates into actual system use. The results obtained and analysis allowed us to indicate important variables that might improve acceptance and influence attributes, behavioral intention, and actual system use. According to the Technology Acceptance Model (TAM) perceived usefulness and perceived ease of use based on analysis, presented on figure 3, were indicated.



**Figure 3.** TAM external variables demonstrated through research.

Source: Own study.

Concerning identified variables and results of the study the older group of users should be the one to which, information campaigns and pessimistic messages should be addressed. Since the research indicates certain inconveniences related to modern forms of delivery, mainly the doubts and beliefs related to them should be refined and clarified to attitudes and behavior change.

## Acknowledgments

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## ABOUT MANAGEMENT OF KNOWLEDGE FOR SMARTENING CITIES

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**Purpose:** The paper presents the thoughts and methodological proposals of the author, aimed at the problems of urban knowledge management and changes in the stock of such knowledge, related to the implemented activities aimed at transforming the city into a smart city. The reason for the preparation of the paper was that the author identified several gaps in the discussed research problems.

**Design/methodology/approach:** As a basis for achieving the presented objective, the article uses the concept of stakeholder and the 5W+H model to show the assumptions for the proposed method of quantifying a set of tasks related to the functioning of the urban organism and the stakeholders whose knowledge determines the feasibility of these tasks. The theoretical scope of the article includes, in addition to the above-mentioned assumptions, proposals for using matrix projection to describe the involvement of individual stakeholders in area tasks, implemented in the city.

**Findings:** The result of the research described in the article is the identification of basic and hitherto unsolved problems of urban knowledge management, such as those arising from the lack of quantitative methods for assessing the stock of knowledge. In addition, the article indicates interesting directions for further research.

**Social implications:** The considerations presented in the paper are intended to increase the quality of processes dedicated to the transforming of city organisms into forms that are more feasible for final users (for inhabitants of smartening urban areas).

**Originality/value:** The paper shows a new approach to managing resources of knowledge in the process of transforming existing urban areas into smarter ones. The paper is addressed both to stakeholders of Smartening Cities and to researchers involved in this area of problems.

**Keywords:** Smart City, stakeholder, knowledge, management.

**Category of the paper:** Research Paper.

## 1. Introduction

It is worth starting this study by noting that the idea of improving urbanized space using modern techniques and technologies has been recording its turbulent career in research and scientific studies for a relatively short time. It is only since the beginning of the current century that research on the so-called smart city (Simmie, Lever, 2002) or the e-managed urban environment (Coe et al., 2001) has gained significant momentum. The term Smart City itself is even a bit younger, and was originally associated with the search by its creator (MIT's Prof. William J. Mitchell's inaugural lecture on "Intelligent Cities" at the University of MIT. "Intelligent Cities" at the University of Catalonia, Spain, beginning of the 2007-2008 academic year, UOC Papers, e-Journal of Knowledge Society, issue 5, 2007, ISBN 1885-1541) or the creators (MIT Smart Cities group) of the analogy between the flow of information in the human body, having its origins in a set of senses treated as analogs of sensors, through the human nervous system assimilated to an information transmission network up to the central nerve center (human brain), whose counterpart in the "urban organism" would be the urban decision-making center (usually: City Hall). It should be noted, by the way, that such a concept has sometimes been criticized in the scientific debate as excessively anthropomorphizing cities (Webb, 2007). However, the author of this study believes that the critics of the approach indicated above made a rather serious mistake, understanding under the term "city" primarily the urbanized space with all its inanimate elements and seemingly forgetting about the presence of people in the city, the key element of the "urban organism." The presence of residents as an essential element of any attempt to scientifically approach the city is also the most essential element of the research, presented below.

It is worth pointing out, moreover, that in the conceptual and research work currently underway and extensively described in the available literature, the Smart City model differs significantly from the - presented above - "humanized" example of a system for data acquisition and information gathering and processing. Because of the limited volume of this study, it is impossible to point out in its content all the elements with which the original model "grew", which in turn generated the current perception of the Smart City as an urbanized space, offering residents and other people residing in this space periodically the maximum possible comfort of life (one can also talk about "quality of life" (Shaheen, Ibrahim, 2021; Pinochet et al., 2019).

As an introduction to the considerations contained in the following sections of this paper, it should still be made clear at this point that these considerations are limited only to situations where existing urban space is being or is to be transformed to achieve Smart City features (Snis et al., 2021). Earlier studies by the author of this article were also based on such an assumption (e.g. (Jonek-Kowalska, Kazmierczak, 2020; Karwot et al., 2016)). Since the scope of issues related to the widely accepted Smart City paradigm, even taking into account the limitation formulated above, is very broad, this paper is limited to the relatively narrow issue of urban

knowledge management and to transform urban space into smart space. The next section outlines the author's thoughts, as well as his original proposals, on this very issue.

## 2. Assumptions for the City Knowledge Management Model

In his earlier publication (Kazmierczak, 2024a) the author of this study proposed that in considering the knowledge of a smart city, the first and foremost thing to do was to effectively identify the needs for knowledge resources that could potentially be useful in city management (including: managing a "smart" city). The purpose of making such an assumption was a kind of limitation, and at the same time a focus of the research area described in this paper.

As for the means and ways of identifying the needs in the area under discussion, the proposal to focus on the needs of those who perform specific tasks in the city or play a role in the urban body seems quite obvious (Olson, 1976b) specific roles. In the publication cited in the previous paragraph, the author of this study proposed using - as a basis for identifying people and entities in the city that use potentially and realistically identifiable knowledge resources - the concept of "stakeholders." The most popular definition of a stakeholder, by R.E. Freeman (Freeman, Evan, 1979; Fassin, 2009) indicates that a stakeholder is any person or group that can influence or is influenced by the achievement of an organization's goals. The next section of this paper presents the city's stakeholders (including the "smart" city) in more detail.

On the other hand, for the method of identifying the above-mentioned needs and defining a set of means and ways (tools) of managing knowledge of both the already existing and created smart urbanized space, as well as managing knowledge in such, the author decided to use the fairly long-known 5W+H model (Hart, 1996), in which the background for solving a problem is described by the questions: *What, Why (why), Where, When, Who, and finally How?* For a specific research area, of course, these questions need to be clarified (developed), and the answers given to these questions make up the action plan, including research-type activities.

Let's attempt here to clarify (develop) the above questions, relating them to the problems of urban knowledge management, in particular: the city being transformed into a smart city. In particular, let's ask (Kazmierczak, 2024a):

- Q1)** What (what - resulting from the identified needs - goal) do we intend to achieve?
- Q2)** Why (why) do we think we need to achieve the identified goal?
- Q3)** Where are we going to implement the planned project?
- Q4)** When do we plan to start and complete this project?
- Q5)** Who will implement and/or participate in this project) and who will benefit from the implementation of the project discussed here?
- Q6)** How (with what means and ways) will this project be implemented?

Answering the question **Q1**, we can state that our goal is to identify, build, and utilize the body of knowledge necessary for the transformation of a selected urbanized space (city) into a smart space and, in turn, for the effective *management* of such a space. In the author's opinion, it is important in the considerations presented here to view such transformation not as a project, but as a process. The project approach seems unwarranted here insofar as activities aimed at transforming urban space into intelligent space cannot be closed in a specific time frame. After all, we are observing the constant development of all kinds of solutions, already used or possible to be used in space, defined by the term "Smart City". The assumption that the possibilities of such development will be exhausted at some point seems unlikely. Certainly, an important, perhaps crucial, aspect of the process approach (Cholewa, Kazmierczak, 1995) is the importance of the passage of time. The relevance of this aspect to considerations of transforming a city into a smart city and the knowledge assets associated with such a process will be discussed in more detail later in this paper. Let us assume here that the process of building a smart urbanized space can be viewed discretely, that is, as a series of discrete states of this process that follow one another, with a specific time step. We can, in this view, imagine the process as an "old-fashioned" movie, and the momentary state of this process as a single frame of the movie). In the study, the term "Smart City (S.C.) process" is used, for the transformation of urban space into a smart space (Smart City), precisely understood in this way. The detailed tasks carried out as part of this process can, of course, be viewed in design terms: such projects are episodes of a film in which the first frame shows the initial state and the last frame shows the assumed final state.

The answer to question **Q2** follows directly from the content of the introduction to this study: we assume that the implementation of a task falling within the S.C. process will contribute to a significant improvement in the quality of life of residents. How to assess this quality of life in such a way that it is possible to determine progress in the area under discussion remains a separate issue

The answer to question **Q3**, the question about place, the purpose of which formulated above, is that such a place is a city and a specific city at that. This statement is based on the fact that each has a unique and unrepeatable character. At the same time, however, different cities have elements of structure that are repetitive, if not identical. The author of this paper thinks that the creation of a universal methodology is currently a research task with a high degree of generality (and therefore of little practical value), it is the current state of thinking about smart urban space that makes it possible to develop more practical "area methodologies", proposing sets of tools and methods for solving the problems of the functioning of the urban organism, for example, in the field of public transport management.

Let's further assume that the answer to **Q4** is "now and in the near and distant future". The term "near future" here refers to the practice of the investment planning and implementation processes carried out by city governments. Such activities, for obvious reasons, have an identified time horizon that is not too distant from the present. The author of this study

assumes that the considerations contained herein do not refer to those elements of the process of transforming a city into a smart city (i.e., the S.C. process), the implementation of which is anticipated in the future so distant that they can be treated as elements of a futuristic nature. Of course, for such intentions, we can also look for relevant knowledge resources, but according to the author of this paper, such knowledge belongs more to newly developed research areas, such as, for example, research on the impact of innovation implementation on society (Technology Assessment - TA (Moniz, Grunwald, 2009; Kazmierczak et al., 2018).

### **3. Stakeholder identification as the basis for a city knowledge-gathering plan**

The next question is **Q5**, or "Who will implement and/or participate in the implementation of the project) and who will derive benefits from the implementation of the project discussed here?". Following the assumption outlined above, the author of this study proposes to use the concept of "stakeholder(s)" as the basis for formulating such an answer. The general concept of treating participants in urban life as stakeholders appears in quite several literature studies (Vasudavan et al., 2019; van Waart et al., 2016; Sharifi, 2020; Marrone, Hammerle, 2018), while according to the author, this approach has not yet been applied to the ownership and management of urban knowledge resources.

Let us assume as a first approximation that the undertakings discussed in this paper should involve as many participants as possible in the processes of creating and using smart urban space (Smart City), as well as all potential beneficiaries of these processes. However, the author decided to detail such an approximation by identifying and naming the group of stakeholders participating realistically or potentially in the processes of transforming urbanized space into smart space and benefiting from their effects.

It is worth noting, first of all, that not only residents should be seen as users (i.e., but stakeholders also) of the urban space being transformed into a smart one. Such space is, after all, an area of various activities of newcomers from outside the city area, who, by the way, also cannot be seen as a homogeneous group. These include, for example, people living outside the city who are associated with the education system at various levels (from kindergartens to universities), i.e. teachers and students living outside the city, people doing business in the city but living outside it, people employed in production and service companies, including, for example, stores or catering, also, people living outside the city, people visiting relatives and friends living in the city, and, finally, participants in various sports, cultural, political or religious events (Rahman, 2016; Santomil, O'Donoghue, 2016; Salam, Dasgupta, 2021; Hernafi et al., 2015). The question arises whether participants in such events, who are

not permanent residents of the city, should be treated as equal stakeholders with permanent residents in the above-mentioned processes.

The author of this study tried in his earlier work (Kazmierczak, 2024a) to justify the assumption that the main stakeholders in the process of transforming the city into a Smart City should be considered:

1. City authorities, empowered to make strategic planning and budgetary decisions, including (depending on the political and legal system at the local level in the country):
  - a. decision-making body: City Council.
  - b. executive body: the Mayor (Mayor) of the City and his deputy or deputies, together with the clerical structures that support them (City Hall).
  - c. other entities whose participation in decision-making regarding the operation of the city is conditioned by existing solutions of a legislative nature.
2. managers of entities responsible for carrying out the tasks of municipal management and other so-called own tasks of the city (for example, in Poland such a task is the organization of education at the level of kindergartens and elementary schools), as well as managers of other public facilities (such as health care facilities or facilities of a cultural and sports or recreational nature);
3. City residents, both participate in the processes in question individually and in groups through entities of a representative nature (residents' associations, NGOs, District Councils, etc.);
4. providers of technical solutions that can be used in S.C. processes (primarily, but not exclusively, solutions from the ICT area);
5. experts, supporting the activities of primarily the city government, but also stakeholders from other groups. The term "experts" is used here to describe all providers of knowledge complementing the stock of such knowledge possessed by the internal stakeholders indicated above to the extent necessary for effective city management.

We can see in this comparison that out of the five stakeholder groups listed, as many as two are individuals and entities "structurally external" to the analyzed urban body (groups (4) and (5) in the list above). In particular, it was assumed that the knowledge of stakeholders from "external" groups should fill in the gaps in the stock of knowledge remaining with internal stakeholders. Each of the above-mentioned stakeholder groups has at its disposal (potentially and realistically) a certain amount of knowledge, acquired in different ways and concerning different aspects of the functioning of "its" urban organism. The knowledge at the disposal of one stakeholder group may not be sufficient to initiate and carry out the tasks of that particular group in transforming that organism into a smart urban space. Therefore, the remainder of this paper attempts to address both the complementarity of the knowledge resources of different (groups of) stakeholders and the complementarity of such resources.



Transferring the above set of tasks to the field of research on knowledge in and about the smart city, it is necessary to reiterate the statement that the development of science and technology offers more and more opportunities to apply innovative solutions in making urban space more user-friendly (smarter?), results in the need for stakeholders of S.C. processes to keep up with such development, also in terms of managing the knowledge necessary in the performance of their tasks. Therefore, a research plan aimed at managing such a body of knowledge should consider, in addition to the need to initially identify the body of available knowledge and determine the means and ways of acquiring, collecting, and sharing it, the need to plan and organize adequate means and ways of supplementing such knowledge. As indicated above, it also seems necessary to consider the passage of time in considering the "development of the city's intelligence". The above desideratum arises, for example, from the tenure of city authorities, with quite obvious consequences in terms of possible personnel changes in city authorities. The progress of the S.C. process can also be significantly influenced by political or legislative changes happening over time, as well as - last but not least - the possibilities of financing the tasks that make up the S.C. process.

Let's now consider what kind of vision the stakeholders of the S.C. processes identified above have and/or should have.

#### **4. Knowledge resources about the city and their use in the management of municipal tasks**

Knowledge of a city includes, from the discrete view proposed here, knowledge of a set of historical states and the current state of that city. The state of a city is identified primarily by:

1. Territorial conditions, such as the location of the city (region, country, continent, climatic zone) and the specifics of the neighborhood influence these conditions, such as the way municipal tasks are carried out. Nowadays, the influence of such determinants has undoubtedly contributed to the spread of the formula of metropolises as peculiar communities of local units (municipalities/cities), established by a group of neighboring units to jointly carry out specific tasks. In the author's place of residence (the Upper Silesia region in Poland) there is a metropolitan structure (the Metropolis GZM), which unites 41 cities and municipalities with a total area of 2500 square kilometers, with a population of 2.3 million. Within the GZM, most of the cities that make up the metropolis are in contact with each other's borders, and some of these cities border only other cities (and not rural areas). Such a structure of neighborhoods caused the participants in the GZM initiative to decide to delegate to the Metropolitan Management Board to carry out its tasks of organizing public transportation in the entire area of the GZM.

2. Geographical, climatic, and geological conditions, establish the way to developing the land. We are talking, for example, about the need for specific solutions in the construction of buildings in zones where earthquakes occur or, as in the case of the GZM, ground movements caused by underground mining operations, in zones threatened by frequent river flooding, or, finally, in zones where existing and planned urban infrastructure may be threatened by the effects of other human activities, such as "acid rain" (e.g. Wei et al., 2022).
3. Urban conditions, that is, existing residential and non-residential development, green, recreational, and sports areas with their infrastructure, cultural monuments, places of religious worship, industrial areas with production facilities, etc.
4. Municipal infrastructure, i.e. road networks, bridges, and viaducts, above- and underground rail networks (streetcar, subway, railroad), electrical networks, gas pipelines, water pipelines, and sewage networks together with their instrumentation (transformer stations, switching stations, pumping stations, treatment plants).
5. The social profile of the city's residents (number of residents, age profile, education, property status).
6. other historical and cultural conditions, such as the presence among the city's residents of adherents of different religions, national minorities, or clusters of immigrants.

Such an existing reality determines - on the one hand - an identified or identifiable, to a greater or lesser extent, stock of knowledge needed in the management of "urban reality" and - on the other hand - a specific set of users, using such knowledge to different extents and in different ways. The type and scope of knowledge collected and stored by stakeholders is linked precisely to how such knowledge is used. For example, the stakeholders in the first group (city authorities) most often and most readily use knowledge based on statistical data, it is the individual city resident who is not interested in being an "average resident". The important detailed knowledge for him is knowledge of his immediate environment (family, neighbors, community) and his personal experience in functioning as a "component of the urban organism".

It seems obvious that, just as the structures of any existing and functioning urban organism are created and developed in stages, the city's intelligence is also built similarly. Since the S.C. process is multi-faceted, i.e., it involves many different aspects of the city's functioning (e.g., communications, security, waste management), the process stages oriented to these aspects may be implemented in parallel or partially overlap in time. However, it must be remembered that each such "mono-aspect goal" is part of an overarching goal: building a smart urban space. It is therefore necessary to ensure that the sub-tasks are properly coordinated. It is unacceptable, for example, that the implementation of a task from the area of implementing new transportation solutions significantly impedes the implementation of a task from the area of restructuring the power grid system (and vice versa). In addition, if we have a basis for predicting that the results of the implementation of a particular stage of the S.C. process may

change the rationale for the implementation of another "sectoral" stage, we should rather plan a serial arrangement of such stages. For example, if we make changes to the road system, it is worth waiting until the completion of the implementation of this work to take measures aimed at reorganizing the public transportation system.

Given the immense complexity of the urban organism, and therefore, as a consequence, the complexity and multiplicity of knowledge resources about such an organism, the author of this study in the paper (Kazmierczak, 2024b) proposed a method of peculiar segmentation of such a knowledge resource, conceived as a basis for creating a list of needs for the various segments of the aforementioned resource. In other words, as a first approximation, the urban knowledge resource will be treated as the sum of resources, related to the realization of individual functions of the city. A separate problem, foreseen as the subject of further research, is how to consider in knowledge management the phenomenon of redundancy of such segmented resources, as well as how to identify and describe gaps in the knowledge resources held by stakeholders. The tool proposed for describing individual segments of the knowledge resource is a matrix projection (Table 1), associating segmented knowledge resources with their gestors in the stakeholder group of the process in which such knowledge is used.

**Table 1.**

*Diagram of the matrix linking the process stakeholders (knowledge gestors) to the partial/area knowledge assets they own (in-house development)*

	Resource R <sub>1</sub>	Resource R <sub>2</sub>	Resource ...	Resource R <sub>M</sub>
<b>Internal Stakeholders (IS)</b>				
Stakeholder IS <sub>1</sub>	x	x		
Stakeholder IS <sub>2</sub>		x	x	x
Stakeholder IS...			x	
Stakeholder IS <sub>I</sub>				
<b>Stakeholders External (ES)</b>				
Stakeholder ES <sub>1</sub>			x	
Stakeholder ES <sub>2</sub>		x		x
Stakeholder ES ...			x	
Stakeholder ES <sub>J</sub>			x	

The matrix shown in Table 1 allows identifying the area knowledge resources included in this matrix of internal stakeholders (IS<sub>i</sub>;  $i = 1, \dots, I$ ; where  $I$  is the number of participating internal stakeholders) or external stakeholders (ES<sub>j</sub>;  $j = 1, \dots, J$ ; where  $J$  is the number of participating external stakeholders) in association with area knowledge resources (R<sub>m</sub>;  $k = 1, \dots, M$ ; where  $M$  is the number of considered, area-based knowledge resources of the city), which can be understood as required for the partial tasks that make up the overall activity of the city body. It also makes it possible to identify stakeholders with an area knowledge resource that allows effective participation in the implementation of a partial task requiring the use of this particular resource. In the work (Kazmierczak, 2024a) the author showed an example of the use of the matrix projection recommended here to illustrate the relationship between stakeholders and the sub-tasks that make up the management of the urban organism in general.

Let's tentatively assume that the knowledge of a particular city is the sum of the knowledge resources of stakeholders operating in that city and its environment (closer and further). Such an assumption is made quite often in studies, the authors of which propose different approaches to how to integrate knowledge. In the available literature, for example, there are works on this issue, embedded in the field of medicine, such as (Hámornik, Juhasz, 2010; Juarez et al., 2009). There have also been studies of a review nature, e.g. (Wiig et al., 1997). Quite popular in the problem area under discussion is the so-called ontological approach (Ramaprasad et al., 2017; Přibyl et al., 2020). However, in the opinion of the author of this paper, there is still no unified and methodologically consistent solution in this area. This problem is discussed in a bit more detail later in this paper.

So, let's assume that the list of sub-tasks, describing the successive columns of the matrix as in Table 1, can be treated as a component of a plan for a particular sub-task in the process of transforming a city into a smart city. Such a plan should also take into account the timeframe for the implementation of the sub-tasks in the S.C. process, as well as the order in which they are to be implemented, especially when the achievement of adequate progress of any such task conditions the possibility of starting the implementation of another or other tasks. The author of this study believes that it is precisely the problem of the passage of time that is somewhat marginalized (or even ignored) in the studies described in the available literature.

Therefore, it is necessary to go back to the one cited earlier in this paper and re-examine the importance of the passage of time in any process, not only in the S.C. process. For example, in considering the impact of the passage of time on the condition of a technical object, there is also the concept of looking at the passage of time in terms of "frames of film" (Masalimov et al., 2022; Gharib, Kovács, 2022). The current state of an object is the state belonging to a point on the timeline that we can refer to as "now". Such an approach makes it possible, in particular, to distinguish past and future times relative to the "now". In research on the possibilities of diagnosing and forecasting the state of technical objects (Cholewa et al., 1995) there also appears a concept distinguished in the real-time  $\{\mathfrak{t}\}$  domain:

- micro time  $\{\tau\}$ ,
- macro time  $\{t\}$ .

For example, macro time  $\{t\}$  describes the elapsed operation time of an object (machine, equipment) and is measured in hours, days, weeks, months, or years. In contrast, micro time  $\{\tau\}$  - figuratively speaking - describes what happens "inside a moment" of macro time (and therefore in a single "frame of film").

It seems that such an approach can also work well for the S.C. process. In this case, a moment on the macro timeline would correspond to a single task, carried out in this process. On the other hand, "inside" such a moment would be recorded the activities comprising that task and, referring to the primary focus of this study, the knowledge resources used. It would be possible to record the involvement of individual stakeholders in the S.C. process at each such moment. Finally, last but not least, considering the passage of time in knowledge management

would make it possible to control the timeliness of the knowledge resource at hand and also, use available methods (Box et al., 2013) to forecast the demand for knowledge in the S.C. process. The problems shown here the author of this paper intends to take up and develop in his further research.

Let's now return to the discussion of the detailed aspects of the proposal to use the matrix projection for knowledge management in S.C. processes. In the case when the knowledge resource of internal stakeholders is insufficient for effective implementation of the task, it is necessary to look for gestors of the required knowledge resources outside the municipal organization implementing the S.C. process. Adding such gestors in the projection as in Figure 1 will mean adding more rows to the table, labeled "external stakeholder (ES)". We will complete the matrix expansion procedure when all the area knowledge resources required in the execution of a given sub-task, which we have decided to use, have their gestor indicated in the first column of the matrix. It should also be assumed that external stakeholders can supplement knowledge in areas already "developed" by internal stakeholders.

The matrix shown in Table 1 can also provide a basis for deciding whether it is possible and reasonable to modify the plan for building a knowledge resource (e.g., for an S.C. process) in such a way that the missing elements of the resource, initially deemed necessary, may not be used at a given (e.g., initial or intermediate) stage with the assumption that they will be obtained and used, if necessary, in advance of the completion of the currently implemented or subsequent stages of the process. If the process in which both owned and acquired knowledge resources are to be used is complex and multi-threaded, it is reasonable to find a solution combining both paths indicated above for gaining access to knowledge resources. The basis for such a solution can be the ranking of the importance of needs (as, for example, in a study by (Akande et al., 2019)), to which the sub-tasks implemented within the S.C. process correspond. One can also reflect here on the multifaceted nature of individual internal stakeholders' knowledge of the city and the individual purposes for which this knowledge is acquired and collected.

A resident of the city collects specific knowledge by various means, facilitating it, for example:

1. moving around the city area using various means and ways of getting around;
2. making purchases of various types of goods;
3. successful leisure activities.

Note that the above seemingly simple purposes of using knowledge about the city show a considerable degree of internal complexity. Knowledge of how to get around the city, for example, refers not only to the use of different modes of transportation to reach a specific "destination", but also to the ability to choose the right (optimal) route to reach that destination, taking into account, for example, the time of day ("traffic jams" during peak traffic hours) or the mode of transportation used (public transportation, private car, bicycle, electric scooter or own legs). It is also the knowledge of what we can do with, for example, a private car or bicycle once we have reached our destination (the possibility of finding a parking space). Also included

in the area under discussion are the difficulties of visitors due to the existence of various types of "traps" in the road network and its signage, which the locals know and effectively, even reflexively, avoid.

Let's also note that by slightly bending the meaning of the words "getting around the city" we find a whole new area of knowledge: knowledge of effective ways to break through various administrative barriers to deal with day-to-day matters, especially administrative ones.

However, the knowledge described above is not always taken seriously by other stakeholders in the practice of urban organisms, including city authorities or entities responsible for the various sectors of the functioning of the aforementioned organisms. The problem of such inconsistency in the knowledge resources of various stakeholders has also been recognized for some time by scholars promoting - not always successfully - the implementation of public participation models in urban management (Afzalan et al., 2017; Castelnovo et al., 2016; Wilińska et al., 2012).

## **5. Selected problems of knowledge management in the process of transforming the city into a smart space**

In his earlier work (Kaźmierczak, 2024b) the author of this paper devoted a great deal of attention to both the analysis of conditions which, in matrix terms presented in Figure 1, can be described by the term "horizontal" (described by the rows of this matrix), and the analysis of selected problems, described in the columns of this matrix. In particular, these are the problems for the solution of which the "sectoral" knowledge resource held by more than one gestor of such knowledge (the sum of the knowledge resources of all or, more often, some stakeholders) is used.

However, let's consider whether and to what extent such conditions, as well as the statements made in the previous chapter about the city's knowledge resources, are relevant to the problem of creating a new quality of such an organism in the process of developing its intelligence. Such a new quality is related, among other things, to the need to answer the following questions:

- a) How will the changes in the urban body generated by the process of transformation into Smart versions translate into the management of such a changed city?
- b) How will the changes made affect the usefulness of knowledge resources held by stakeholders before the above changes began?
- c) How much of such "starter" knowledge will become useless in the new reality?

- d) What new knowledge will stakeholders acquire in the course of implementing changes in the urban body (what new knowledge will they acquire by participating in the implementation of a specific stage of the S.C. process)?
- e) Acquisition of what additional knowledge will be needed - in each stakeholder category - to "find themselves" in the new reality?

Such questions can probably be both formulated differently and multiplied, but in terms of some degree of formalization, the problem of the state of stakeholder knowledge before and after the implementation of a particular stage of the S.C. process can be presented using the following notation:

- Suppose  $R_{S,i,m}$  denotes the initial (before the start of the S.C. process step) knowledge resource of the  $i$ -th stakeholder in the  $m$ -th area knowledge resource, where:
  - $i = 1, \dots, I$ ;  $I$  - the total number of stakeholders involved in a given stage of the S.C. process.
  - $m = 1, \dots, M$ ;  $M$  - the total number of area knowledge resources, used in a given stage of the S.C. process.
- Suppose  $R_{F,i,m}$  denotes the final (after the completion of the S.C. process step) knowledge resource of the  $i$ -th stakeholder in the  $m$ -th area knowledge resource, where:
  - $i = 1, \dots, I$ ;  $I$  - the total number of stakeholders involved in a given stage of the S.C. process.
  - $m = 1, \dots, M$ ;  $M$  - the total number of area knowledge resources, used in a given stage of the S.C. process.

We should - first of all - check whether, as a result of the implementation of activities falling within the S.C. process stage, there has been an increase in the  $i$ -th stakeholder's knowledge stock in the  $m$ -th area of the city's knowledge stock (or no such increase has been recorded):

$$R_{F,i,m} > R_{S,i,m} \quad \text{true or false} \quad (1)$$

or

$$R_{F,i,m} = R_{S,i,m} \quad \text{true or false} \quad (2)$$

We can also operate with incremental notation by assuming that the change in the  $m$ -th area knowledge resource under the responsibility of the  $i$ -th stakeholder, associated with the realization of a particular stage of the S.C. process, will be described as  $\Delta R_{,i,m}$  where:

$$\Delta R_{i,m} = R_{F,i,m} - R_{S,i,m}; \Delta \geq 0 \quad (3)$$

It would be easiest if, to carry out an assessment of both the initial and final knowledge stock and changes in such a stock, it would be possible to use a uniform and widely accepted quantitative method for such assessment. Publications showing attempts at quantitative knowledge assessment are few and usually concern very specific problem areas (e.g., the work of (Chu et al., 2020) deals with knowledge of traditional Chinese medicine). Therefore, the author of this paper believes that it is reasonable to use qualitative assessments in evaluations of urban knowledge resources and the effects of transforming a city into a smart city (Chen et al., 2021). Moreover, due to the specificity of urban knowledge already pointed

out in the previous chapter of this study, the author proposes that the basis for estimates of changes in knowledge resources should be the method of self-assessment (as, for example, in (Dari et al., 2023)), carried out by the stakeholders of the S.C. process. Work and development of the method of such assessment has already been undertaken, and the results will be presented in the author's subsequent publications.

The available literature also presents examples of the implementation of the S.C. paradigm in different cities, with an emphasis on comparing the results obtained by city X with the achievements of other cities (Anthopoulos, 2017; Caird, 2018). However, one can conclude that such case descriptions tend to be geographically limited and primarily oriented toward highlighting one's achievements.

According to the author of this study, a real exchange of experience would be more useful here, which is, for example, the premise of the European Union's "European Smart Cities" initiative. The authors of the publication (Paskaleva, Cooper, 2022), ask whether this initiative will improve the lives of residents of European cities. According to the author of this paper, the above question is incorrectly formulated. The most important result of the success of this initiative can and should be the exchange of experience between different cities not so much as to the achievement of the undoubtedly overarching goal of improving the quality of life of residents, but as to the means and ways of implementing the various stages of the process of achieving the aforementioned goal in different cities. By adopting a uniform methodology for evaluating similar stages in different S.C. processes, such as the methodology proposed in this study for evaluating the incremental knowledge of stakeholders, it is possible to make it possible not only to determine whether the incremental knowledge achieved (see relationship (3) as above) is non-zero, but also to show that such an increment could be greater (more significant). This kind of research is also what the author of this publication is aiming to initiate soon.

## 6. Summary

The problems of knowing how to make urban space smarter and more livable go well beyond the issues discussed in this paper. Consider, for example, the somewhat naive concept of B. Cohen (Cohen, 2015) regarding the possibility of classifying S.C. projects due to the involvement of stakeholders in these processes. It is worth considering whether the transition from, for example, the state of Smart City 1.0 to the state of Smart City 2.0 is a leap (Heaviside leap), or whether such a change is more "stretched" over time. And if so, what model can be used to describe the transition from state A to state B (e.g., from S.C. process 1.0 to S.C. process 2.0)? Perhaps, also in this case, the basis of the model could be an assessment of the stakeholder's knowledge stock and changes in that stock. Another problem, possibly related to



urban knowledge, is the problem of leadership in the urban organism, not only at the level of the mayor and City Hall but also at other levels of leadership.

The author of this study, realizing the breadth and complexity of the issue of urban knowledge and the management of the resources of such knowledge, intends to continue his research in the area in question. However, the purpose of preparing this paper will also be achieved if any reader feels inspired by the considerations presented here.

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## DYNAMIC ABC ANALYSIS FOR ASSORTMENT MANAGEMENT IN 3PL

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**Purpose:** The purpose of this article is to present the impact of the developed dynamic ABC tool on inventory management within the operations of a third-party logistics (3PL) company.

**Design/methodology/approach:** The research focused on designing the dynamic ABC tool and subsequently using it in a case study involving 52 customers for whom a 3PL logistics operator provides services. The customers were grouped into categories such as food, nonfood, pharma, and other, and the study encompassed 10 physical depots located in Poland and the Czech Republic.

**Findings:** The implementation of the dynamic ABC tool will influence the inventory management of the 3PL company. Furthermore, the dynamic ABC tool performs similarly under various conditions for different types of customers, which could indicate its attributes related to universality of application.

**Research limitations/implications:** The main limitations of the study are the p-value results from the conducted correlation analysis, suggesting that alternative tests should be considered for correlations. Additionally, the conducted quantitative studies should, in the author's opinion, be complemented by a thorough qualitative analysis of the described phenomena.

**Originality/value:** The presented results provide a significant contribution to understanding the impact of a dynamic SKU classification approach on inventory management in the context of a logistics operator. Through literature analysis, it can be observed that traditional ABC methods primarily rely on historical data, limiting their flexibility. In this context, dynamic ABC analysis, combining classification with predictive data analysis, could serve as a valuable tool for enhancing inventory management efficiency.

**Keywords:** 3PL, logistic operator, ABC analysis, inventory management.

**Category of the paper:** Research paper.

### 1. Introduction

The contemporary economic world presents numerous challenges to logistics operators, linked to increasingly complex supply networks (Datta et al., 2013; Maas et al., 2018), dynamic

market changes (Arun, Yildirim Ozmutlu, 2022), and growing competition (Vivaldini et al., 2008). Effective goods distribution has become a crucial factor for the success of many companies, and logistics operators play an incredibly significant role in ensuring its smooth operation. To meet these challenges, logistics operators must make strategic decisions that have a crucial impact on inventory management, costs, and customer satisfaction. Efficiency and effectiveness in managing warehouses, deliveries, and goods flow are key elements in achieving competitive advantage (Baruffaldi et al., 2020). In this context, ABC analysis stands out as a powerful tool to support decision-making processes. Often referred to as Pareto analysis or the 80/20 principle (Rusanescu, 2014), it is based on dividing elements of a set according to their significance or impact on a given phenomenon. Through ABC analysis, logistics operators can focus their efforts on key products that have the greatest impact on business outcomes, as well as on customers who constitute a significant portion of turnover. This method classifies set elements into three categories: A, B, and C. Class A elements are those with the greatest impact on outcomes, typically representing about 20% of the whole set, but accounting for 80% of value or turnover. Class B elements are moderately significant, while Class C elements have the smallest impact on outcomes but constitute a large portion of the set.

ABC analysis allows logistics operators to understand which products, customers, or suppliers are crucial for achieving business goals (Abbas Shojaie et al., 2016; Beheshti et al., 2020). This enables them to more precisely direct their actions, concentrating their resources and efforts on the most important areas of operation. The result is optimized inventory management, avoidance of unnecessary costs, and better fulfillment of customer needs and expectations. ABC analysis becomes an invaluable tool for logistics operators, enabling higher efficiency, competitiveness, and increased satisfaction for both customers and the company itself. With the support of this method, logistics operators can make more rational and informed decisions that will yield positive results in their operations. However, the ABC method has several limitations, which are mitigated by various extensions and modifications (notably observed in Abdolazimi et al., 2021b and Millstein et al., 2014). One of these limitations, focused on in this article, is the fact that the ABC method relies on historical data, thus solely on information related to what has already happened. Even the XYZ method, which supports ABC through an additional dimension, still relies on historical data for analysis. To address this issue, the author suggests introducing a tool for dynamic ABC analysis, which would also incorporate information provided by predictive tools used by 3PL operators to forecast future demand. The aim of the article is to present the functioning of this tool based on a conducted case study. The article attempts to verify the hypotheses:

H1: Dynamic ABC analysis will impact SKU allocation in 3PL warehouses, influencing inventory management.

H2: Regrouping in ABC caused by the application of dynamic ABC will exhibit correlations within physical depots and product groups.

These hypotheses will be verified based on literature analysis and the results of the conducted case study. The presented article provide a significant contribution to understanding the impact of a dynamic SKU classification approach on inventory management in the context of a logistics operator. Through literature analysis, it can be observed that traditional ABC methods primarily rely on historical data, limiting their flexibility. In this context, dynamic ABC analysis, combining classification with predictive data analysis, could serve as a valuable tool for enhancing inventory management efficiency.

## **2. Theoretical background**

### **2.1. 3PL in the contemporary market**

The logistics industry has undergone a significant transformation thanks to technological advancements. Third-party logistics (3PL) companies specialize in providing integrated logistics services, such as transportation, warehousing, inventory management, packaging, and information management, to facilitate the movement of goods from suppliers to customers (Mangan, Lalwani, 2016). These companies act as intermediaries between shippers and carriers, offering value-added services like order fulfillment, consolidation, customs clearance, and reverse logistics to improve supply chain performance (Ajakaive, 2012). 3PLs offer a comprehensive suite of logistics services tailored to meet the specific needs of each customer, including transportation, warehousing, distribution, inventory control, order processing, and information management (Griffis et al., 2007). They optimize the flow of goods and information across the supply chain through services like freight forwarding, customs brokerage, transportation management, and value-added activities (Herold et al., 2021).

By embracing digital technologies, data analysis, and data-driven insights, 3PLs can streamline their processes and provide value-added solutions to clients. Digitalization allows for automation of manual tasks like order processing, inventory management, and shipment tracking. Advanced software systems and technologies improve the accuracy and speed of operations, leading to enhanced efficiency and cost savings. Automation also reduces the risk of human errors, enabling 3PLs to focus on strategic activities that require human expertise.

3PLs are essential players in the global supply chain, offering logistics services to businesses across various sectors (Huge-Brodin et al., 2020). Their services cover transportation, warehousing, inventory management, order fulfillment, and other value-added activities. They act as intermediaries between manufacturers, suppliers, retailers, and end consumers, ensuring a smooth flow of goods and information. The adoption of technology, including digitization of information and the use of advanced software systems, has improved visibility and transparency across the supply chain. Data analytics and predictive modeling empower 3PLs to make data-driven decisions, optimize routes, and streamline operations,

leading to cost savings and improved service levels (Sanchez-Rodrigues, Kumar, 2019). E-commerce and increasing consumer expectations for fast deliveries have driven innovation in last-mile logistics, with 3PLs using route optimization algorithms, mobile apps, and real-time tracking systems to enhance delivery efficiency and provide accurate updates to customers. Moreover, emerging technologies like the Internet of Things (IoT), blockchain, and artificial intelligence (AI) have found adoption in the logistics industry, offering opportunities for improved supply chain visibility, enhanced security and traceability, and automation of various logistics processes. Overall, technology has played a crucial role in reshaping the logistics industry, with 3PLs embracing digital transformation to optimize operations, improve customer service, and stay competitive in the global supply chain (Sashi, 2023). By leveraging advanced technologies and data-driven insights, 3PLs can navigate logistics complexities more efficiently and effectively.

## 2.2. ABC analysis

The ABC method, in relation to inventory classification, is a well-known and widely practiced inventory management technique (Kampf et al., 2016; Pawar, Landage, 2023). Its application can lead to cost reduction and increased operational efficiency for a company (Kiyak et al., 2015). The ABC method also finds application in other fields of knowledge; it can be used for classifying suppliers, projects, and other elements (Rusanescu, 2014). In business practice, the ABC method is often applied to categorize raw materials used in manufacturing processes (Pandya, Thakkar, 2016). However, it's worth noting that this method is not limited solely to raw materials and can be used across various product and service groups. Implementing ABC allows for effective inventory management, increased management efficiency, and improved profit margins (Liu, Wu, 2014). The main steps in the traditional application of the ABC method include (Indrasan et al., 2018):

- Step 1: Determine the unit cost and usage of each material over a specified period.
- Step 2: Multiply the unit cost by the estimated annual usage to obtain the net value.
- Step 3: Create a list of all items and arrange them in descending order of value (annual value).
- Step 4: Accumulate values and sum the number of items, then calculate the percentage contribution to the total inventory value and item count.
- Step 5: Plot a graph of percentage of items and value.
- Step 6: Mark appropriate boundaries for the A, B, and C categories on the graph.

If the ABC method is not implemented correctly, it can lead to serious problems and incidents in inventory management (Dhoka and Choudary, 2013). As some authors suggest, the use of ABC can also be part of the design of supply chains (Abdolazimi et al., 2021a). The traditional ABC method is straightforward to implement, but some researchers have gone further by exploring potential extensions of this method to create more flexible groups that can even accommodate complex business scenarios. An overview of the most popular ABC extensions is presented in Table 1.



**Table 1.***Traditional ABC modification propositions*

<b>Traditional ABC modification proposition</b>	<b>Research papers</b>
ABC grouping supported by Analytic Hierarchy Process (AHP) method.	(Partovi, Burton, 1993)
ABC assortment grouping using multiple criteria	(Ng, 2007; Hadi-Vencheh, 2010; Flores, Whybark, 1987; Ramanathan, 2006; Zhou, Fan, 2007; Yu, 2011; Li et al., 2019)
ABC supported by weighted linear optimization and other optimization methods.	(Ramanathan, 2006; Zhou, Fan, 2007; Millstein et al., 2014)
ABC supported by artificial intelligence methods for classification.	(Yu, 2011)
ABC supported by artificial neural networks (ANN) and cluster classification	(Saric et al., 2014)
Multicriteria ABC inventory classification using acceptability analysis	(Li et al., 2019)
ABC supported by advanced mathematical models.	(Abdolazimi et al., 2021b)
Mixing the qualitative and quantitative methods for ABC calculation.	(Torabi et al., 2012)
ABC grouping based on distance optimization in the internal logistics.	(Bhattacharya et al., 2007)
ABC supported by fuzzy classification methods.	(Chu et al., 2008, Chawla et al., 2024; Khan, Khan, 2023)

Source: own elaboration.

As evident in Table 1, one of the most frequently addressed topics in modifying the traditional ABC approach is enhancing ABC classification with multi-criteria analysis. In the literature, numerous models utilize multi-criteria analysis in conjunction with ABC, such as the PROAFTN model presented by Douissa and Jabeur (2016) or the GAMIC model (Guvener, Erel, 1998; Ravinder, Misra, 2014). However, ABC is more commonly recognized and employed as a component of models for determining order quantity (Nallusamy et al., 2017). The classification itself is often used as a complement to ordering methods based on economic order quantity (EOQ), as seen in Kachitvichyanukul et al. (2012) and Vanesa and Helma (2023), or for inventory control, particularly when combined with the MIN-MAX method (Asana et al., 2020).

In practical business applications, ABC is most commonly used in conjunction with the XYZ method (Suryaputri et al., 2022; Pandya, Thakkar, 2016; Dhoka, Choudary, 2013). Common approaches to XYZ analysis include determining the coefficient of variation (CV) value (Suryaputri et al., 2022) or utilizing ex-post errors (Al-Dulaime, Emar, 2020). The CV is calculated using the following formula (Brown, 1998):

$$CV = \frac{S}{\bar{x}}, \quad (1)$$

where:

S – standard deviation,

$\bar{x}$  – average value.

CV describes the degree of data variability; therefore, in the context of inventory management, it provides information about the variability of demand for a particular product. In the literature, attempts have been made to categorize XYZ groups based on CV values.

One of the classifications, proposed by Kaczorowska et al. (2019), has been presented in Table 2.

**Table 2.**

*XYZ classification based on CV indicator*

Group	CV value
X	<0; 0,5>
Y	(0,5; 0,9>
Z	(0,9; ∞)

Source: own elaboration.

Certainly, it's important to be aware that when determining CV values, the ranges should be established based on a good understanding of the assortment being managed in inventory management. Various factors influence these groups, and rigid categorization may not be suitable in this context. For example, SKU (Stock Keeping Units) on the warehouse shelves in the FMCG (Fast Moving Consumer Goods) industry will be structured differently compared to industries where rotation and frequency of issues don't reach such levels (e.g., construction industry). Another mentioned method of classification involves categorization using ex-post errors generated for individual SKUs. If forecasts are created within inventory management, the errors and forecasting accuracy can be used for XYZ classification. Ex-post errors in forecasting vary, but the most commonly mentioned ones (including in Satchell and Hwang (2001) and Ostertagova and Ostertag (2012)) for XYZ analysis and inventory management are MAE (Mean Absolute Error), MAPE (Mean Absolute Percentage Error), and RMSE (Root Mean Square Error). Table 3 compiles these mentioned errors along with explanations of how they are calculated.

**Table 3.**

*The most popular ex-post errors in the case of XYZ analysis*

Forecasting error	Equation	Description
MAE	$\frac{1}{n} \sum_{i=1}^n  y_i - y_i^* $	$y_i$ – real value in i-period. $y_i^{\wedge}$ – forecast value in i-period. n – number of observations.
MAPE	$\frac{1}{n} \sum_{i=1}^n \left  \frac{y_i - y_i^*}{y_i} \right $	
RMSE	$\sqrt{\sum_{i=1}^n \frac{(y_i - y_i^{\wedge})^2}{n}}$	

In the case of XYZ classification, selecting appropriate values that suggest an SKU is placed in the right class is also an individual matter. Despite certain authors providing guidelines (such as Herlambang and Parung (2021)), who suggest the following classes for specific MAPE error ranges: X for results less than 35%, Y for results less than 60%, and Z for the rest,

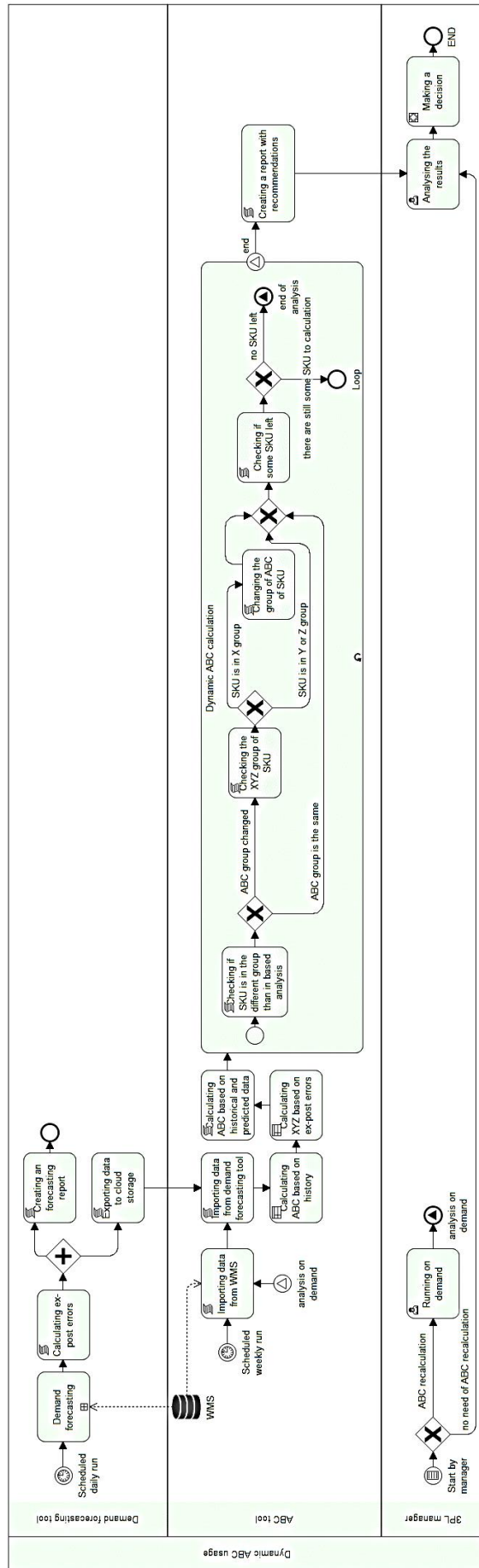
the treatment of forecast errors as small or large depends on many factors related to business strategy, SKU type, and the operational environment of the company. However, advanced forecasting systems nowadays offer the possibility of minimizing errors and increasing forecast accuracy.

### 3. Methods

#### 3.1. Dynamic ABC idea

As mentioned earlier, a commonly recognized drawback of ABC is its reliance on historical data, often conflicting with its flexibility. Apart from the advanced modification methods discussed earlier in the literature, the potential of prediction in inventory management is also emerging. Some authors emphasize that predictive capabilities can lead to a decrease in the total number of parts inventoried monthly, resulting in greater storage space availability and lower stock holding costs (Ternero et al., 2023). On the other hand, some authors clearly showcase ABC models supported by value estimation (Chen, 2011). Certain authors see an opportunity to support classical ABC with forecasting (Sharma, Tripathi, 2023; Quiroz-Flores et al., 2023) or suggest combining ABC with a forecasting module in MPS (Master Production Schedule) to minimize production costs (Simanjuntak et al., 2022). Meanwhile, Muenjitnoy et al. (2023) suggested that their research results could be applied to the ABC analysis technique to select inventory and then forecast demand for the most accurate inventory estimate based on MAPE. It is on these foundations that the concept of dynamic ABC emerged, as presented in the article. Dynamic ABC is based on combining ABC classification with predictive data analysis in the decision-making and relocation processes. The operational idea of a SKU classification tool based on dynamic ABC is depicted in Figure 1 using BPMN 2.0 (Business Process Modeling and Notation 2.0).

The research was conducted in the form of a case study within the operations of a selected third-party logistics (3PL) operator that operates in multiple distribution networks. The chosen 3PL company is an international logistics firm specializing in supply chain services. They provide solutions in procurement, warehousing, distribution, transportation, and supply chain management. The company's activities span across various industries, such as food, industrial products, electronics, and many other goods. Their services are offered both in the domestic and international markets. Equipped with advanced technologies and IT systems, the company can track shipments, manage inventory, and optimize logistics processes. Their focus is on delivering high-quality customer service by adapting flexibly to customer needs and swiftly responding to changing market requirements. Sustainability is also a key aspect of their operation, aiming to minimize their impact on the environment. The company holds a strong position in the logistics market, continually expanding and enhancing its competencies on a global scale.



**Figure 1.** Process of dynamic ABC tool usage mapped in BPMN 2.0 (for better quality check the: <https://tiny.pl/crpdv>).

Source: own elaboration.

The tool developed by the author requires the utilization of a forecasting tool, which provides information about forecasts and the verifiability of expired forecasts. Such a forecasting tool, applicable in such scenarios, is presented in the work by Kmiecik and Wolny (2022). The values for XYZ classification of SKUs were determined individually, depending on the specifics of each service recipient's operations. Based on the XYZ analysis, the tool decides whether to change the ABC group calculated based on historical data to the group calculated based on predictive data. This change occurs only when the SKU is in group X, and the ABC calculation using predictive data indicates a change. The stringent rules for changing the group are linked to the need for obtaining high-quality information (information with a high probability of accuracy) to justify the reorganization of products in the warehouse, including the allocation of resources for SKU relocation.

### 3.2. Data description

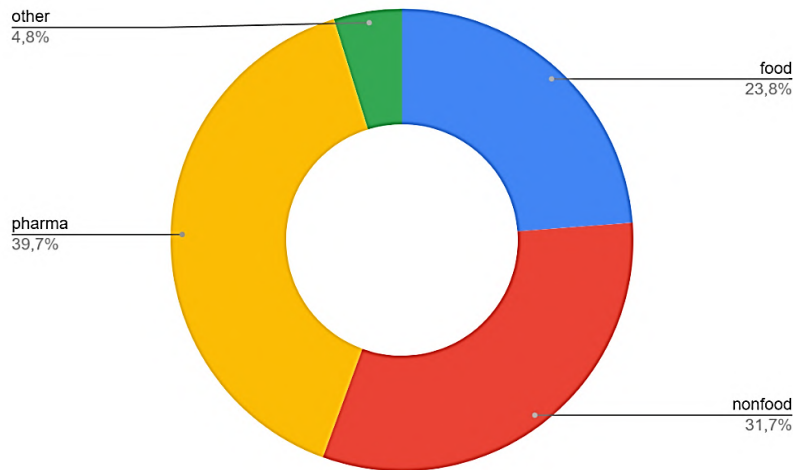
To construct the case study, data collected from 10 warehouses located in Poland (7 warehouses) and the Czech Republic (3 warehouses) were utilized. The total number of service recipients examined within the scope of logistic services outsourcing by the 3PL in these mentioned warehouses amounts to 52 service recipients. An overview of the recipients is available in Table 4 (Appendix 1). The examined service recipients were classified into groups representing industries such as food, non-food, pharmaceutical (pharma), and others. The number of service recipients in each warehouse is presented in Table 5.

**Table 5.**

*Number of service recipients in the particular warehouses*

Warehouse	Number of customers	Number of SKU	food	nonfood	pharma	other
Physical depot 01 PL	1	160 862	0	1	0	0
Physical depot 02 PL	3	48 330	3	0	0	0
Physical depot 03 PL	31	105 448	0	5	25	1
Physical depot 04 PL	3	13 419	3	0	0	0
Physical depot 05 PL	3	17 235	1	2	0	0
Physical depot 06 PL	2	34 662	0	2	0	0
Physical depot 07 PL	1	7 644	1	0	0	0
Physical depot 08 CZ	5	375 265	2	2	0	1
Physical depot 09 CZ	2	144 225	1	1	0	0
Physical depot 10 CZ	1	13 467	0	1	0	0
<b>TOTAL</b>	<b>52</b>	<b>920 557</b>	<b>11</b>	<b>14</b>	<b>25</b>	<b>2</b>

Source: own elaboration.



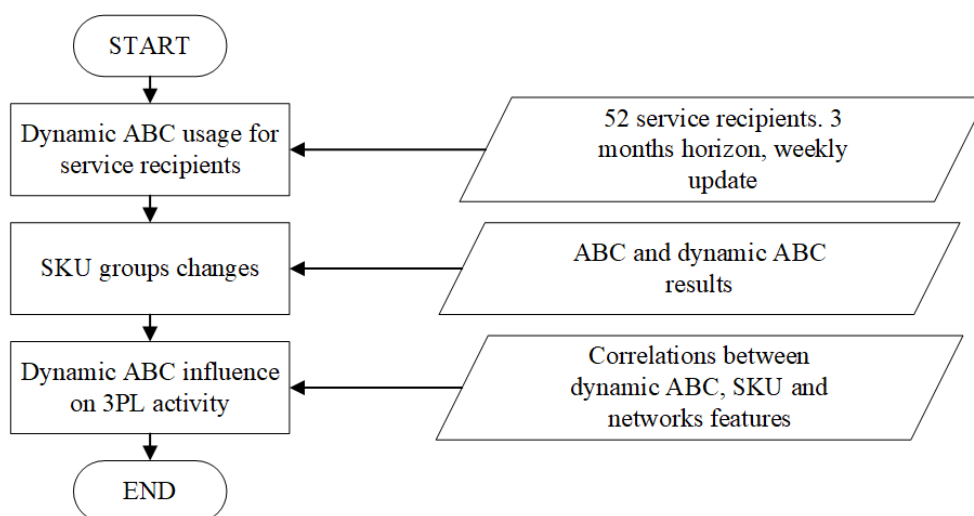
**Figure 2.** Types of service recipients in the case study.

Source: own elaboration.

Approximately 40% of the examined recipients are recipients of logistic services, involving handling products from the pharmaceutical industry. However, the significant presence of food (around 23%) and non-food (around 32%) enterprises will diversify the results of the conducted case study, thus ensuring a satisfactory level of research universality. The data pertains to the classification performed by the presented tool for around 920,000 SKUs that exhibit movement (dead SKUs were excluded from the study) across the 10 warehouses located in two countries. The analysis verified the last 3 months for ABC group calculation and the last 6 months for forecast verifiability calculation. The forecast horizon, which was used to change the group within the ABC group, was determined individually for each service recipient and ranged from 1 week to 1 month.

### 3.3. Main research steps

The research procedure focuses on completing several predefined research steps (Figure 3).



**Figure 3.** Main research steps.

The research is focused on 52 service recipients for whom the dynamic ABC tool was utilized (Figure 1). The period of tool application for each of the service recipients was 3 months, covering standard operational months for the operator, without exceptional sales peaks, promotional activities, or holiday periods. The choice of this period aimed to standardize the research. The dynamic ABC tool was executed once a week. Daily execution of the tool would not be efficient due to the constant need for product relocation in the storage area, which would consume resources and time without compensating for the benefits of using the tool. The tool was activated weekly, allowing for a potential change of SKUs between groups during the mentioned 3-month period to occur 12 times. The decision to use the tool on a weekly basis was a strategic decision made by the managerial level of the operator. This way, the average percentage of SKUs that switched to another group with each tool activation was calculated. Group changes mainly occurred between the extreme SKUs that were located at the border of groups A and B, as well as B and C. In the final step, a correlation analysis was conducted between the outcomes of ABC group changes influenced by the tool's operation, the specifics of the service recipient's activity, and the number of SKUs present for each service recipient. R software was employed for the correlation analysis, using three widely used methods for calculating correlations: Pearson correlation, Spearman rank correlation, and Kendall's tau correlation (Chok, 2010). The calculation method for these correlations is presented in Table 6.

**Table 6.**  
*Chosen correlation coefficients*

Correlation	General equation	Assumed values interpretation	Part of R script
Pearson	$r = \frac{n \sum XY - \sum X \sum Y}{\sqrt{(n \sum X^2 - (\sum X)^2 - (n \sum Y^2 - (\sum Y)^2))}}$ <p>where: n – number of data points, X – x-values in the data set, Y – y-values in the data set.</p>	<p> r  = 0 – no correlation.  r  = 1 – perfectly correlation.  r  ∈ (0;0,3] - negligible correlation.  r  ∈ [0,3;0,5] – moderate correlation.  r  ∈ (0,5;1) – highly correlated.</p>	<p><i>cor.test(X, Y, method = c("pearson"))</i></p>
Spearman	$p = \frac{6 \sum d_i^2}{n(n^2 - 1)}$ <p>where: d – difference between ranks.</p>	<p> p  = 0 – no correlation.  p  = 1 – perfectly correlation.  p  ∈ (0;0,3] - negligible correlation.  p  ∈ [0,3;0,5] – moderate correlation.  p  ∈ (0,5;1) – highly correlated.</p>	<p><i>cor.test(X, Y, method = c("spearman"))</i></p>

Cont. table 6.

Kendall	$k = \frac{C - D}{C + D}$ where: C – the number of concordant pairs, D – the number of discordant pairs.	k  = 0 – no correlation.  k  = 1 – perfectly correlation.  k  ∈ (0;0,3] - negligible correlation.  k  ∈ [0,3;0,5] – moderate correlation.  k  ∈ (0,5;1) – highly correlated.	$cor.test(X, Y, method = c("kendall"))$
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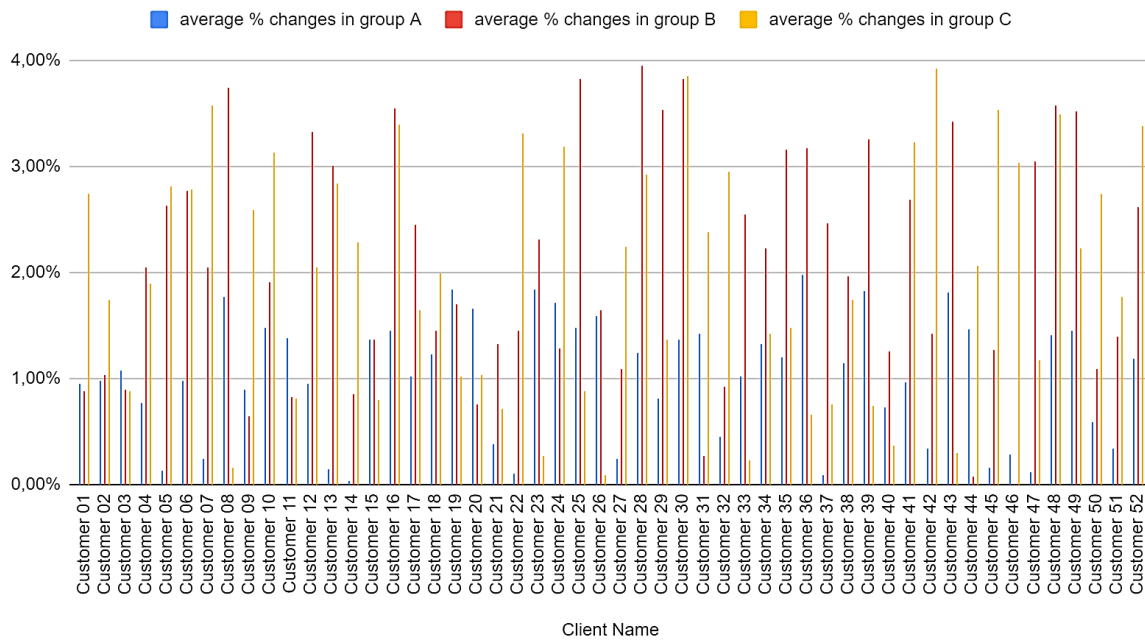
Source: own elaborated based on Cohen et al. (2009), De Winter et al. (2016), Abdi (2007) and www.RDocumentation.org

The analysis was conducted by examining correlations using the Pearson linear correlation coefficient, Spearman's rank correlation, and Kendall's tau correlation between the specified factors, with a statistical significance level set for results with a p-value < 0.05. Adopting a p-value of this level is common in scientific articles (Genovese et al., 2006; Goodman, 2008). In statistics, the p-value is a measure that determines the statistical significance of test results (Andrade, 2019). When calculating correlations, the p-value indicates whether the detected correlation between variables is statistically significant or could be a result of chance. A p-value < 0.05 means that there is less than a 5% chance that the observed correlation was obtained randomly in the sample. In other words, if the p-value is less than 0.05, the result can be considered statistically significant, suggesting a genuine relationship between the variables being studied. If the p-value is greater than or equal to 0.05, it means there is not enough evidence to reject the null hypothesis, which states that there is no correlation between variables. This does not automatically mean that there is no correlation, but it suggests that we do not have enough certainty to conclude that one exists.

## 4. Results

In the research conducted using the created tool, it was demonstrated that in the case of each service recipient, the tool influences the reassignment of SKUs among the different ABC groups (Figure 4).





**Figure 4.** Average percentage changes in ABC groups per service recipients.

The relocation of the number of SKUs among different product groups was a significant aspect of the analysis, with an average level of change not exceeding 4% (differences ranged from 0.08% to 3.95% depending on the specific group). When considering the overall number of SKUs, which was an impressive 920,557, managed by a dedicated logistics operator as part of their services for customers, it becomes evident that the global modifications in warehouse management yielded scalable results. In practical terms, this means that an average transfer of 736 to as many as 36,362 SKUs took place across Poland and the Czech Republic, signaling substantial changes in warehouse space organization and logistics process optimization. These balanced relocations have the potential to contribute to more efficient resource utilization, optimized inventory management, and improved product availability for end customers. The average percentage of SKU movement within specific ABC groups was also analyzed for individual physical depots (table 7) and different types of service recipients (table 8).

**Table 7.**

*Average percentage changes in ABC groups in the particular physical depots*

Physical depot	average % changes in group		
	A	B	C
Physical depot 01 PL	0,96%	0,88%	2,74%
Physical depot 02 PL	0,94%	1,32%	1,51%
Physical depot 03 PL	1,06%	2,14%	1,94%
Physical depot 04 PL	1,07%	2,53%	1,05%
Physical depot 05 PL	1,18%	2,40%	1,44%
Physical depot 06 PL	1,08%	2,42%	2,11%
Physical depot 07 PL	1,46%	0,07%	2,07%
Physical depot 08 CZ	0,69%	2,29%	2,69%
Physical depot 09 CZ	0,47%	1,24%	2,26%
Physical depot 10 CZ	1,18%	2,62%	3,38%

Source: own elaboration.

**Table 8.***Average percentage changes in ABC groups in the particular service recipients types*

Service recipient type	average % changes in group		
	A	B	C
food	1,08%	2,05%	1,95%
nonfood	0,88%	1,98%	2,14%
pharma	1,07%	2,23%	1,82%
other	0,80%	0,77%	2,96%

Source: own elaboration.

Analyzing the movements between different ABC product groups within each physical depot, it was observed that SKU relocations between these groups occurred in all three categories (A, B, and C). The percentage values of these movements varied, with the highest number of changes observed in group C, accounting for approximately 2.12% of all SKUs. On the other hand, group A exhibited a lower level of movements, around 1.01%. Group B, meanwhile, encompassed about 1.79% of SKUs that were transferred between the different product groups. When examining the data from the perspective of different types of service recipients, a similar tendency towards even SKU movements across different recipient categories was noted. For the "food" category, an average of 1.69% of all SKUs were relocated, while for "non-food," it was 1.67%, "pharma" showed 1.71%, and other types of recipients had 1.51%. Incidentally, the structure of changes in the ABC groups reflected similar patterns to those in the physical depots. Focusing on movements within these groups, analogous trends were observed. Group A showed the lowest level of changes, averaging around 0.96%. Group B fell in the middle, with around 1.76% of SKUs being relocated. Group C, with the highest percentage of SKU movements, represented about 2.22% of the total number of SKUs within the group. Overall, these findings suggest certain similarities in the dynamics of SKU movements, both in the context of physical depots and different types of service recipients and ABC groups. Analyzing these patterns can contribute to a better understanding of inventory management strategies and optimization of logistic processes, which could benefit both the logistics operator and their clients. Demonstrating the SKU movements caused by dynamic ABC in comparison to traditional ABC confirmed the positive verification of the first hypothesis (H1: Dynamic ABC analysis will impact the allocation of SKUs in 3PL warehouses, i.e., inventory management strategies – confirmed). To verify the second hypothesis (H2), correlations and p-values were calculated from the collected data resulting from the conducted research. The calculated correlations according to Pearson, Spearman, and Kendall coefficients, along with p-values, categorized by individual ABC groups, physical depots, and service recipient types, are presented in table 9.

**Table 9.**  
Correlation coefficient with p-value per ABC groups

		Correlation coefficient with p-value		
		Pearson	Spearman	Kendall
Correlation of average percentage changes in A group with	physical depot	p  = 0,15 p-value = 0,28	s  = 0,14 p-value = 0,31	k  = 0,11 p-value = 0,31
	service recipient type	p  = 0,09 p-value = 0,52	s  = 0,01 p-value = 0,92	s  = 0,00 p-value = 0,96
Correlation of average percentage changes in B group with	physical depot	p  = 0,01 p-value = 0,93	s  = 0,04 p-value = 0,78	s  = 0,03 p-value = 0,77
	service recipient type	p  = 0,01 p-value = 0,97	s  = 0,14 p-value = 0,31	s  = 0,11 p-value = 0,29
Correlation of average percentage changes in C group with	physical depot	p  = 0,21 p-value = 0,13	s  = 0,14 p-value = 0,31	s  = 0,00 p-value = 0,97
	service recipient type	p  = 0,04 p-value = 0,76	s  = 0,08 p-value = 0,56	s  = 0,06 p-value = 0,56

Source: own elaboration.

The conducted research indicated a lack of significant correlation between the analyzed variables. The absence or weak correlation, as expressed by Pearson, Spearman, and Kendall coefficients, conveys significant information about the nature of the relationship between these variables. The absence of Pearson correlation, which describes a linear relationship between variables, signals that the variables do not exhibit consistent changes in accordance with each other. As a result, it can be inferred that the variables are largely independent of each other, meaning changes in one variable do not lead to consistent changes in the other variable. The absence or weak Spearman correlation suggests that there is no clear pattern of order between the variables. This implies that the variables do not exhibit a consistent arrangement of rank values in the context of their mutual relationship. Similarly, weak Kendall correlation suggests a lack of clear order between the variables, indicating that the variables are significantly independent of each other and their mutual relationship is not clearly defined. In summary, the absence or weak correlation described by these three measures indicates a small or even missing interdependence between the analyzed variables. This suggests that these variables do not exhibit consistent behavior patterns with respect to each other, which may imply that their relationship is either random or ambiguous. Furthermore, it's worth noting that the p-value results in the case of the analyzed patterns did not reflect statistical significance. This suggests that the differences between the variables are not large enough to be considered statistically significant. Ultimately, the lack of statistical significance indicates that these differences may result from random fluctuations or variables that do not significantly influence each other. The presented results prevented a positive verification of the second hypothesis (H2: Regrouping in ABC induced by dynamic ABC exhibits correlations within physical depots and product groups). For the investigated tool, this could suggest, among other things, its stable operation regardless of the type of products and distribution networks in which it is used.

## 5. Discussion

### 5.1. Dynamic ABC as a tool for supporting the inventory management in 3PL

The conducted analysis was related to a significant transformation of the standard ABC groups, which are assigned based on a standardized procedure grounded in historical data analysis. This method aims to provide a more accurate determination of individual product groups or items based on their value or importance in the context of management and analysis. In the discussed approach, the method described in the study includes the incorporation of predictive data as a supporting element for ABC group analysis. Nevertheless, only those predictive data showing appropriate forecasting effectiveness are utilized. This means that only predictive data demonstrating a high level of consistency between forecasted values and actual outcomes are included in the analysis. Such an approach aims to ensure that predictive data used in the ABC grouping process are reliable and trustworthy. To sum up, this analysis introduces an innovative approach to determining ABC groups by utilizing proven historical data alongside precisely selected predictive data. Through this approach, ABC groups can better reflect current trends and changes in the value or significance of individual elements, contributing to more efficient resource management and decision-making. The combination of ABC with forecasting has already been applied in literature. Kartika et al. (2023) demonstrated a similar line of reasoning using examples from the pharmaceutical industry. The study's author further develops this line of reasoning in ABC classification, extending it to products from other industries and demonstrating the method's universality. The method is also applied in the case of logistics service providers who manage an assortment to which they do not formally hold ownership rights.

Within the research, the results of dynamic ABC were correlated with the outcomes of conducted XYZ analysis. This is justified due to the need to determine the degree of acceptability of forecast verifiability in the dynamic ABC method itself. However, the literature also presents other methods that, according to the author, could be considered as complements to the dynamic ABC analysis. Most frequently, the benefits of combining ABC with the VED (Vital, Essential, Desirable) method are highlighted. VED is an inventory classification method that helps identify different levels of importance or significance of items in a warehouse. The VED method assists organizations in focusing on inventory management based on its criticality to the company's operations. The significance of combining VED with ABC is shown, among others, by Amer and Jawad (2023), Gupta et al. (2007), and Ceylan and Bulkan (2017). Literature also explores modifications of VED, such as VEN (Vital, Essential, Non-essential), for situations similar to the one described. This modification is proposed, for example, by Mfizi et al. (2023). Therefore, the proposed tool carries various directions for its development.

## 5.2. Direction of further research and main limitation

One of the intriguing directions for tool development and further research is the integration of forecasting methods, fuzzy methods, and AHP within the framework of creating ABC. A similar logic is demonstrated, among others, in Valdivia Seminario et al. (2023). Another area to focus on in the future could be the combination of the proposed dynamic ABC with simulation models. The integration of traditional ABC with simulation models has been demonstrated, for instance, in Hidayatuloh et al. (2023), and these studies could be expanded to incorporate dynamic ABC in simulation models for warehouse management. Taking it a step further and considering the possibilities of creating Digital Twins (DT) by 3PL (Kmiecik, 2023), one can also explore the potential of supporting DT with such tools, which encompass not only historical but also predictive data.

The author is also aware of the limitations present in the conducted research. Firstly, the author has reservations about the p-values resulting from the conducted correlational analysis, which might suggest that different tests than those presented should be chosen for correlations. Additionally, the quantitative studies conducted should, according to the author, be complemented in the future by a thorough qualitative analysis of the described phenomena. Qualitative analysis could offer an interesting expansion to the conducted research.

## 6. Conclusions

In summary, this study focused on the analysis of a dynamic inventory classification method based on a modified ABC concept. The presented results provide a significant contribution to understanding the impact of the dynamic approach to SKU classification on inventory management within the context of a logistics operator. Through literature analysis, it becomes apparent that traditional ABC methods primarily rely on historical data, limiting their flexibility. In this context, dynamic ABC analysis, combining classification with predictive data analysis, can offer a valuable tool for enhancing inventory management efficiency. The study's findings revealed that the dynamic ABC tool led to the reclassification of a considerable number of SKUs across product groups. Although the relative percentage changes in the overall SKU count (920,557) are modest, they possess the potential to result in substantial alterations in warehouse layout and logistic process optimization. Analysis of movements within ABC groups and physical warehouses highlighted diverse trends in SKU movement across ABC groups. The introduction of the dynamic ABC tool enabled a more precise allocation of resources and improved product availability for customers. The author acknowledges the constraints inherent in the undertaken study. Firstly, there are concerns about the validity of the p-values derived from the correlational analysis, implying the need for alternative tests beyond

those currently presented. Furthermore, the author proposes that future investigations incorporate a comprehensive qualitative examination of the described phenomena to complement the quantitative studies. Such qualitative analysis could provide a valuable augmentation to the conducted research. An intriguing avenue for tool development and ongoing exploration involves the amalgamation of forecasting methods, fuzzy methods, and AHP within the framework of constructing ABC. Another promising area for future emphasis could be the amalgamation of the proposed dynamic ABC with simulation models. Instances of such integration between traditional ABC and simulation models have been exemplified and these studies could be extended to incorporate dynamic ABC into simulation models specifically designed for warehouse management. Going a step further and considering the prospect of creating Digital Twins by 3PL one might explore the potential of fortifying DT with tools that encompass not only historical data but also predictive data.

It's also worth noting that the correlational analysis between variables did not exhibit significant correlations. The absence or weak correlation between different measures affirmed the limited interdependence between the analyzed variables. This suggests that the dynamic ABC tool operates stably regardless of product type and distribution network in which it is employed. Based on the study's outcomes, it can be observed that the dynamic ABC tool could present a valuable alternative to traditional inventory classification methods. It opens doors to more flexible inventory management based on predictive data analysis, potentially contributing to the enhancement of logistic operations' efficiency. Further research is also encouraged to gain deeper insights into the impact of the dynamic ABC tool on logistic operations and future innovations in inventory management.

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## Appendix

**Table 4.**

*General description of chosen case studies*

country	Physical depot	Client Name	number of SKU	General type (food/non-food/pharma/other)	Brief description	shares of SKU at physical depot	shares of SKU in whole activity (PL+CZ)
PL	Physical depot 01 PL	Customer 01	160 862	nonfood	Furniture and interior furnishings.	100,00%	17,47%
PL	Physical depot 02 PL	Customer 02	369	food	Food products (e.g., juices).	0,76%	0,04%
PL	Physical depot 02 PL	Customer 03	46 269	food	Food products (e.g., sweets, beverages).	95,74%	5,03%
PL	Physical depot 02 PL	Customer 04	1 692	food	Food products (e.g., desserts, creams).	3,50%	0,18%
PL	Physical depot 03 PL	Customer 05	43	nonfood	Electronics	0,04%	0,00%
PL	Physical depot 03 PL	Customer 06	1 066	pharma	Medical products and dressings.	1,01%	0,12%
PL	Physical depot 03 PL	Customer 07	1 233	pharma	Pharmaceutical products.	1,17%	0,13%
PL	Physical depot 03 PL	Customer 08	149	pharma	Pharmaceutical products.	0,14%	0,02%
PL	Physical depot 03 PL	Customer 09	14 288	nonfood	Packaging and labels.	13,55%	1,55%
PL	Physical depot 03 PL	Customer 10	65	pharma	Pharmaceutical products and drug samples.	0,06%	0,01%
PL	Physical depot 03 PL	Customer 11	44	pharma	Pharmaceutical products.	0,04%	0,00%
PL	Physical depot 03 PL	Customer 12	538	pharma	Pharmaceutical products.	0,51%	0,06%
PL	Physical depot 03 PL	Customer 13	926	pharma	Pharmaceutical products.	0,88%	0,10%
PL	Physical depot 03 PL	Customer 14	589	pharma	Pharmaceutical products.	0,56%	0,06%

PL	Physical depot 03 PL	Customer 15	551	pharma	Pharmaceutical products.	0,52%	0,06%
PL	Physical depot 03 PL	Customer 16	65	pharma	Pharmaceutical products.	0,06%	0,01%
PL	Physical depot 03 PL	Customer 17	284	pharma	Pharmaceutical products.	0,27%	0,03%
PL	Physical depot 03 PL	Customer 18	2 809	pharma	Pharmaceutical products.	2,66%	0,31%
PL	Physical depot 03 PL	Customer 19	3 220	pharma	Pharmaceutical and cosmetic products.	3,05%	0,35%
PL	Physical depot 03 PL	Customer 20	1 885	pharma	Cosmetic and dermatological products.	1,79%	0,20%
PL	Physical depot 03 PL	Customer 21	109	pharma	Pharmaceutical products.	0,10%	0,01%
PL	Physical depot 03 PL	Customer 22	21 560	pharma	Pharmaceutical and cosmetic products.	20,45%	2,34%
PL	Physical depot 03 PL	Customer 23	74	nonfood	Cosmetic products.	0,07%	0,01%
PL	Physical depot 03 PL	Customer 24	192	pharma	Pharmaceutical products.	0,18%	0,02%
PL	Physical depot 03 PL	Customer 25	258	pharma	Healthcare and cosmetic products.	0,24%	0,03%
PL	Physical depot 03 PL	Customer 26	62	pharma	Pharmaceutical products.	0,06%	0,01%
PL	Physical depot 03 PL	Customer 27	307	pharma	Pharmaceutical products.	0,29%	0,03%
PL	Physical depot 03 PL	Customer 28	2 181	pharma	Pharmaceutical products.	2,07%	0,24%
PL	Physical depot 03 PL	Customer 29	460	pharma	Pharmaceutical products.	0,44%	0,05%
PL	Physical depot 03 PL	Customer 30	51 784	nonfood	Plumbing and bathroom fixtures.	49,11%	5,63%
PL	Physical depot 03 PL	Customer 31	317	other	Various of products	0,30%	0,03%
PL	Physical depot 03 PL	Customer 32	14	nonfood	Services related to communication and marketing.	0,01%	0,00%

PL	Physical depot 03 PL	Customer 33	20	pharma	supply for drug stores	0,02%	0,00%
PL	Physical depot 03 PL	Customer 34	21	pharma	Pharmaceutical products.	0,02%	0,00%
PL	Physical depot 03 PL	Customer 35	334	pharma	Pharmaceutical products.	0,32%	0,04%
PL	Physical depot 04 PL	Customer 36	3 455	food	a lot of food kinds, wholesaler	25,75%	0,38%
PL	Physical depot 04 PL	Customer 37	1 492	food	Food products (e.g., chocolates, cookies).	11,12%	0,16%
PL	Physical depot 04 PL	Customer 38	8 472	food	Food products (e.g., confectionery).	63,13%	0,92%
PL	Physical depot 05 PL	Customer 39	14 656	nonfood	Containers and products related to food storage.	85,04%	1,59%
PL	Physical depot 05 PL	Customer 40	119	nonfood	Finishing materials for construction and renovations.	0,69%	0,01%
PL	Physical depot 05 PL	Customer 41	2 460	food	Food products (e.g., snacks).	14,27%	0,27%
PL	Physical depot 06 PL	Customer 42	21 242	nonfood	Cosmetic and personal care products.	61,28%	2,31%
PL	Physical depot 06 PL	Customer 43	13 420	nonfood	Toys for children.	38,72%	1,46%
PL	Physical depot 07 PL	Customer 44	7 644	food	Pet products, mainly pet food.	100,00%	0,83%
CZ	Physical depot 08 CZ	Customer 45	3 093	other	tabacoo products	0,82%	0,34%
CZ	Physical depot 08 CZ	Customer 46	244	nonfood	Packaging.	0,07%	0,03%
CZ	Physical depot 08 CZ	Customer 47	8 383	nonfood	sport equipment	2,23%	0,91%
CZ	Physical depot 08 CZ	Customer 48	157	food	Food for children	0,04%	0,02%
CZ	Physical depot 08 CZ	Customer 49	363 388	food	Products for infants and children.	96,84%	39,47%
CZ	Physical depot 09 CZ	Customer 50	56	food	Food products, may vary.	0,04%	0,01%

CZ	Physical depot 09 CZ	Customer 51	144 169	nonfood	Building materials and renovation articles.	99,96%	15,66%
CZ	Physical depot 10 CZ	Customer 52	13 467	nonfood	No specific information about the products.	100,00%	1,46%

Source: own elaboration.





## RELATIONSHIP BETWEEN UNIVERSITY AND BUSINESS: COOPERATION OR COLLABORATION?

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**Purpose:** The purpose of the study is to perform the assessment of developmental level of cooperation/collaboration between Polish universities and the business. The basis of research is the concept assessing the level of integration starting from identification and/or creation of networks till the organizations of collaboration.

**Design/methodology/approach:** The article is a conceptual analysis of the maturity of university-business collaboration development.

**Findings:** Based on the process of cooperation development, assumptions were presented to assess the maturity of collaboration between universities and business. The proposed cooperation maturity model between a university and business is a solution based on the network integration process and description of such network discriminants as: network governance, value (network rent), structuralism, network competences.

**Originality/value:** Well-founded collaboration mechanism, stimulating the pursuit for perfection has a significant meaning for the creation of new knowledge within the scope of general development of a society based on science and studies and for the innovation systems. Being traditional and single projects oriented, it has its unquestioned benefits however, it poses problems not only for the new developed ideas exceeding beyond the limits of the existing well defined domains and scope but also for new and emerging technologies. Cooperation between the universities and business striving for collaboration based on better understanding of commercialization processes of the research results, their innovativeness and adaptation to the needs of the economy and society

**Keywords:** university - business relationship, collaboration, cooperation.

**Category of the paper:** Viewpoint.

### 1. Introduction

The process of applying and using research and development studies in the business, as well as conducting activities aimed at spreading knowledge and technology (and their corresponding patent and license services) should become the important factors of new strategies and

institutional programmes of universities. Direct relationships with the industry, based on contract and advisory research, are established. In most cases, the problem is specified by the industry and the role of a university is to offer solutions to these problems. Unfortunately, such a cooperation is often limited to short-term problems. As a result, it is not bound by long-term strategy and research agenda which would be based on a well-defined technological strategy (Gebhardt et al., 2021). This mostly applies to small and medium-sized enterprises (SMEs) which additionally face the problem of finding a suitable partner at a given university (which is perceived as a large and complex entity).

Collaboration between universities and the industry sector is an element of a sustainable system of the national innovation system and cannot be aimed at disregarding any of these entities (Kempton et al., 2013; Cloutier et al., 2019). It is necessary to accept the fact that both of the partners in such a collaboration have different motivations and goals. Different features characterizing such partners lead to a necessity of such collaboration to be managed, coordinated or moderated in order to ensure added value for each of the partners. That is why collaboration should be interpreted as a complex communication process between two different worlds with different systems of goals, rationalities, knowledge and different approaches to management, values and interests. A well established and consolidated collaboration mechanism, stimulating striving for perfection bears a significant value for the creation of new knowledge (within the scope of general development of a society based on science and studies) and for the innovation systems (Guimón, 2013). Traditional, single-project oriented collaboration mechanism has its unquestioned benefits, however it raises problems not only for the new ideas which are being developed within the well-known and elaborately described fields, but also for new, emerging technologies.

The adopted assumption states that the basis for science-business relationship is the attainment of mature cooperation with elements of collaboration. The article consists of three parts:

- in the first one the literature analysis was made, considering the difference between cooperation and collaboration;
- in the second part the cooperation maturity model which characterises science-business relation was proposed;
- the third one evaluates the maturity of science-business cooperation in Poland.

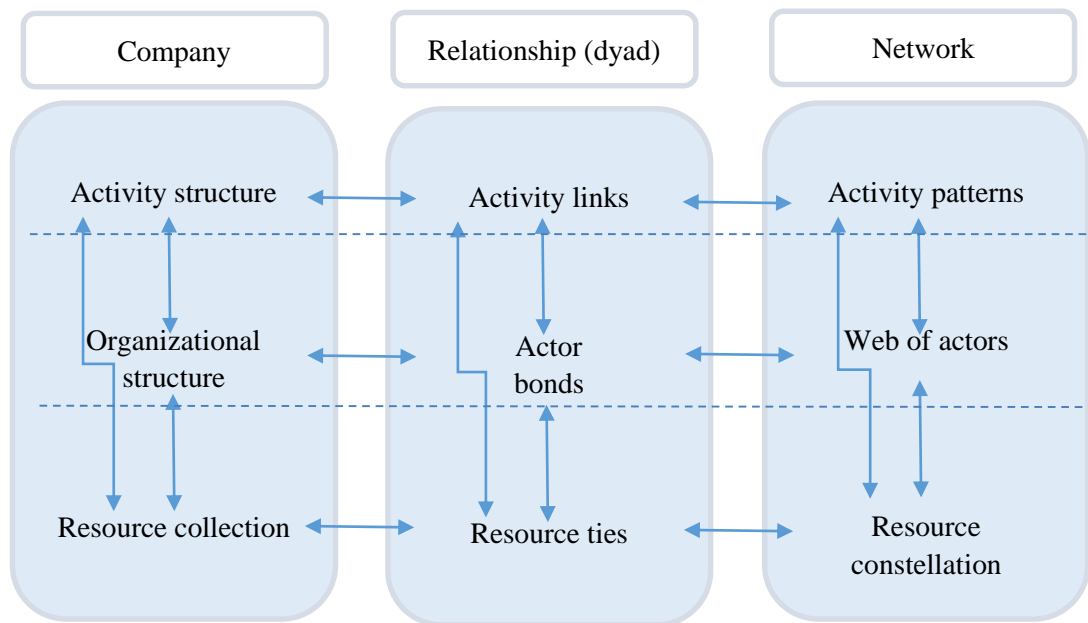
The purpose of this article is to assess the level of advancement of cooperation between Polish universities and the industry. The basis for this research is the concept which differentiates the level of integration from identification and/or creation of network of organizations with the aim to collaborate. The originality of the discussion in the article includes, on the one hand, the distinction in the science-business relationship between the issues of collaboration and cooperation. On the other hand, an attempt was made to present the level of maturity of science-business collaboration in Polish conditions.

## 2. Cooperation and Collaboration within inter-organizational networks. Literature Review

Discussion about the difference between cooperation and collaboration is often of intuitive nature, however for many researchers these terms remain indistinguishable. The difference becomes apparent when we picture the issue against the background of network considerations, which create a particular process of maturation of cooperation between these organizations. Along with that, the recognition that networks are not only the domain of management studies is essential. Network approach is being used in mathematical sciences (graph theory and neural networks), sociology (social networks), geography (networks in economic geography), management (business networks and strategic networks), and economics (regional development theory, network effects, and spatial economics). Considerations on inter-organizational networks have been conducted for several decades. Scholars and professionals both have shown a keen interest in inter-organizational collaboration for more than 25 years (Le Penneç, Rauffle, 2018). Easton and Araujo (Easton, Araujo, 1996) and Grandori and Soda (Grandori, Soda, 1995) have identified almost 20 different approaches or schools in inter-organizational networks. As Möller and Rajala (Möller, Rajala, 2007) point out “This great diversity in network research produced important new knowledge but also, unfortunately, resulted in conceptual confusion of the core phenomenon itself”. Research led by Czakon & Kawa (Czakon, Kawa, 2018), Olko (Olko, 2023) confirm that. Interdisciplinarity allows for better understanding of the problem of inter-organizational cooperation which grew on (Ratajczak-Mrozek, 2017):

- social exchange theory (Blau, 1968; Cook, Emerson 1978, Granovetter, 1973);
- interorganizational theory (Thompson, 1978; Brunson, 182; Gulati, Garigulo, 1999);
- new institutionalism with some general economic studies (Penrose, 1959; Richardson, 1972).

As it has been emphasised, various theories influenced understanding and development of the network approach. Numerous social and behavioural studies are important sources of inspiration. In the research on networks there are noticeable links towards inter-institutional theory and institutionalism. Fundamentals in microeconomic theory (Williamson, 1975) had a significant influence on the development of the network approach. Even if the transaction-based approach initially overlooked relationships, its purpose was to explain phenomena similar to the network approach, i.e. economic exchange (Coase, 1937). Since the late 80's of the last century, researchers have been recognising enterprises as conditioned by the network of relations, not as a completely autonomous entity (Czakon, 2012). Therefore, the key to consider the networks is relations the essence and functions of which are presented in Figure 1.



**Figure 1.** From company to network - critical issues in coping with business relationships.

Source: Håkansson, Snehota, 1995, p. 47.

To describe the relations, three interrelated perspectives (enabling the creation of description) of the relationships are being used. In case of a single enterprise, actions are being undertaken within the limits of its structure (using accumulated resources). Bilateral relations are based on related operations which use connections (often formal) between the actors and connections between the resources. In case of networks, we deal with models of enterprises based on constellation of available resources and network of actors. For each of the layers in the model a set of basic propositions is offered and a number of empirically based conclusions about the nature of interaction are drawn, such as about resource interaction as an evolutionary process, about activity interaction as balancing processes and about actor interaction in a narrow and wider network context (Håkansson, Snehota, 1995).

Detailed considerations on inter-organizational cooperation are being based on a few theories:

- transaction cost theory (Williamson, 1975),
- the resource-based view (Pfeffer, Salancik, 1978; Barney, 1991),
- the theory of industrial organization (Tirole, 1988),
- the theory of competitive positioning (Porter, 1980),
- the network theory (Borgatti, Foster, 2003).

Using these theories in practice assumes that the inter-organizational networks are usually associated with additional possibilities of gaining strategic advantage. Arguments for improvement of strategic position of the network, and separately its entities, are i.e.: full and fast information flow between the apexes of the network (Miles et al., 1978), better, than in case of individual organizations, access to rare and valuable resources (Gulati, Garigulo, 1999),

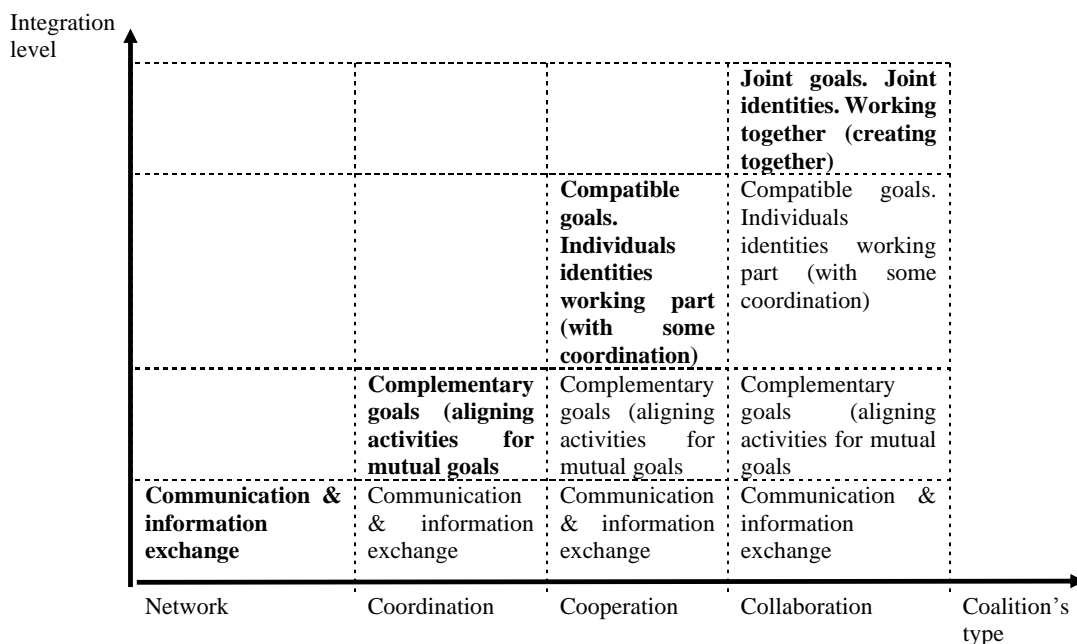
occurrence of synergistic effect in collective actions (Burt, 2002), benefits resulting from exchange of knowledge and experiences, obtaining a network rent (Niemczyk, 2013).

Inter-organizational networks - just like organizations - are prone to changes over time. This is related to maturation of networks, especially in terms of cooperation. Studies on the networks and their level of maturity were presented by Schöttle (Schöttle et al., 2014). Based on the literature, they distinguished the following factors estimating the maturity of cooperation: willingness to compromise, communication, commitment, trust, transparency/information exchange, knowledge sharing, willingness of client to take risk, independences between partners, control, coordination, conflict potential. An interesting interpretation of maturation of inter-organizational networks was presented by Machnik-Słomka & Kordel (Machnik-Słomka, Kordel, 2012). In their opinion, the inter-organizational networks at the emergence stage are characterised by searching for the inter-organizational connections and complementary resources for identifying, designing and implementing the inter-organizational value creation chains. Seed networks are characterised by new value creation chains, undeveloped inter-organizational relations structure, high fluctuation of networks' entities, implementation of radical changes, presence of highly developed technologies and high uncertainty both in the field of actions undertaken and the entities themselves. The inter-organizational networks tend - at the stage of growth - to focus on reinforcing and rising the efficiency of already existing value creation chains, rather than searching for the new ones. Growth networks are characterised by developed value creation chains with a big growth potential, stable structure of the inter-organizational relations, implementation of incremental innovations and stability of the behaviour of networks' entities (Knop, Brzóska, 2016). Mature networks are created by well-defined and consolidated value creation chains with low growth potential. Entities of such networks are very well distinguished (well-established leaders of networks appear), structure of inter-organizational relations is firmly solidified, applied technologies are mature, management procedures become consolidated and later on reproduced behaviour patterns.

More synthetic analysis of networks was presented by Czakon (Cakon, 2015). According to his assumptions, network research is characterized by specific features. The first of them is the view on networks from the perspective of network governance, so-called multiple coordination (Czakon, 2008). In the pure form, this characteristic means intentional forming of coordination mechanisms of many actors. Cooperation leads to formulation of an opinion that „strategy in the network approach is a collection of actions oriented at optimal contract management from the point of view of the stakeholders” (Niemczyk, 2013). The second characteristic is the network rent (Niemczyk, 2013) which is oriented at identification of: achievable surplus resulting from functioning in the network, sources of this surplus, methods of protecting it from copying by competitors, methods of appropriating it by companies. Networks in that area open brand new exploration field. Sources of advantage move from the inside of organization to outside of it where they focus, among others, on: individual

connections, their systems and ways of organizing the cooperation. The third characteristic takes the sociological perspective through an analogy to social networks and close connection with human economic activity (Granovetter, 1985). The discriminant can be described as structuralism because it examines such measures of the networks as: size of the network – measured by number of nodes, – density of the network – measured by number of connections, and heterogeneity – measured by diversity of nodes and connections. The fourth characteristic of the networks research – as stated by Czakon – is seeking for the competences of forming the relations with surroundings of sources of competitive advantage (Klimas, 2013; Stachowicz-Stanusch, Aleksander, 2017).

Slightly different approach in the research was proposed by Camarinha-Matos (Camarinha-Matos et al., 2008). Characteristics of maturation of the cooperation process, as a part of the inter-organizational network, was measured by them primarily with the indicator of integration (see Figure 2). The assumptions of such approach were used in the further part of the article, focusing on the development of networks' characteristics as well.



**Figure 2.** Interaction maturity levels.

Source: Camarinha-Matos et al., 2008.

Using the model presented on the figure, each of the maturity stages of cooperation covers (Polenske, 2004; Camarinha-Matos, Afsarmanesh, 2008, Czakon, 2015, Amici, Bietti, 2015; Kotzab et al., 2019; Wankmüller, Reiner, 2020). Ghasemi et al., 2023):

- Networking - at the initial stage of network cooperation, we deal with development of communication process and information exchange oriented on mutual benefits. This is the time for identification of entities functioning in the network, development of tools aiming for the information exchange, presentation of offers, organization of seminars and conferences oriented on realisation of shared activities. There doesn't

necessarily exist a common goal or structure which influences the participation of individual members, therefore there is no shared value generation. At this stage we study parameters of the network and assess the possibility of creating network competences.

- Coordination of the network – in addition to information exchange, at this stage, coordinated actions are proposed in order to achieve more effective results. Cooperation that has been undertaken within the network adopts certain organizational forms, common associations are being instituted, coordinator is being appointed or constituted, tasks are being assigned to complementary contractors. Coordination is an act of harmonious cooperation, searching for common suppliers, creating a business support system, organising cyclical meetings, indicating the fields of common actions. However, it is assumed that each entity may have a different goal and use its own resources and methods for value creation. Network structuralism is being strengthened.
- Cooperation - includes not only information exchange and adaptation of actions, but also sharing the resources in order to achieve consistent goals. Cooperation is being achieved by division of tasks and resources exchange. In this case, aggregated value is the result of addition of specific „components” of values generated by various participants in a quasi-independent manner. Traditional supply chain based on relations with suppliers and predefined roles in the value chain is an example of the process of cooperation between its components. Each participant does his/her part of work in a quasi-independent manner (although coordinated with others). There is a common cooperation development program that assumes realisation of common projects. The role of coordinator is strengthened and individual goals are compatible in such a way, that their results may be added or created in the value chain leading to the final product or service.
- Collaboration - a process in which entities share their information, resources and responsibilities in order to plan, implement and evaluate actions together with the aim to achieve a common goal. This concept is perceived as a process of joint creation; the process in which a group of entities increases their capabilities. This means sharing the risk, resources, responsibilities and rewards. Cooperation includes mutual involvement of participants in order to solve the problem together (which embodies mutual trust and therefore requires time, effort and dedication). Individual contribution in value creation is hard to determine. The effect of the functioning of the network is visible and the individual contribution into creating the value is much more difficult to determine.

Research on inter-organizational collaboration has focused on two main areas (Le Penne, Raufflet, 2018):

- organizational motivations for collaborating: organizational image, knowledge transfer and creation, innovation, access to networks, market intelligence;
- identification of key success factors.

Based on the idea of learning through collaboration and cooperation some researchers define inter-organizational collaboration and inter-organizational cooperation differently, showing the differences between these terms. Inter-organizational collaboration refers to relations between business partners wherein each company attains benefits and learns from the partners in order to achieve their goals more effectively. Within the scope of the inter-organizational collaboration, the companies remain autonomous and their relations can be broken any time without an impact on the goals of single companies. In case of the inter-organizational cooperation, the companies cooperate in order to achieve a common goal. In such relations, none of the parties can effectively compete without a continuous input of the remaining partners (Albani, Dietz, 2009). Roschelle & Teasley (Roschelle, Teasley, 1995) describe cooperative work as a task that is accomplished by dividing it among participants, where “each person is responsible for a portion of the problem solving,” and they see the collaborative work as “the mutual engagement of participants in a coordinated effort to solve the problem together”. Following this path, we try to understand the differences between cooperation and collaboration. Interesting research results in this area are presented by Schöttle (Schöttle et al., 2014), who have analysed over 40 papers in order to compare the terms cooperation and collaboration. Table 1. presents the research results and differentiates some criterions of comparison between these two terms.

**Table 1.**  
*Comparison of the terms: cooperation and collaboration*

<b>Main criteria</b>	<b>Cooperation</b>	<b>Collaboration</b>
<b>Authority</b>	Retained by each organization	Determined by new structure
<b>Control</b>	Central	Shared and mutual
<b>Cost affection</b>	Lower transaction costs	Lower adaptation costs
<b>Economies of scale</b>	External	External
<b>Information</b>	Exchange according to needs	Key, shared and using
<b>Leadership</b>	Unilateral	Dispersed, supportive
<b>Organization</b>	Separated	New and jointly developed
<b>Planning</b>	Separately	More comprehensive
<b>Relationship</b>	Informal	Informal and formal
<b>Resources</b>	Separated	Pooled and shared
<b>Rewards</b>	Separate	Shared
<b>Risk</b>	Virtually no risk	Pooled and shared
<b>Structure</b>	Less flexible, not commonly defined	New and clearly defined, jointly developed, shared
<b>Trust</b>	Not necessary	Necessary
<b>Value generation</b>	By various participants	Jointly
<b>Vision/mission/goal</b>	Independent	Common

Source: Schöttle et al., 2014.

While reviewing international literature, we can find various definitions of the word „cooperation” referring to the words used in English language interchangeably – “cooperation” and “collaboration”. Mattessich and Monsey (Mattessich, Monsey, 1992) define cooperation as „informal relations which exist without any common mission, structure or effort of planning”, whilst collaboration is perceived as „separated organizations with new structure and full



commitment towards common mission". Others describe collaboration as „creating dynamic links without the need for having a predefined role structure" (Sioutis, Tweedale, 2006). While analysing the table, we compare two columns which describe Cooperative Network and Collaborative Network. In the first one, we can find: information exchange, communication, compatible goal (which according to the definition of Polish Language Dictionary means „capable of interacting with another factor, element, without causing interference; complementary; compatible with something"), on which each entity works independently, with the element of the whole process coordination, designed by one entity, which requires low level of cooperation. Kumar & van Dissel (Kumar, van Dissel, 1996) assume that an increased level of independence enhances conflict potential which results in the need of coordination. This means that cooperation has a higher conflict potential than collaboration - because the level of independence in cooperation is higher than in collaboration. The second column represents Collaborative Network - a higher level - characterized by common goal, interactive contribution of participants, high quality relationships between the stakeholders. It is a process in which the entities share their information and resources with an intention to reach the common goal. When the process of common creation means risk sharing, it implies mutual trust, therefore requires time, effort and dedication. Such an approach may be an obstacle against quick reaction of e.g. research partner and while entering into cooperation with the industry. Collaboration level requires potential partners to be prepared beforehand and be able to participate in such a collaboration. Such readiness includes compatibility in terms of the usage of infrastructure, common operational rules and collaboration agreement. Collaboration is strongly correlated with „soft" characteristics. Trust, communication, commitment, knowledge sharing and information exchange are strong factors. This shows that collaboration will not occur immediately, automatically. It requires maturity both parties' maturity, development process, and is strongly connected with cultural factor based on relations and transparency of both parties (Gulati et al., 2012).

Some researchers take the hierarchical approach while defining these terms. They believe that collaboration describes relationships between partners whose tasks are already coordinated (here, coordination is sometimes perceived as a next step further, after cooperation). Different approach defines coordination and cooperation as the basis for collaboration because it offers the highest level of commitment, trust and information sharing. Sometimes the distinction of these terms is related to the level of trust and commitment, length, quality and proximity of relations, willingness to share the information and level of quality of common partnership in management. Therefore, we define the terms of cooperation and collaboration based on literature as follows:

- Cooperation is an interorganizational relationship between participants of a project, which are not commonly related by vision or mission. This results in a separate project organization with independent structures, where the project culture is based on control and coordination in order to solve problems independently and to maximize the value of the own organization.
- Collaboration is an interorganizational relationship with a common vision to create a common project organization with a mutually defined structure and a new (and jointly developed) project culture. This is based on trust and transparency; with the goal to jointly maximize the value for the customer by solving problems mutually through interactive processes, which are planned together and by sharing responsibilities, risk and rewards among the key participants.

In both of the cases above, we talk about the realization of common projects and the commitment of their actors. However, reaching the stage of collaboration requires major commitment from actors. It should be noted, that not every cooperation will turn into collaboration. There arises a question, is it possible in case of university-business cooperation?

### **3. Conceptual Framework**

Engagement of the scientific participants and orientation on the needs of the economy is important and strongly underlined in the national and international policies, as well as in the new development programmes of research entities. Collaboration between universities and the industry sector must become a closely specified part of the institutional mission and the organizational development plan of a university. It should be positively assessed when evaluating institutions and employees and it cannot hinder academic career paths. That is why a well-designed organizational support mechanism with an especially prepared interdisciplinary research plan is a chance for a long-term collaboration.

It is obvious that universities play the key role in the social and economic development of both countries and regions. Evidence suggests that a successful mobilization of the university's resources may have a disproportionately positive impact on the national and regional economics as well as on the comprehensive strategies of development. The bigger the aspiration of a university to become a world-class one, the more it is willing to engage in global projects in terms of dimension and character. In this area certain models characterising universities have emerged (Guimón, 2013):

- Leading American and British universities conduct researches on global civilization challenges. This is a part of their tradition but it also contributes to their position in rankings, ensures high level of publication citation and creates competitive advantages that are particularly important when the results of the research are patents, licenses and products for which the demand is global;
- Major part of European and Japanese universities engage in global scientific projects provided that the area of research is compatible with priority areas of national or regional economy development. Thanks to that, universities can count on support from national and regional research funds coming from both private and public sources.
- In certain, closed national systems, universities which are not considered as “elite” try to elevate their position by preparing a perfect didactic and research offer that is oriented towards foreign recipients and students. Their studies concentrate on regional issues.

The priorities and scope of university-industry collaboration differ significantly between developed and developing countries, as shown in Table 2.

**Table 2.**

*Different priorities of universities at different stages of economic development*

<b>Type of university</b>	<b>Most developed countries</b>	<b>Least developed countries</b>
<b>Research University</b>	<ul style="list-style-type: none"> <li>– Research consortia and long term research partnerships to conduct frontier research</li> </ul>	<ul style="list-style-type: none"> <li>– Building absorptive capacity to adopt and diffuse already existing technologies</li> <li>– Focus on appropriate technologies to respond to local needs</li> </ul>
<b>Entrepreneurial University</b>	<ul style="list-style-type: none"> <li>– Spin-off companies, patent licensing</li> <li>– Entrepreneurship education</li> </ul>	<ul style="list-style-type: none"> <li>– Business incubation services</li> <li>– Entrepreneurship education</li> </ul>
<b>Teaching University</b>	<ul style="list-style-type: none"> <li>– Private participation in graduate programs</li> <li>– Joint supervision of PhD students</li> </ul>	<ul style="list-style-type: none"> <li>– Curricula development to improve undergraduate and graduate studies</li> <li>– Student internships</li> </ul>

Source: Guimón, 2013.

According to the textbook S3 (Kempton et al., 2013), the concept of entrepreneurial discovery (Martínez-López, 2013), the exchange knowledge (Ankrah, Al-Tabbaa, 2015):

- Universities can play a key role in defining a regional S3 by contributing to a rigorous assessment of the region’s knowledge assets, capabilities and competencies, including those embedded in the university’s own departments as well as local businesses.
- Universities can contribute to the regional entrepreneurial discovery process by bringing global awareness and partnerships across regional borders into the frame through evidence-based identification of competitive advantages around which regional strategies and resources can be concentrated.
- Universities can provide a specialist research expertise and links to national and international networks of knowledge, becoming critical agents in the entrepreneurial discovery process and establishing whether a region has the assets needed to specialise in particular areas.

- Through their teaching programmes (including Continuing Professional Development and Lifelong Learning as well as under and post graduate courses) universities can enhance the skills and competencies of staff working in the field of economic development through training, consultancy services and supply of graduates, thus improving the capacity of the region to deliver S3.
- On the demand side, while a university or universities are located in a specific region there might be a limited absorptive capacity in local enterprises, especially SMEs or the branches of multinational companies with no local in-house R&D. Universities can contribute to a process of building capacity on the demand side through new businesses and student enterprises formation, and graduate placements as well as encouraging staff to actively engage in the cooperation with local businesses.
- In terms of institutional leadership and governance, particularly in regions where local government is fragmented and unable to act beyond its own immediate boundaries, universities as the key anchor institutions can play an important role in building the social relations which underpin the regional innovation system for the formulation and, in fact implementation of S3.
- Furthermore, in order to meet major societal challenges (that have both global and local dimensions), such as how to move towards a low carbon economy or how to meet the needs and realise the opportunities of ageing population, universities can contribute to local knowledge creation and its transition into innovative products and public or private services. Creative artists, social scientists and technical and industrial scientists may be involved while addressing the challenges stated above.

It is claimed that a university may play a bigger role in innovative societies based on knowledge. Moreover, it can use the knowledge produced by itself which provides a new way of knowledge generation (Ryszko, 2016). Experience of various countries show that universities are an important driver of economic development and contribute to social and economic development. However, it is a successful cooperation of an industry with universities that must support missions and incentives of each of the partners. University and industry are two different systems with distinct goals. The goal of improvement of cooperation between university and industry should not be to reverse the roles of these entities, so that the university becomes the industry and/or vice-versa. It should be accepted that both parties in this process are driven by different motives and goals (Table 3).

**Table 3.***Motivations for universities to enter into relationships with industry*

<b>Motivators</b>	<b>Universities</b>	<b>Industry</b>
Necessity	<ul style="list-style-type: none"> <li>– Responsiveness to government policy</li> <li>– Strategic institutional policy</li> </ul>	<ul style="list-style-type: none"> <li>– Responsiveness to government initiatives/policy</li> <li>– Strategic Institutional policy</li> </ul>
Reciprocity	<ul style="list-style-type: none"> <li>– Access to complementary expertise, state-of-the-art equipment and facilities</li> <li>– Employment opportunities for university graduates</li> </ul>	<ul style="list-style-type: none"> <li>– Access summer internship or hiring for students</li> <li>– Hiring faculty members</li> </ul>
Efficiency	<ul style="list-style-type: none"> <li>– Access to funding for research (Government grant for research &amp; Industrial funding for research assistance, lab equipment, etc.)</li> <li>– Business opportunity, e.g. exploitation of research capabilities and results or deployment of IPR to obtain patents</li> <li>– Personal financial gain for academics</li> </ul>	<ul style="list-style-type: none"> <li>– Commercializing university-based technologies for financial gain</li> <li>– Benefiting financially from serendipitous research results</li> <li>– Cost savings (easier and cheaper than to obtain a license to use foreign technology)</li> <li>– National incentives for developing relations such as tax exemptions and grants</li> <li>– Enhancing the technological capacity and economic competitiveness of companies</li> <li>– Shortening product life cycle</li> <li>– Human capital development</li> </ul>
Stability	<ul style="list-style-type: none"> <li>– Shifting to the knowledge based economy (broadening the knowledge)</li> <li>– Discovering new knowledge/test application of theory</li> <li>– Obtaining better insights into curricula development</li> <li>– Exposing students and faculty to practical problems/applied technologies</li> <li>– Publication of papers</li> </ul>	<ul style="list-style-type: none"> <li>– Shifting to the knowledge based economy (broadening the knowledge)</li> <li>– Business growth</li> <li>– Access to new knowledge, cutting-edge technology, state-of-the art expertise/research facilities and complementary know-how</li> <li>– Multidisciplinary character of leading edge technologies</li> <li>– Access to research networks or pre-cursor to other collaborations</li> <li>– Solutions to specific problems</li> <li>– Subcontract R&amp;D (for example due to lack of inhouse R&amp;D)</li> <li>– Risk reduction or sharing</li> </ul>
Legitimacy	<ul style="list-style-type: none"> <li>– Societal pressure</li> <li>– Service to the industrial community/society</li> <li>– Promotion of innovation (through technology exchange)</li> <li>– Contribution to regional or national economy</li> <li>– Academics' quest for recognition or achievement of eminence</li> </ul>	<ul style="list-style-type: none"> <li>– Enhancement of corporate image</li> </ul>
Asymmetry	<ul style="list-style-type: none"> <li>– NA</li> </ul>	<ul style="list-style-type: none"> <li>– Maintaining control over proprietary technology</li> </ul>

Source: Ankrah, AL-Tabbaa, 2015.

Different features of these two systems must be administered, coordinated or moderated in such a way which will ensure the value-addition and enhance innovative processes that are being created. What does work, are the interactive models based on the definition of collaboration in which mutual work of scientists and industry experts may ensure more favourable cooperation results than in the traditional approach where connections are determined through contract research, consultations and supply of services. In such scheme usually it is the industry that defines the problem, whilst a scientist or a group of university scientists offer their solution options. However, this approach is limited to short-term ad hoc problems only and does not include long-term, well designed technological strategy. Clear strategies, plans and decisions based on a common concept that combines various approaches based on the strengths of entities (considering also specific economic and social environment), are certainly more promising and closer related to the assumptions of collaboration than letting everything be dependent on coincidence only.

The option of collaboration is especially important in dynamic and uncertain environments in which unusual situations require coordinated actions (Blomqvist, Levy, 2006). Collaboration is crucial in the process of creation and knowledge transfer. The role of collaboration is highlighted in the markets based on technology, where we deal with uncertainty and technological or organizational complexity and, as a result, a high need for creating information and knowledge (Tyler, 2001). Collaboration is based on voluntary interaction, trust and commitment, on the contrary to cooperation which is based exclusively on external motivators such as money. Cooperation as a form of action, based solely on external motivation and economic justification is not enough when dealing with today's global, knowledge-based competition. The idea that allows and explains many successes in creating the knowledge and innovation is based on collaboration. It emphasises relational aspects, it is clearly multidimensional - trust, communication and dedication are the key factors distinguishing relational exchange (collaboration) from transactional exchange (cooperation) (Blomqvist, Levy, 2006).

In order to present the process of cooperation development and science-business relations, the concept of distinguishing the level of integration from identification and/or creation of networks of organizations (with a purpose to make a collaboration) was used. Four levels of integrity have been distinguished in this regard: networking, coordinated networking, cooperation and collaboration. The cooperation development process was described based on four distinguishing features of inter-organizational networks, i.e. network governance, value, structuralism and network competence. Details are presented in Table 4.

**Table 4.***The process of maturing of cooperation between science and business.*

<b>Main criteria</b>	<b>Networking</b>	<b>Coordinated networking</b>	<b>Cooperation</b>	<b>Collaboration</b>
Network management	Communication and information exchange. No coordination system. Identification of key network actors.	By appointing the coordinators or determining coordination principles, the access to complex University units is easier to get. They become more open through the creation of internal organizational structures. Formation of social relations (e.g., conferences, meetings, social networks).	The coordination system based on participation, engagement of each of the cooperation parties.	Working together (Creating together). Coordination system based on participation, engagement of each of the cooperating parties, joint responsibility. Effectiveness and transparency.
Value (network rent)	Within the science – business relations it is present in a minimum degree. In business, the reduction of transaction costs is noticeable and the synergy effect is obtained based on the value chain.	Goals based on complementarity. Rental aligning activities for mutual benefit. The synergy effect by way of the value workshop – built based on the university - business feedback. Transfer of university-generated IP (such as patents) to firms (e.g., via licensing).	Compatibility of goals. Individual identities. Working apart (with some coordination). Network effect perceived as multiplication of connections (simple summing of nodes potentials). Development and commercial exploitation of technologies pursued by academic inventors through a company they (partly) own (spin-off companies).	Joint goals. Joint identities. Working together (Creating together). Joint responsibility. Network effect - connecting another sets to the network, increasing the value of the whole network as well as individual sets. Inter-organizational arrangements for pursuing collaborative R&D, including research consortia and joint projects.
Structuralism	Network actors are identified, actions nodes emerge. Diffusion of knowledge transferred within hierarchical knowledge diffusion process.	Increased number of actors and frequency of relations, especially within the scope of commercialization ecosystem development. Diffusion of knowledge using the system approach instruments, empowered by e-communication tools.	Noticeable ecosystem of scientific effects of commercialization. Diffusion of knowledge using the holistic approach instruments.	Hub is created wherein organizations, employees and the society are characterized by proper closeness and frequency of relations. Diffusion of knowledge using the complexity instruments theory. Shared infrastructure: using university labs and equipment by firms, business incubators, and technology parks located within universities.

Cont. table 4.

Network competences	Identified competences of entities supporting the development of the science-business relations	Special ecosystem is created and is related to the commercialization of the research results. There are new competences merging the needs of the science and business (e.g. technology or innovation brokers). Using the codified scientific knowledge within the industry.	Competences of the ecosystem actors are clearly defined. The synergy effect is obtained through their addition. Training of industry employees, internship programs, postgraduate training in the industry, secondments to industry of university faculty and research staff, adjunct faculty of industry participants.	Development of network competences is natural. Resources and skills are used for research works. Research-related activities commissioned to universities by industrial clients, including contract research, consulting, quality control, testing, certification, and prototype development.
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Source: own elaboration based on (Czakov, 2015; Organa, Niemczyk, 2017; Klimas, 2013).

The next stages of maturity of cooperation between science and business university-industry collaboration involve:

- Networking. At the initial stage of network cooperation, we deal with the development of communication process and exchange of information oriented on mutual benefits. This is the time for identification of business environment institutions. Competences of entities supporting the development of science-business relations are identified. At this stage, the key value is to find out about the needs of the scientific and business community and to build a climate of cooperation.
- Coordination of the network. Cooperation that has been undertaken in terms of the network adopts certain organizational forms. Associations or, e.g. special purpose vehicles (SPV) are established. They serve primarily to commercialise R&D results and facilitate the university's contacts with business. A particular ecosystem of commercialisation or innovation is being created, where new competences are being developed. They combine the needs of science and business (e.g. technology or innovation brokers). A network effect is achieved through an understanding of the complementarity of activities and the implementation of - mostly - single science-business or business-science projects. However, it is assumed that each entity may have a different goal and use its own resources and methods of creating values.
- Cooperation. It includes not only information exchange and adaptation of actions, but also sharing the resources in order to achieve compatible goals. Cooperation is being achieved through division of tasks and exchange of resources. The aggregated value is the result of addition of specific „components” of values, which are generated by the business and university. A joint programme for the development of cooperation is developed, involving the implementation of joint projects on which each entity works independently, with an element of coordination of the whole process, designed by one



entity. However, the role of coordinators is strengthened, e.g. special purpose vehicles (SPV) and new ecosystem actors (like financing institutions, social and public partners) emerge. Examples of American, Israeli or German ecosystems show a large open community that creates the environment in which you work on your own projects. However, there are other people and entities around, implementing these innovations.

- Collaboration. A process in which business and university share their information, resources and responsibilities for a long-term cooperation and common projects. This step is perceived as a process of mutual creation. This means sharing the risk, resources, responsibilities and rewards. Cooperation covers mutual involvement of participants in order to solve the problem together. And that means mutual trust. The effect of the network operation is visible and the individual contribution into creating the value is much more difficult to determine. This process requires maturity of both parties – business and university - to be able to participate in such a collaboration. Moreover, it is strongly connected with cultural factor based on relations and transparency of both entities. International ecosystems create highly diverse, goal-oriented environments where cooperation between university and industry creates optimal mutual benefits and synergies. Universities, through the creation of external organisational structures, e.g. special purpose vehicles (SPV) become more open to the transfer of knowledge (which is existing at the university) and its use by business.

#### **4. Cooperation or collaboration – Polish case studies – results and discussion**

Science-business cooperation should be one of the most significant factors of innovative processes (knowing the expectations of both parties), let us take a look on what kind of cooperation in Poland we are talking about. In 2019, the first competition in the programme „Excellence Initiative - Research University” (IDUB) has been announced. „Excellence Initiative - Research University” (IDUB) is the key initiative of the 4-year long reform period of the Polish university education system implemented by the “Constitution for Science”. The 20 best universities that presented an ambitious development plan with a clear strategy to achieve the best results in studies and gain a good networking within the international community have been qualified for the competition. Ten universities - that will strive to attain the statute of a research university and will effectively compete with the best academic centres in Europe and in the world - have been selected. These are:

1. University of Warsaw.
2. Gdańsk University of Technology.
3. Adam Mickiewicz University in Poznań.
4. Stanisław Staszic University of Science and Technology in Cracow.
5. Jagiellonian University.
6. Warsaw University of Technology.
7. Medical University of Gdańsk.
8. Silesian University of Technology.
9. Nicolaus Copernicus University in Toruń.
10. University of Wrocław.

The „Excellence Initiative - Research University” (IDUB) was to present strategic operations - invented by Polish universities – which would raise the level of scientific studies and the quality of education and would also contribute to the increase of the international meaning of a given entity. The priority research areas are fields where the universities will perform intensified scientific operations. Their presentation is a sort of an invitation to collaborate with the industry sector; collaboration that can be characterized by innovativeness, flexibility and openness to a changing economic conditions. If modern companies want to implement their strategic goals related to innovation absorption, they should establish multi-level relationships with other entities, including scientific ones. Willingness to take advantage of the offer proposed by the universities will bring measurable benefits to all parties by concentrating on the fields and functions which each of the entities performs best. The brief characteristics of Polish Research Universities are presented in the table 5.

**Table 5.**

*Short characteristics of Polish Research Universities (research area)*

No.	Characteristics of Polish research universities.
1	<p><b>University of Warsaw</b>            It was established in 1816. Today, it educates 48 thousand students and offers over 100 faculties and specializations within the scope of humane, social, mathematical and environmental sciences. Archaeologists, astronomers, physicists and information technology engineers as well as specialists in other domains developed by the University of Warsaw on 21 faculties (and the remaining scientific and research centres) are very successful in their fields of study. Six Nobel Prize winners have studied at the University of Warsaw. It represents the following Priority Research Areas:</p> <ul style="list-style-type: none"> <li>• Earth science;</li> <li>• mathematical and information tools for big data analysis;</li> <li>• innovations related to new materials;</li> <li>• broadening the humane discipline limits;</li> <li>• searching for regional solutions to global challenges.</li> </ul> <p>UWRC Ltd. – Special Purpose Vehicle (SPV).</p>

Cont. table 5.

2	<p><b>Gdańsk University of Technology</b></p> <p>This University is the organizer of numerous national and international conferences, symposiums and seminars. The priority research areas are focused on the most promising directions of scientific research and implementation of innovations in Europe and around the world: health, safety, digital technologies and supporting technologies, climate protection, gaining and conversion of energy, mobility, food and rational utilization of natural resources. Since 2017, the university has been entitled to use the <i>HR Excellence in Research</i> logo. It represents the following Priority Research Areas:</p> <ul style="list-style-type: none"> <li>– Health;</li> <li>– Safety;</li> <li>– Digital technologies and supporting technologies;</li> <li>– Climate protection;</li> <li>– Gaining and conversion of energy;</li> <li>– Mobility;</li> <li>– Food;</li> <li>– Rational utilization of natural resources.</li> </ul> <p>EXCENTO Ltd. – Special Purpose Vehicle (SPV).</p>
3	<p><b>Adam Mickiewicz University in Poznań</b></p> <p>It is the home for almost 38 thousand students and 5 thousand employees. In 20 different discipline-oriented departments and 4 remote facilities (in Kalisz, Słubice, Gniezno and Piła) the university offers 80 faculties and 237 specializations of the 1<sup>st</sup> and 2<sup>nd</sup> degree and 50 post-graduate courses. Since the beginning of 2018, the university, together with 7 European universities, has been forming the EPICUR consortium within the scope of the European Universities network. Last year, the university scientists have implemented 595 research projects of a value equal to 279 million PLN and published almost 8 thousand papers, including: 1273 in magazines from the IRC list and 318 monographs. It represents the following Priority Research Areas:</p> <ul style="list-style-type: none"> <li>– life sciences, i.e. the field of biology, chemistry, physics;</li> <li>– exact sciences: mathematics, information technology;</li> <li>– humane and social sciences.</li> </ul>
4	<p><b>Stanisław Staszic University of Science and Technology in Cracow</b></p> <p>The university has been established in 1913 and opened in 1919. It educates at over 60 faculties within 16 departments. It offers education at the doctoral level and over 100 types of post-graduate studies. It employs over 2000 scientists, including 600 independent science employees. It uses 800 laboratories equipped with modern instrumentation. Reliable position of the university is confirmed by many successes in many international rankings. In the <i>Academic Ranking of World Universities 2019</i> (known as the Shanghai list) that presents 1000 best universities in the world, the University of Science and Technology in Cracow has been classified within the range 601-700, having the 1<sup>st</sup> place among Polish technical universities and the 3<sup>rd</sup> place on the general list of Polish universities. It represents the following Priority Research Areas:</p> <ul style="list-style-type: none"> <li>– Sustainable power technologies, renewable sources of energy and energy storages as well as resources management;</li> <li>– New technologies for the closed loop economy: combination of business models with eco-innovations;</li> <li>– Water-energy-climate: interdisciplinary approach to sustainable development;</li> <li>– Application of mathematics, information technology and electronic tools in solving the macro, micro and nano problems;</li> <li>– Biotechnology and bioinspirations in the engineering and materials science, biosensors, bioenergy, biocatalysis, biocomputers and biocalculations;</li> <li>– Smart information, telecommunication, computer and control technologies;</li> <li>– Designing, production, studies of modern materials and future technologies based on multidisciplinary approach;</li> <li>– Experimental physics of high energies, extreme states of matter, advanced technologies in detection of radiation, transdisciplinary studies and applications.</li> </ul> <p>Krakowskie Centrum Innowacyjnych Technologii INNOAGH Ltd. - Special Purpose Vehicle (SPV).</p>

Cont. table 5.

5	<p><b>Jagiellonian University</b></p> <p>The oldest university in Poland and one of the oldest in this area of Europe. It was founded by Kazimierz Wielki in 1364. Today, the university employs over 540 professors, 730 Philosophy Doctors (PhD), 2600 other people who are the teaching staff and over 3.5 thousand administration employees. It educates about 50 thousand students and doctors at 16 departments, including 3 medical departments that came back to the University in 1993 and form the so called Collegium Medicum. The university continuously improves and develops its infrastructure through the construction of: "Kampus 600-lecia Odnowienia Uniwersytetu Jagiellońskiego" (600 Anniversary of the Jagiellonian University Campus), Environmental Education Centre and Geology Institute, construction of new and modernization of the existing Paderevianum object for the Philological Faculty, complex modernization of Collegium Novum and the streets of the "University Block".</p> <p>It represents the following Priority Research Areas:</p> <ul style="list-style-type: none"> <li>- Heritage (cultural heritage);</li> <li>- FutureSoc (interdisciplinary studies on functioning of societies of the future);</li> <li>- BioS (structural and translational biology);</li> <li>- qLife (social and civilization diseases, reproductive health and regenerative medicine);</li> <li>- SciMat (advanced materials);</li> <li>- DigiWorld (digital technologies);</li> <li>- Anthropocene (global changes of the environment).</li> </ul> <p>INNOCEL Ltd. - Special Purpose Vehicle (SPV).</p>
6	<p><b>Warsaw University of Technology</b></p> <p>It began its independent operations in 1915. But its history is much longer - it has been educating generations of engineers since 1826 and brought its significant input into the development of technical sciences in Poland and around the world. This is a well renowned university which is built on numerous successes of its scientists, employees, students and graduates. New faculties, new laboratories, close cooperation with companies and foreign centres ensure the development perspective and the best technical education in the country.</p> <p>It represents the following Priority Research Areas:</p> <ul style="list-style-type: none"> <li>- photonic technologies;</li> <li>- artificial intelligence and robotics;</li> <li>- cybersecurity and data analysis;</li> <li>- biotechnology and biomedical engineering;</li> <li>- material technologies;</li> <li>- physics of high energy and technique of experiment;</li> <li>- energy conversion and storage.</li> </ul> <p>Instytut Badań Stosowanych Politechniki Warszawskiej Ltd. - Special Purpose Vehicle (SPV).</p>
7	<p><b>Medical University of Gdańsk</b></p> <p>For almost 75 years is has been providing high level of education within all medical professions. It runs scientific research at the highest, world-class level. The university educates over 6000 regular students, Ph. D. students and post-graduate students. There are 935 foreigners who represent 15 percent of all of the university's students. It is a modern academic centre recognized in the country and around the world. It represents the following Priority Research Areas:</p> <ul style="list-style-type: none"> <li>- oncology;</li> <li>- cardiology;</li> <li>- cardiovascular medicine;</li> <li>- biochemistry;</li> <li>- genetics;</li> <li>- molecular biology.</li> </ul> <p>Centrum Innowacji Medycznych Ltd. - Special Purpose Vehicle (SPV).</p>

Cont. table 5.

8	<p><b>Silesian University of Technology</b></p> <p>The oldest technological university in the region of Upper Silesia. It was established in 1945. The mission of the university, as a prestigious European technical university, is related to innovative scientific studies and development works, training highly qualified personnel in aid of the society and economy based on knowledge as well as active influence on the development of the region and local societies. The university, which is based on continuous improvement of processes and organizations, is a friendly and open area, designed for working and development of the academic society. Until today, the Silesian University of Technology has promoted over 200 thousand engineers. It represents the following Priority Research Areas:</p> <ul style="list-style-type: none"> <li>– computational oncology and personalized medicine;</li> <li>– artificial intelligence and data processing;</li> <li>– materials of the future;</li> <li>– smart cities, mobility of the future;</li> <li>– automation of processes and Industry 4.0;</li> <li>– protection of climate and environment, modern power engineering.</li> </ul> <p>Innowacje Politechniki Śląskiej Ltd. - Special Purpose Vehicle (SPV).</p>
9	<p><b>Nicolaus Copernicus University in Toruń</b></p> <p>It was established in 1945. It consists of 16 departments and the Interdisciplinary Centre for Modern Technologies. Today, 22 thousand students (more and more from abroad) study at the university that is the home for over 4 thousand employees. It offers studies within almost all disciplines of knowledge. Except the traditional study faculties, there is also medicine, arts and technical science. The medical faculties are located in Bydgoszcz. The university has its entities also far away from Poland: since 1975, there is a Polar Station on Spitsbergen Island) established by the University) and in Würzburg, Germany where the University has established the Polish Historical Mission. This university represents the following Priority Research Areas:</p> <ul style="list-style-type: none"> <li>– astrophysics and astrochemistry;</li> <li>– fundamental optics for biophotonic applications;</li> <li>– dynamics, mathematical analysis and artificial intelligence;</li> <li>– personalized medicine (interactions - mind, society, environment).</li> </ul> <p>Centrum Transferu Technologii UMK Ltd. - Special Purpose Vehicle (SPV).</p>
10	<p><b>University of Wrocław</b></p> <p>About 25 thousand students, Ph. D. graduates and post-graduate students gain their knowledge which is delivered by 2 thousand academic teachers and over 450 professors. The University of Wrocław is the leader among Polish universities (it is most often chosen by foreign students). Today, almost 1500 foreigners study at this University. It represents the following Priority Research Areas:</p> <ul style="list-style-type: none"> <li>– new materials;</li> <li>– big data;</li> <li>– artificial intelligence;</li> <li>– health - from the analysis of genes to designing medicine, human being between nature and culture;</li> <li>– human being - city and environment, multiculturalism.</li> </ul> <p>Centrum Innowacji i Transferu Wiedzy Uniwersytetu Wrocławskiego Ltd. - Special Purpose Vehicle (SPV).</p>

Source: own elaboration based on universities websites and interviews.

The chance to participate in the competition became an incentive to consider and show the priority research areas wherein intensified scientific operations will be performed and to analyse strengths and weaknesses of the university. Priority Research Areas organised by the universities in Poland, constitute an offer and invitation towards undertaking common actions. They may become a starting point for verification of the level of cooperation or collaboration at which we currently are and towards which we should strive.

At this moment - in Poland - the science-business relation can be characterized at the level of the coordinated networking – cooperation. There appear coordinators, e.g. goal oriented companies (acting at the universities) which create commercialization or innovation ecosystems (Knop, Odlanicka-Poczobutt, 2018). The effect of commercialization in the form of spin off or sale of licenses is based on a so-called value workshop that is built based on single university – business interfaces. Proposals and needs of interested parties are identified, however the network effect is not detected yet, because the present density of the network is not permanent and the relations are based on a case analysis (not on the ecosystem impact). The network competences are based on brokers. If mutual openness for cooperation is to acquire a special dimension and intensity in Poland, the next step needed is to build a local community open to connections and cooperation in international environments. Thinking in the aspect of, not dominating such place by one company but creating a system made up of network of companies, individual consumers, consumer communities cooperating with each other and creating value, is needed (Yigitcanlar et al., 2020). In such environments, knowledge is being disseminated amongst many players, and companies are encouraged to make use of available information and ideas of others. Cambridge Innovation Center (CIC) is an excellent example for creating technological societies and environment which favours cooperation between various groups of stakeholders. Its founder, Tim Rowe, said that "this is an environment that operates as a hub. You work on your own projects in it but there are other people around who introduce innovations and it is them, who most probably will be able to open for you the doors which cannot be open in a another way". Currently, there are seven centres of innovations, so-called District Halls, that create international ecosystem allowing to support entrepreneurs and respond to changing reality even faster. It is a place where people can work, exchange knowledge and build strong relations by associating each and every potentially interested party in the local ecosystem. Diversity of such entities is the key. Starting with individual entrepreneurs and scientists, inventors as well as small teams devoted to innovations and ending up with large corporations and representatives of the public sector. Accidental contacts within the innovative society can help understanding the meaning of existence of such spaces. There are infrastructural elements that enable such interaction available on the campus. The key is the so-called District Hall. In Boston, the central hub, is the place where people from around the city can meet, exchange knowledge, build valuable relations. This is the city that teems the economic life with a very high level of competition and continuous development of new ideas and new companies. The universities are the main motive power in Boston and the CIC is the catalyst that releases and binds the university studies and entrepreneurship with money from the investment funds. These centres require strong educational infrastructure with world-class universities, delivering new ideas through basic research, technological innovation and capital. At last, flow of ideas and people from other regions is needed, while innovators should be encouraged to stay in the region when being offered a high quality of life (Majava et al., 2013). In the District Hall, the communication problem disappears. An access to complex

university units becomes easier and the universities themselves become more open by creating internal organizational structures that have clearly defined interface and access to the outside world. It is this field, where universities will be able to play an important role, granted that they are capable of developing and offering new, suitable concepts of using expertise and skills and if they are able to realise projects for the selected industry target groups, based on identified strengths of the university. They could then organise their relations in the world more systematically. It is a complex, but highly diversified environment at the same time. It produces interactive goal-oriented processes, which are suitable for reinforcement of collaboration between the university and the industry, and creates optimal benefits and synergies. It is important not to perceive mutual interactions in a short-term perspective where the transfer of knowledge which already exists at the university can be reduced to a specific application and its use. Long-term horizon is the key. It will allow to generate processes and effective communication between entities involved in the District Hall, such as: science, economy, administration, financing institutions, social partners, public opinion.

Priority Research Areas proposed by ten universities in Poland also consist of aspects connected to the development of international cooperation. World-class universities open their campuses in the developing countries in order to engage themselves in research and development. It allows universities to use their reputation and knowledge globally, as exemplified by Georgia Institute of Technology, one of the best research universities in the USA, which established new campuses and research and development centres in France, China, Costa Rica, Ireland and Singapore. Research universities in Poland should also focus on the development of international potential through participation in international innovation systems. Creation of campuses and research and development centres will simplify close cooperation with local entities in terms of generation and dissemination of knowledge and technology. Above all, such creation will develop the value of collaboration defined by Schrage (Schrage, 1995) as „a process of common creation: two or more people with complementary interaction skills create shared understanding that was not possessed by anyone before and could not be created on one's own”.

Moreover, it should be emphasized that there are many regions in Poland in which, as a result of centuries of the history, many economic, social and environmental problems accumulated and these were related to the restructuring of the economy and often degradation of the natural environment. Thanks to the experience - gained already in the processes of economic and social transformation - and conditions, such as the network of adjacent cities, population density as well as technical infrastructure and industrial tissue, the Silesian Voivodeship may be the best example for testing and implementing solutions aimed at effective cooperation. These activities are multi-threaded and comprehensive. They can be analyzed in terms of increasing the attractiveness of cities, strengthening competitiveness, changing the image of the cities or even increasing the quality of life of residents. In order for the above tasks to be viable, it is necessary to constantly develop knowledge using the latest, advanced methods

in biology, biochemistry, hydrobiology, hydrogeology, biophysics and other natural sciences, but is also necessary to make compromises resulting from various management, social and economic decisions. Cooperation seeking collaboration should be based on proposing actions aiming at building a synergistic, regional system to support transformation processes by mobilizing and systematizing existing, dispersed human and organizational resources. This can be achieved, among others, by looking for development niches, popularizing new technologies (including within traditional industries) and their opportunities for further development, including testing processes and experimenting with different solutions and pilot activities. Moreover, the social dimension will be of key importance. Social dimension understood here as the identification of recipients of planned activities and services, analysis of needs and adaptation of tools to the expectations of those recipients. This will allow the inclusion of interested entities such as scientists, innovators, enterprises, urban activists and NGOs in project consortia focused on solving key problems and developing a collaboration-oriented model focused on transformation processes.

## 5. Conclusions

Fast-paced technical progress and globalization processes force entrepreneurs to invest in the access to new technologies and knowledge. If modern companies want to implement their strategic goals related to innovation absorption, they should establish multi-level relations with other entities, including scientific ones. Such collaboration allows for mutual complementation and improvement of operations related to development and introduction of new products and services to the economy. The will to use the offer proposed by the universities will bring measurable benefits to all parties by focusing on these areas and functions that are best performed by each of the entities. The university education system and business are different and thus are managed by different regulations, therefore it is necessary to remodel the approach to the contemporary universities. Nowadays, universities provide education based on the state-of-the-art scientific studies. Moreover, they put emphasis on practical application of know-how, where the collaboration at the contact point between science and business becomes one of the most important factors of innovative processes. However, entrepreneurs await transfer of knowledge performed by the people who have such knowledge.

The proposed cooperation maturity model between a university and a business is a solution based on the network integration process and description of such network discriminants as: network governance, value (network rent), structuralism, network competences. Cooperation between science and business striving for collaboration based on better understanding of commercialization processes of the research results, their innovativeness and adaptation to the needs of the economy and society. This does not preclude the individuality of the goals,



especially within the scope of research independence performed by scientists. Coordination process (network governance) is based on engagement, responsibility, effectiveness and transparency of entities. The developed cooperation principles, alike in case of the District Hall, create hub, wherein organizations, employees and the society characterized by proper closeness and density can meet, share knowledge or build valuable relations. This allows for creating special network competences that have strong positive impact on the technological cooperation scope between organizations and on the product innovative success or operations.

The authors of the study are aware of the limitations of the presented considerations. The article is of conducive nature and assumes deepening of the research in this area. The article is focused on searching for a way to collaboration within the science-business relationship. Detailed analysis of the cooperation maturation process in different countries will be the subject of next articles and studies. In case of Poland, that undergoes the process of significant changes in the area of science, this is the grounds for future operations. Moreover, comparative analyses allow for verifying the presented proposition of the cooperation maturing process in the science – business relationship.

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## PROSPECTS FOR POLAND'S SUSTAINABLE DEVELOPMENT IN THE CONDITIONS OF NEW GLOBALIZATION AND INDUSTRY 5.0

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**Purpose:** The article aims to assess the possibilities of Poland's future development in rapidly changing external conditions. Particular emphasis was placed on global economic problems.

**Design/methodology/approach:** The research is based on a critical analysis of the available literature on ongoing global economic changes and future studies.

**Findings:** The literature review concludes that the dynamics of the changes and uncertainty are growing. In addition to existing and well-identified threats, such as the growing risk of global conflict, migration, or increasing competition and tension in international relations, new challenges are being observed. They are related to the development of information and communication technologies, especially artificial intelligence, which permanently change interpersonal relations and communication methods.

**Originality/value:** Current and new development concepts, such as sustainable development and economy 5.0, mean that strategic concepts of the country's development should consider a new set of factors determining the effectiveness of economic development in the long term.

**Keywords:** new globalization, climate change, economy 5.0, sustainable development, Poland.

**Category of the paper:** Research paper.

### 1. Introduction

The work is theoretical and empirical. It concerns the scope, role, and mutual relations of challenges, factors, and barriers to the sustainable socio-economic development of Poland in the conditions of the changing nature of globalization and threats of the 21st century. These include rapidly progressing, catastrophic changes in the Earth's climate and environmental degradation, mainly due to irresponsible human activity. The first half of this century will bring further quantitative and structural demographic changes, growing migrations and wanderings of peoples, regrouping of the positions of superpowers and regional powers

and their competition, including military, for economic supremacy and political hegemony on land, oceans, continental shelves, and international straits, in the Arctic and Antarctica, in cyberspace, the Internet, and in space. Many countries and regions of the world are witnessing the degradation of democracy and the intensification of authoritarian, nationalist, and neo-imperialist tendencies.

Along with climate cataclysms and the accumulating effects of global warming, geostrategic and resource conflicts (the fight for access to drinking water, arable land, food, energy sources, and rare earth raw materials, etc.) as well as economic, financial, and social conflicts are growing, accompanied by movement of people from least developed countries and countries affected by natural disasters and war to richer and safer countries in the world. Rapid climate change and the mechanisms of power struggle are nothing new in human history. However, the growing population and the possibilities of modern technologies may threaten human life and the Earth's biosphere (Popkiewicz, Karda, Malinowski, 2018; *Climate Change...*, 2020; *Green Finance*, 2023).

## 2. Methods

The primary method used in the work was a critical analysis of the literature on economic development strategies, economic changes, and future studies. The study used texts written in Poland and abroad. That is due to the nature of the work, i.e., analysis of external conditions that relate to the future development of Poland. Both books and scientific articles from recognized databases of scientific articles were used.

The inference was made using the inductive method, which allowed for general conclusions to be made based on the collected information.

The described economic changes have been confirmed by appropriate statistical data. For this purpose, information from international databases, including the World Bank, OECD, UNCTAD, and UNDP, was used.

## 3. Results

The global financial crisis in the first decade of the 21st century ended the era of dynamic development of globalization and international trade processes, supported by the United States and international economic organizations of the United Nations system, including the World Bank, the International Monetary Fund and the OECD, acting following the neoliberal principles of the Washington Consensus, meeting has faced growing social criticism, especially



since the global financial crisis of 2008-2009 and its repercussions in the following years. We adopt the definition of globalization used by the Council of Europe, also used in practice, as: "increasingly closer economic integration of all countries of the world resulting from liberalization and, as a consequence, an increase in both the volume and diversity of international trade in goods and services, a decrease in transport costs, a growing international intensity capital penetration, the enormous growth of the global labor force and the accelerated worldwide spread of technologies, in particular communications (Eurostat, 2017, p. 8).

After the global financial crisis in 2008 and 2009, globalization took on a new character. The primary beneficiaries and leaders of the "new globalization" have become China and other countries with emerging markets and developing economies, which in the second decade of the 21st century have become the largest producer of goods and services and the fastest growing, at a rate of 4.5-5% per year, segment of the global economy. At that time, developed (economically advanced) countries slowly regained the production level from before the global crisis, growing at a rate of less than 2.5%. The first twenty years of this century brought profound changes in the world's economic structure and regions, accompanied by shocks, threats, and crisis phenomena. As a result of structural changes in various areas and cross-sections - geographical, population, production and goods, technology, military, trade, and finance, a significant reconfiguration of the economic and geopolitical global scene took place compared to the state of the last decade of the 20th century (Kotyński, 2019).

Different challenges and areas of activity also characterize the new globalization. The ongoing changes in civilization mean that, in addition to the real economy and finances, activities in the virtual sphere, especially those related to the use of information, begin to play an increasingly important role. The initial rapid growth of the Internet and the businesses using this technology was slowed by the financial crisis, but this did not last long. The benefits that economies and countries achieve from better access to information often begin to determine economic success. For this reason, we are observing subsequent stages of the development of the virtual economy, of which the development of information and communication technologies (ICT), e.g., 5G, autonomous vehicles, and artificial intelligence, should be considered the most breakthrough. The scale of these phenomena is so large that we are increasingly discussing a new stage of human development - the information civilization. Dynamic development processes mean that activities in the sphere of ICT are subject to intense competition and even espionage activities, thus creating another level of distrust in global relations.

Donald Trump's presidency in the United States, with slogans of limiting imports and reversing the tendency to transfer (relocalize) the main phases of production from the USA to China and other rapidly developing countries with emerging economies, low labor costs, and growing competitiveness, also in the field of modern branches of production and services, resulted in the disruption of international value chains, leading to price increases and a collapse in the import of essential components and products to the markets of the USA, Europe and other highly developed countries. That concerned, for example, medicines, food, and semiconductors

necessary for the electronics industry and the development of advanced communication technologies. The decline of globalization and the rise of isolationism were deepened by the outbreak of the COVID-19 coronavirus pandemic, the closing of economies, and the growing crisis in 2020. It also contributed to high inflation, which became visible during the recovery in 2021, stimulated by the loosening of economic policy, continued in many countries, including Poland, also in 2022-2023, after the intensification of the aggression of the Russian Federation against Ukraine and the introduction of economic sanctions against Russia by the U.S. and NATO countries. Producers and transnational corporations have used them to raise food and energy prices. These events and threats to the security of supplies and the crisis of confidence in cooperation with distant countries initiated a new phase of globalization - its temporary regression, uncertainty, and segmentation within allied and geographically and/or politically close groups of countries (e.g., BRICS or ASEAN), concentrated around the USA and China - rival superpowers of the 21st century.

Based on the above considerations, the new globalization should be considered through the prism of three factors: the shift of the center of economic development to developing countries, mainly in Asia, the rapid growth of technologies based on the use of information, and the growing distrust and even regression in international relations, which leads to segmentation of cooperation between countries and economies. As a result, the new globalization still causes an increase in the internationalization of economies. Still, it is selective, i.e., it is increasingly directed not globally but at the development of specific interest groups and alliances.

Global challenges and changes taking place in the world are also noticed in the European Union, which is trying to reconcile the latest trends in economic development with counteracting threats resulting from the destruction of the natural environment. The most expressive manifestation of this is the currently applicable development strategy of the European Union, i.e., the European Green Deal (European Commission, 2019a). One of its basic assumptions is to create a modern, sustainable, resource-efficient, and competitive economy in the E.U. (European Commission, 2019b). This new economy should also be just and inclusive for all. The reform is based on three general assumptions: achieving zero net emissions of greenhouse gases by 2050, economic growth decoupled from resource use, and no person and no place left behind.

Many specific strategies are intended to achieve these goals. One of them is Industry 5.0 (European Commission, 2021). It is a concept of economic development highlighting the critical role of changes in the industry. It recognizes that this sector can play a crucial role in providing solutions to reduce social problems, especially climate change. Industry 5.0 should be considered a development version of the earlier concept of Industry 4.0. The changes aim to increase the emphasis on sustainable development, human orientation and resilience in European industry. However, these three main components (Principal Components) of Industry 5.0 mentioned by the E.C. are not particularly new, e.g., in comparison to the definition of the

Emerald Economy, which is a condition for sustainable development, understood as a green economy linked to an innovative, democratic and pro-social economy. And purple, which also takes into account cultural and civilizational development factors. The concept and scheme of the emerald economy, with its attributes or pillars, are presented in the monograph (*Self Management...*, 2022), in chapter 2 (Kotyński, 2022a, p. 22).

The European Union defines Industry 5.0 as the key to achieving the future industrial economy. It is to be an economy focused on people and their needs, not production. At the same time, the new industry is to be as friendly to the natural environment and human health as possible (European Commission, 2022). That is changing the philosophy of the sector. That is not only about entering a new stage of development in which man will develop the economy and production based on the widespread use of information and adapting products to the needs of users but above all, Industry 5.0 is based on the recognition that man is an element of the natural environment and his actions must be consistent with the needs of nature and must not undermine the resilience of the environment. That means appropriate, effective use of available resources, reducing emissions of pollutants and waste, and caring for other species' well-being and survival conditions. The means to achieve this goal is to implement the assumptions of the circular economy concept to the greatest possible extent.

A manifestation of placing human development at the center of the Industry 5.0 concept is the recognition that the new economy, especially in the digital sphere, is to be the basis for creating a contemporary, modern society referred to in the literature as Society 5.0. However, unlike Industry 5.0, the concept of the new society does not come from the European Union but from Japan. It is assumed that Society 5.0 is no longer just an information society that commonly uses information resources available in the cloud but a society that uses the capabilities of artificial intelligence to identify critical data and even create proposals for solutions to many problems (Cabinet Office, 2023).

The creation, in two different parts of the world, of the mutually complementary concepts of Industry 5.0 and Society 5.0 and their broad approach has resulted in the idea of economy 5.0, combining these two concepts, being less frequently used in the literature. In practice, the Industry 5.0 concept goes significantly beyond industry problems and is more of an economy-wide concept. Its name indicates the essence of industry transformation to achieve new socio-economic goals.

#### **4. Discussion**

Nowadays, no country is able to develop without taking into account international conditions. That also applies to Poland, which, as a member of the European Union, must consider the changes taking place in its immediate and distant environment in its

development strategies. State development strategies, especially long-term ones, should be constructed in such a way as to flexibly respond not only to current but also future challenges, i.e., both opportunities and threats (Kleer, Prandecki, 2020). They should be the subject of thorough analysis, also on a global level, including results from membership in NATO - a global alliance.

As previously indicated, the new globalization is characterized by a shift in economic centers and an increase in distrust and tensions in the political sphere. Limiting or segmenting globalization (decoupling – Rodrik, Walt, 2022), caused by geopolitical and strategic considerations regarding economic and political security, generates costs that not all countries are willing to bear. In the case of NATO, this is visible in the actions of Hungary and Turkey, for which maintaining tensions related to the war in Ukraine is downright harmful. For Poland, however, economic and political cooperation with the USA and the Euro-Atlantic alliance, which increased its strength and numbers on the northeastern flank after the summit in Vilnius in July 2023, is critically important. Similarly, it is essential to improve and activate cooperation within the European Union and deepen economic and technological cooperation with democratic Asian countries, including the Republic of Korea, India, and Japan, while maintaining mutually beneficial relations with China. These are opportunities to strengthen Poland's security and resilience to threats to its sustainable development and modernization and strengthen its position in the global economy by supporting the energy transformation, increasing defense forces, and building a green economy. In Poland, threats to sustainable economic and social development resulting from global climate warming and the degradation of the natural environment and their effects are increasingly noticed and felt (*Science of Climate*, 2018), requiring participation in solidarity fight for the implementation of the decisions of the Paris UN Sustainable Development Summit of 2015 and agreements from subsequent years, as well as the creation and implementation of new development strategies and adaptation activities (Prandecki, 2023) to the future climatic situation - the beginning of a new era, threatening water scarcity, steppes of arable lands, migration of peoples and the influx of refugees to developed countries, exposed in their areas to lack water and food, as well as internal fights and armed conflicts, known from the history of humanity (Kotyński, 2019; Prandecki, 2022). These threats overlap with the harmful effects of expected demographic changes and slowdown in global development, including weakening the growth of gross global product - to approximately 2% in 2060 and convergence at this level of annual GDP changes in developed and developing countries, according to forecasts (OECD, 2018), today considered too optimistic.

On the other hand, the world is facing the prospect of breakthrough technological changes, progress in the digital economy (UNCTAD, 2019), and innovations, carrying potential development opportunities but also various types of risks that threaten the survival of humanity and the Earth's ecosystem. In the OECD's "positive" scenario (2018), the situation of developing and developed countries could be improved by maintaining free trade and carrying out deep

institutional and social reforms with the participation of the state, e.g., in the field of pension systems, supporting health and family protection, education policy and labor market, which would also help maintain the balance and security of public finances. Pandemic threats growing with globalization, and especially the outbreak of the COVID-19 coronavirus pandemic, have made citizens and governments aware of the need to give special priority to investments in social development (human development) related to the increase in expenditure on modern education, labor market development, health, and family protection. The World Bank report on world development, devoted to the new nature of work, showed how important a factor in maintaining sustainable economic and social development in the future are investments in human capital, especially in education and health care, as well as changes like human work. The Human Development Index was presented there, which measures the consequences of failure to invest in human capital resulting from the loss of productivity of the next generation of employees. The analyses suggest that in countries with the lowest investments in human capital, the labor force in the future will be only one-third or half as productive as it could be if the population of these countries enjoyed total health and received a full-fledged education (UNDP, 2019).

In the emerging era of new globalization and Industry 5.0, one of the conditions for maintaining sustainable development will be the flexible adaptation of countries and enterprises to the requirements of an innovative, pro-ecological, and pro-social economy, new forms of digitization and communication and the development of intelligent software (A.I. artificial intelligence), evolving with changes in clients' requirements. The role of education and social development (human development), necessary to meet new quality challenges in the national and global labor market and global competition, should increase. Operating in conditions of rapid climate, demographic, geopolitical, and social changes will require governments, entrepreneurs, and societies to have strategic thinking skills, adaptive capacity, and resistance to risk (resilience or antifragility: Taleb, 2012). On the other hand, current and future generations will be beneficiaries but also possible victims of the next wave of innovation and progress of Industry 5.0 in the field of technology, biotechnology, communication, and finance, as well as the growing use of artificial intelligence (AI) in many areas, including the military and safety.

Rapid changes in the geographical and political structure of production and population of the world, characterized by the growth of the position of China, India, and other countries in East and South Asia and the Pacific region in the first decades of the 21st century, including the years of economic and financial crises and pandemics, were accompanied by changes in the nature and the structure of globalization and the processes of international, regional integration - their institutional forms, configurations, structures, and leaders. We live in times of intensifying competition between the superpowers of this century - the United States of America and China, but also in a period of dynamic reshuffles on the geopolitical map of the world, resulting from the rapid growth of population and the power of regional, emerging

powers on various continents, as well as the loss of leading positions by some highly developed countries with market economies and former empires of the 19th and 20th centuries. Among contemporary powers, we can distinguish those that are faithful to the principles of liberal democracy and respect for human rights, and their power is of a defensive nature, related to participation or leadership in a democratic system of collective security, such as NATO, unlike authoritarian states whose neo-imperialism is of a nature expansionist, combined with the pursuit of global or regional hegemony, threatening the stability of the system of balance of power and international security (Kotyński, 2022b). In Europe, after three decades of complex transformation and the emergence of new powers on the world stage, in most democratic countries, the neoliberal economic paradigm of the Washington Consensus has given way to various varieties of the social market economy (Mączyńska, Pysz, 2020; Mączyńska, 2021) - declared, but to varying degrees implemented in practice. Such provisions are also included in the Constitution of the Republic of Poland of April 2, 1997. Soft power measures are still crucial for the position of individual countries in international relations but insufficient to ensure the security of respective peripheral, smaller countries (Nye, 2009), such as Poland and most European Union countries. Poland and other countries of Central and Eastern Europe, located on NATO's eastern flank, are particularly vulnerable to provocations, cyberattacks, the use of economic pressure tools, and other forms of hybrid warfare used by authoritarian neighbors seeking to weaken the unity and solidarity of EU and NATO countries. The European Union has a unique role to play for the political, economic, and social security of European countries as well as their reconstruction after the collapse caused by the COVID-19 pandemic and global turbulence, as it is implementing the most extensive package of measures in history to revitalize the European economy - the Recovery Plan for Europe - an economic reconstruction instrument worth over EUR 800 billion. The EU could play the role of collective power and an essential actor on the contemporary international scene while maintaining the sovereignty of member states. However, this would require overcoming the centrifugal, authoritarian, and nationalist tendencies, which are intensifying especially after Brexit, contrary to the principles of the rule of law and democracy, judicial independence, equality of citizens, freedom of association, organization of meetings, and freedom of the media, which have been present in some countries for several years in European Union, including Poland (Wilkin, 2017). Such conduct was inconsistent with the Treaties and fundamental principles of the Union, weakening its strength and integrity in a time of growing risk and global challenges while threatening the economic and social development and security of Member States. The resulting financial penalties and the threat of loss or delay in the inflow of E.U. funds increasingly burdened Polish citizens and were compensated by increasing taxes and an automatic "inflation tax", affecting the administration's representatives and supporters of the ruling right-wing conservative parties to the slightest extent. Poland's groundbreaking return to the path of democratic development and the rule of law, as well as deepening political, economic, and financial ties with other European Union countries, occurred as a result of the victory in the parliamentary elections achieved by

the democratic "October 15 Coalition" and the election of Donald Tusk as Chairman of the Council of Ministers in December 2023.

These events were generally consistent with the scenario of countries returning or entering the path of democratization, presented in the book by a professor of political science and international relations at George Washington University (Miller, 2021). This author used the most extensive qualitative and quantitative analyses of the democratization process, presenting "a new theory of democratization that focuses on how events such as coups, wars, and elections challenge autocratic regimes and trigger democratic change". Miller showed that since 1800, over 90% of democratic transitions have occurred in one of two ways: "countries democratize after a major violent shock or democratize through elections and regain power in a democracy".

## 5. Summary

The takeover of power in Poland by the democratic coalition at the threshold of 2024 took place in challenging external, internal, political, and social conditions, requiring overcoming the accumulated neglect and inequalities in meeting the material and health needs of the population after several years of inflation and increasing public debt. There is a need to quickly implement the necessary, costly reforms in many areas of state management and economic development towards a modern, green economy 5.0, using support from European Union funds. Fundamental and expensive are the investment needs and expenses necessary to strengthen the state's defense, to which at least 2% of GDP is to be allocated. That is required by the international situation, including the uncertain results of the U.S. presidential elections in the fall of 2024, and especially the devastating war ongoing in Ukraine, which threatens Poland as a result of Russia's criminal aggression in this country (Budzisz, 2023).

In such dynamically changing conditions, building development strategies should be based on analyzing the broadest possible spectrum of challenges, interpreted in the long term. Not only the previously noticed threats should be taken into account, but especially new ones for which there are no developed procedures. State institutions should prepare for them in advance, assuming that problems of this type will grow and not solve themselves. For this reason, in addition to the rapidly changing military security conditions, it is also necessary to consider the activities undertaken in the information space. In practice, most countries do not have tools to counteract widespread hate speech or fake news on the Internet. Typically, these types of threats are individual, but in the future, they may evolve even to a scale that threatens the state's existence.

The country's sustainable development should be holistic in nature, and development strategies should be aimed at maximizing profit and taking into account the needs of humans and the environment. That means that in the coming decades, we can expect rapid economic changes comparable to the 5.0 revolution, which will affect industry and the general perception of the economy and development.

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## STUDY OF EMERGENT PHENOMENA IN THE ORGANIZATION

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**Purpose:** The aim of this article is to draw attention to the specificity of emergent phenomena in organization and management, the study of which requires an approach derived from complex adaptive systems.

**Design/methodology/approach:** The article uses a critical analysis of research on emergent phenomena in organizations from the perspective of complex social systems. This analysis made it possible to distinguish types of emergence in organization and management depending on the type of agents (members) and interactions that take place in the organization and indicated the causes of emergent phenomena.

**Findings:** The article creates a research framework for complex emergent phenomena and shows how to use computer simulation to study complex emergent phenomena in organizations.

**Originality/value:** A relatively new direction of research analyzes within the theory of complex adaptive systems, the aim of which is to model and explain the behavior of systems of interconnected objects based on knowledge about the laws of individual elements (at the local level) and the structure of their connections. Therefore, it seems interesting to use computer tools developed based on complexity theory, especially agent-based models, as proposed in this article to study emergent phenomena in organizations. Since there are many approaches and ways of using computer simulations to study complex adaptation phenomena, a method of creating a simulation model and a method of conducting research using it were proposed.

**Keywords:** Emergent phenomena, Complex adaptive system, Organization and management, Agent-based models.

**Category of the paper:** Research paper, Literature review.

### 1. Introduction

Today's organizations are complex systems that consist of heterogeneous elements that interact with each other and with the environment that are difficult to understand, predict and control. Their characteristic feature is the ability to exhibit complex emergent properties.

This means that it is difficult to predict the effects of micro-level interactions on the system (organization) as a whole, even if the behavioral patterns of individual agents are known. However, usually the effect of interaction at the micro level is adaptation towards changes that will ensure survival in the environment and on the market. Moreover, in organizations, people or groups adapt to feedback on the behavior of others and act without clear coordination and central communication (Anderson, 1999; Maguire, McKelvey, 1999). Organizational members often form informal groups that function through local interactions without central control or management

Understanding and managing the internal complexity of an organization therefore requires strategies that go beyond traditional analytical methods. A new way of examining processes taking place in an organization is agent-based simulation (ABS) (Gotts et al., 2003). ABS allows you to recreate interactions between people within an organization or between organizations in a marketplace to assess the aggregate outcome of their behavior. The basis for studying organizations from the perspective using ABS is an attempt to explain the behavior of the entire system (at the macro level) based on the recognition of the rules of behavior of its components (micro level).

In this article, the concept of emergence from the theory of complex adaptive systems (CAS) is used (Kauffman, 2000; Axelrod, 1997; Axelrod, Cohen, 2000; Bonabeau et al., 1999). This approach is consistent with the proposed method of studying social phenomena in organizations based on computer modeling. The basis for researching organizations in the context of CAS is the perception of organizations as a complex social system. Numerous studies in the field of social sciences indicate that individuals are embedded in the networks of social relations and interactions (Borgatti et al., 2009).

According to Plsek and Greenhalgh (2001), CAS is a collection of individual agents with freedom of action, which is not always entirely predictable. In addition, agents are so connected to each other that the behavior of one agent changes the context for other agents. As emphasized by Mille and Page (2007) in CAS there are therefore units at the micro level that, through mutual interactions, form global system properties, which then, by feedback, affect the interaction at the micro level. In addition, CAS through interaction with the environment modifies its behavior, adapting to changes in the environment (Rammela et al., 2007; Rotmans, Loorbach, 2009). This behavior of the system is a manifestation of its adaptability. Complex adaptive systems are also characterized by emergence (Mitleton-Kelly, 2003). The system has emergent properties if its presence is new at the evolutionary level or at the physical level of the complexity of the system in which it occurs (Newman, 1996). It is the emergence of new and consistent structures, patterns and properties in the processes of self-organization occurring in complex systems (Goldstein, 1999). In the case of organizations or organizational management, it is difficult to predict the effects of interactions at the micro level for the organization as a whole, even if the behavioral patterns of individual members (elements) of the organization are known. The behavior of the organization as a whole is emergent.

It should also be noted that in such systems rules at the local level, i.e. at the level of individual units or networks of units, as well as the way they interact, are often more important than global directives. In addition, as Sanders and McCabe (2003) show, understanding of the local dynamics of the system can allow insight into the behavior of the entire system and help identify key reasons for changes and transformations.

The aim of this article is to draw attention to the specificity of emergent phenomena in organization and management, the study of which requires an approach derived from complex adaptive systems. Such an approach is computer simulation based on agents. The article shows that emergent phenomena, depending on agents/individuals and system behaviors/interactions, may occur at four different levels. Moreover, it was shown that ABM is an appropriate tool for examining emergent phenomena.

## **2. Emergent phenomena in the organization**

Emergence is the formation of new and coherent structures, patterns and properties in self-organization processes occurring in complex systems (Goldstein, 1999). Checkland (1981) defines emergent properties as those emerging from the system of human activity as a single whole, which results from the activities of the components and their structure, but cannot be reduced only to them. Emergence is, therefore, the appearance of properties that have not been previously observed in the behavior of the system and which cannot be reduced to the properties of its individual components.

In complex adaptive systems, we can distinguish behaviors that influence the phenomenon of emergence (Plowman et al., 2007; Lichtenstein, Plowman, 2009). In such systems, global changes are generated based on local behavior, which in turn change local behavior (Burkhart, 1996). By interacting with and learning from the environment, a complex adaptive system modifies its behavior to adapt to changes in the environment (Rammela et al., 2007). The adaptability of CAS therefore lies in the ability to change and learn from experience, i.e. these systems can respond and adapt to changes occurring in their environment (Rotmans, Loorbach, 2009). Adaptability in CAS is, of course, a manifestation of emergence, which is visible in modifications of behavior under the influence of the environment, adapting the system to the requirements set in the environment. These modifications are made thanks to appropriate interactions, which are intense, non-linear and contain feedback. A special role here is played by the openness features of the system, i.e. appropriate opportunities and methods of interaction with the surroundings (environment).

Fundamental changes generated by these interactions are implemented in subsequent stages of system functioning thanks to processes defined as coevolution and self-organization (Mitleton-Kelly, 2003). Adaptive movements of individuals are the effects of agents'

interactions (e.g. changes in attitudes, views, level of knowledge, etc.) referred to as coevolution. The effect of these changes at the level of the entire adaptive system (macro level) is co-evolution with its environment, i.e. responding to changing external requirements (Mitleton-Kelly, 2003). One of the effects of co-evolution is self-organization, i.e. a phenomenon in which the elements of a complex system become spontaneously ordered. This ordering is the result of independent interactions between individual agents within the system and/or agents and the environment (Mainzer, 1994). Self-organization therefore refers to the ability to develop a new system structure resulting from the internal structure of the system and its interaction with the environment, but not the external management of the system.

Taking into account the specific characteristics of CAS behavior, it can be concluded that most organizations are characterized by a set of attributes and special behaviors typical of adaptive complex systems. First of all, an organization, is perceived as a group of people, i.e. related elements (agents) interacting with each other in various ways. These interactions are rather intense and non-linear (with many feedback loops), which means that each member of the organization influences many others and vice versa, and the influence of even one person or small group can cause significant changes in entire spheres of the organization's activity (e.g. innovations, knowledge, culture, leadership, etc.). Moreover, organizational members also react to information flowing directly or indirectly from the environment.

The behavior of the organization as a whole is emergent because it is difficult to predict the effects of micro-level interactions on the organization as a whole, even if the behavioral patterns of individual agents are known. Usually, however, the effect of interactions at the micro level is co-evolution towards changes that will ensure survival in the environment and on the market.

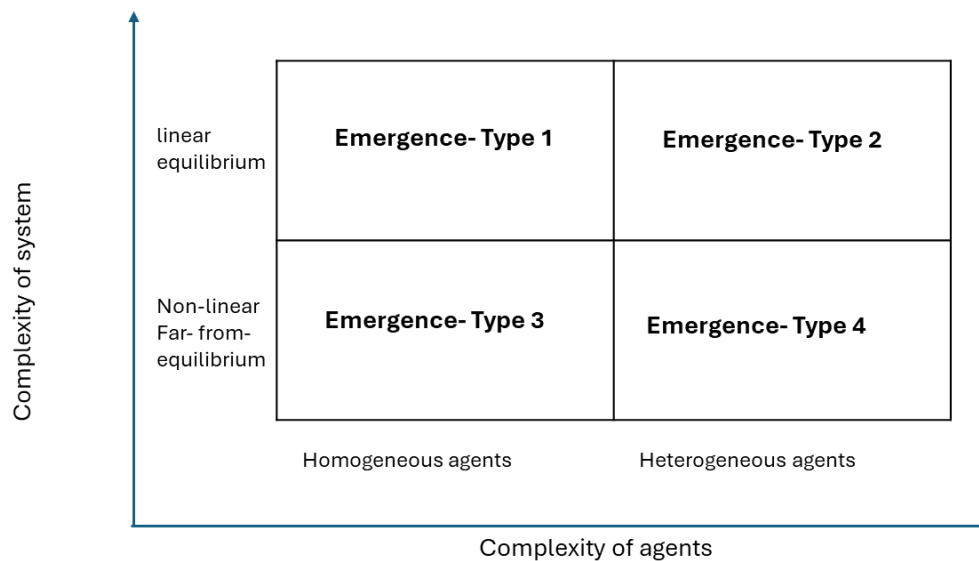
As Lichtenstein and Plowman (2009) emphasize, emergence in an organization is the result of interactions between a group of agents - individual members and managers, networks and organizations. Even relatively simple elements interacting may generate new and surprising behaviors, which make it impossible to predict future states (Bohórquez Arévalo, Espinosa, 2015). As shown above, the main causes of emergent phenomena taking place in the organization are adaptability, co-evolution, feedback and states far-from-equilibrium, as shown in Table 1.

In the study of emergent phenomena occurring in social systems, types of emergence can be distinguished due to the complexity of agents (individuals) and the systems themselves (Lichtenstein, McKelvey, 2011). Individuals can be homogeneous or heterogeneous. The complexity of a system, on the other hand, can be determined by the interactions and behaviors that take place in the system. The interactions may be non-linear and the system may operate in conditions far from equilibrium, or the interactions may be linear and the system may operate in equilibrium conditions. Taking these dimensions of complexity into account, four types of emergence can be identified. Taking these dimensions of complexity into account, four types of emergence can be identified (Fig. 1).

**Table 1.***Causes of emergent phenomena in the organization and management*

Cases	Definition/Study
<b>Adaptability</b>	Heterogeneous, autonomous individuals have the ability to learn from experience, which gives them the ability to respond and adapt to changes in their environment (Rotmans and Loorbach, 2009).
<b>Co-evolution</b>	Usually, the effect of interactions at the micro level in an organization is co-evolution towards changes that will ensure survival in the environment and on the market (Ferloni, 2022; Quitzow, 2015; Edmonson et al., 2019)
<b>Feedback</b>	Feedback in human interactions means influence that changes (strengthens or weakens) potential actions and behaviors (Mitleton-Kelly, 2003) Individuals influence each other, either directly or through feedback loops that continually evolve and adapt to achieve overarching goals (Sanders, McCabe, 2003)
<b>Far-from-equilibrium</b>	This is due to the characteristics of interaction processes, which are, by definition, dynamic (variable at each step and dependent on each step). A state of equilibrium would mean the absence of interactive processes. (Meyer et al., 2005)

Source: own study.

**Figure 1.** Typology of emergence.

Source: own study based on Lichtenstein and McKelvey (2011).

As can be seen in Figure 1, Type 1 emergence occurs when agents are homogeneous and the interactions between them are linear. Examples of research on such emergence concern primarily group behavior (Granovetter, 1978, Macy, 1991), emerging structures of behavior in social networks (Burt 1992), competitive advantage (Porter, Siggelkow, 2008), entrepreneurship and start-ups (Ganco, Agarwal 2009); technological innovation (Flemming, Sorenson, 2001).

It should be noted that Type 1 research on emergence covers the interactions between elements and the structure of the system to the smallest extent. Research taking into account emergence focuses here on the properties of the system; the nature of the whole can be known by deduction based on knowledge about the nature of its components.

The second type of emergence (Type 2) concerns heterogeneous agents and linear interactions. In this case, the emergent property or structure is defined as "different in kind" from its ingredients. The elements of an emerging strategy arise from interactions at the individual and group levels (human, social and relational capital). Agents become increasingly complex as the hierarchical relationships between parts and wholes become more intense. Examples of research on such emergence include the creation of emergent strategies (Nonaka, 1994); self-organization based on simple rules: urban segregation (Schelling, 1978); alliances and other group formations (Axelrod et al., 1995).

In the third type of emergence (Type 3), agents are homogeneous, but interactions are nonlinear and occur in states far from equilibrium. Co-evolution and self-organization as well as adaptation take place. What emerges at the macro level of a system can causally influence its elements, changing the behavior of its parts, while the parts (elements/units) simultaneously change the nature of the larger whole (Thomas et al., 2005). Research also concerns emerging institutions, for which it is examined how structures at the macro (institutional) level supervene on behavior at the micro (individual) level (Contractor et al., 2000).

Examples of research at four levels of emergence that concern management and processes taking place in the organization are presented in Table 2.

**Table 2.**

*Examples of research for four types of emergence in organization and management*

Emergence	Study
<b>Type 1</b>	Self-organizing criticality: - most job changes generate very small vacancy chains, but sometimes one job change can trigger a large cascade of subsequent changes in the organization (Gunz et al.; 2001) - propositions about emergent leadership (Lichtenstein, Plowman, 2009) - examples of SOC in economic and financial markets (McKelvey, Salmador Sanchez, 2011)
<b>Type 2</b>	Simple rules for agents lead to self-organizing behavior: - a model of urban segregation based on the cellular automata (Schelling, 1978) - agent-based models (cellular automata) for studying word of mouth marketing (Kowalska-Styczeń, Sznajd Weron, 2012) - a spatial simulation model in which business activities, initially randomly dispersed, always evolve into a highly ordered distribution around a central business district (Krugman, 1996)



<b>Type 3</b>	The use of genetic algorithms: - simulation of an organization consisting of agents (Crowston, 1996) - model adaptations to organizational structure by examining the adaptation of financial trading firms (Paul et al., 1996)	individuals influence each other, either directly or through feedback loops that continually evolve and adapt to achieve overarching goals (Sanders & McCabe, 2003).
<b>Type 4</b>	Simulation on many levels: - a four-level simulation that consists of small groups interacting employees (agents) led by an executive team that develops firm-level strategy based on environmental inputs (Carley and Lee, 1998; Carley, 1999a) - agent-based model (ABM) including cellular automata, genetic algorithms and neural network for stock-market trading (Lebaron, 2000)	

Source: own study.

### 3. Tools for examining emergent phenomena in organizations

Choosing the right way to research and analyze emergent phenomena in an organization, attention should be paid to the limitations caused by the nature of such systems. These limitations are as follows:

- a large number of basic elements of such systems (agents/ individuals), hence also a large number of interactions,
- the high complexity of real organizations/institutions (study too many aspects at the same time is actually not possible),
- the need to take into account changes in time, limits the ability to analyze the dynamics of real-world behavior in the long-term.

As Table 2 shows, the most frequently used approach to studying emergent phenomena are agent-based models (ABM), including cellular automata (CA). Agents (actors) in such models (as in real social systems) interact and influence each other, learn from their experiences and adapt their behavior to the environment (Macal, North, 2010). They can represent people, but also companies, organizations or states. Moreover, as Artime and De Domenico (2022) emphasize, in ABM, when interactions occur between individual agents, emergent phenomena occur, consisting in the spontaneous emergence of surprising results at a higher level of aggregation that could not be predicted at the model construction stage.

To create an agent-based model describing a phenomenon, the following elements must be defined:

- Goal.
- Agents.
- Properties, attributes for agents.
- Rules for agents.
- Simulation steps and duration of the simulation.
- Model verification and validation.

Therefore, the construction of ABM requires a thorough understanding of the phenomenon being modeled and consists of many stages. A thorough analysis of the examined problem allows for the creation of a theoretical model, which is then implemented in the form of a computer program. Moreover, the results obtained during simulation using a computer program must be verified and validated.

Model verification involves checking its compliance computer implementation with assumptions expressed in the form of a conceptual model (Tucker, 2014), while validation ensures that both conceptual models and computer models are an appropriate representation of the theory or phenomenon under study (David, 2013).

In the case of social simulation, the verification methods include:

- dynamic methods that rely on checking the computer program through various ranges of input parameters,
- static methods that mainly focus on the detection of program code errors and are aimed at showing that the computer model adequately performs its tasks without software flaws.

In the case of validation, it is important whether the goal of the model is prediction or explanation. The purpose of social simulations is mainly to explain modeled phenomena. In this case, validation consists in demonstrating that the mechanisms created in the model through simulation are able to reproduce behavior similar to real ones, i.e. assess whether the structure of mechanisms at the micro level allows for the creation of effects at the macro level consistent with known theories or real data

It should be noted that, unlike mathematical models, descriptions of simulation models are often chaotic and incomplete. As a result, replication of the achieved results is difficult or impossible. Therefore, in addition to the usual description of the model, it can also be described according to the ODD protocol (i.e. The Overview, Design concepts and Details). The ODD protocol is a set of rules that standardize the description of an agent model, ensuring that this description is consistent, logical and complete (Grimm et al., 2022).

The ODD protocol consists of seven parts, sequentially presenting the most important aspects of the ABM (Grimm et al., 2010, 2022):

- *Purpose and patterns*, devoted to presenting the purpose of building the model and planned evaluation methods.
- *Entities, state variables and scales*, devoted to the modeled agents and global variables governing the course of the simulation.
- *Process overview and scheduling*, devoted to the processes that units in the model are subject to, with particular emphasis on the order in which these processes occur.
- *Design concept*, devoted to eleven key aspects building a ABM.
- *Initialization*, devoted to the mechanism of initialization of the simulation model.
- *Input data*, dedicated to those used for parameterization given model.
- *Submodels*, dedicated to component models that are part of the main model.

## 4. Conclusion

An organization is a multidimensional, multi-aspect and complex system, especially an organization considered in the context of a social system. There are many emergent phenomena in such a system. Undoubtedly, this state of affairs is an impulse to look for specific tools to analyze and describe the processes taking place in the organization. A new direction is analysis within the theory of complex adaptive systems, which aim to model and explain the behavior of systems of interconnected objects based on knowledge of the laws of individual elements (at the local level) and the structure (network) of their connections. Therefore, the use of computer tools developed based on complexity theory, especially agent-based models, seems interesting. This approach is postulated by Lichtenstein and McKelvey (2011) after an in-depth analysis of emergent phenomena in organization and management. Moreover, as Seel (2000) points out, change in an organization used to focus on "change planning"; it is now seen rather as "facilitating emergence."

The complex phenomenon of emergence offers insight into issues that are increasingly important to management researchers and increasingly relevant to the leaders of our 21st century organizations.

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## LEADERSHIP COMPETENCIES AND BUSINESS PERFORMANCE IN THE HOTEL INDUSTRY

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**Purpose:** The aim of this study is to investigate the relationship between hotel managers' leadership competencies, such as cognitive competencies, functional competencies, social competencies, and meta-competencies, and high hotel performance.

**Design/methodology/approach:** A qualitative comparative analysis using a fuzzy set (fs/QCA) was conducted, examining the configurations of leadership competencies that are associated with hotel performance. This method is suitable for analyzing the relationship between the outcome (i.e. hotel performance) and all possible combinations of potential causal conditions (i.e. cognitive, functional, social, and meta-competence of hotel CEOs).

**Findings:** The results reveal the existence of different configurations that lead to the desired performance outcomes. Each configuration combines two or three causal conditions – leadership competencies. Three solutions were found to explain how different leadership competencies of hotel CEOs configure the achievement of high hotel performance.

**Practical implications:** The existence of alternative configurations indicates that hotels may follow alternative paths to achieve high performance (as measured against competitors) in conjunction with the different combinations of leadership competencies of their top managers. Focusing on just one competence (i.e. cognitive, functional, social, and meta) is insufficient to achieve high performance. Each leadership competence must be analyzed in combination with at least one more to allow the hotel to achieve its performance objectives.

**Originality/value:** By examining hotels on the Baltic Sea coast in Poland this research contributes to understanding how the leadership competencies of hotel managers, such as cognitive, functional, social and meta-competencies combine and interact to build high hotel performance. Unlike quantitative estimation techniques, fs/QCA is not symmetric. Thanks to the use of fs/QCA, it was also checked which combinations of leadership competencies lead to low hotel performance. As research results indicate, low hotel performance is caused by a combination of low cognitive, functional and social competencies. Importantly, although hotel managers' social competencies are important for high hotel performance, they are irrelevant for low hotel performance.

**Keywords:** leadership, competencies, hotel performance, hotel manager, fs/QCA.

**Category of the paper:** research paper.

## 1. Introduction

Over the past six decades, the tourism industry has been the leading and fastest growing industry in almost the entire world (Alizadeh, Isa, 2015; Liu-Lastres et al., 2022; Gursoy et al., 2022), and tourism affects many sectors of the economy. Tourists spend money on dining, sightseeing, shopping, culture, and a wide variety of leisure activities, but above all on accommodation, making the hotel industry the most important part of the tourism industry. The multifaceted nature of tourism and hospitality makes the industry one of the largest and fastest growing in the world.

Poland is part of the global tourism market with the number of foreign tourists visiting increasing year on year. Seacoasts, both in Poland and worldwide, are the most used type of tourist space. The Polish Baltic coast is the main area of leisure tourism in Poland. The coastal region concentrates on the largest number of hotel places and facilities nationwide. With the growing interest in Polish seaside destinations among foreign tourists, there has been a dynamic, quantitative development of the hotel base over the past two decades. As a major component of the tourism industry, the hotel sector is one of the largest contributors to the Gross Domestic Product (GDP) of the global economy World Travel and Tourism Council (WTTC, 2021).

The crisis caused by the pandemic situation and the war in Ukraine has caused hotel companies to face additional problems and difficulties. Furthermore, in the face of globalization trends, market changes, and technological innovations, service industries must maintain and further increase their competitive edge. An important factor in the success of a company is the quality and competence of its managers. The above applies even more so to managers in the hospitality industry, a sector that has recently been hit hard by the Covid-19 pandemic and the restrictions put in place. Tourism still accounts for the largest and still growing industry in the world (Goeldner, Ritchie, 2009; Lin et al., 2022) and the quality of services provided, the growth of the tourism business, and the maintenance of a competitive advantage rely heavily on the work and commitment of managers.

Human capital, which refers to the knowledge, competencies, aptitudes, and skills of people that enable innovation and organizational development (Baron, Armstrong, 2007) is critical to the success of hotels (DiPietro, 2008; Salama et al., 2022; Alreahi et al., 2022). The process of hotel management is becoming extremely dynamic and complex, where managers have to deal with many issues and difficulties, as well as the rapid changes and challenges of operating in today's turbulent economy. These challenges are increasing the demands and role of managers in the hospitality industry, where developing leadership competencies to meet specific conditions and achieve desired hotel performance is becoming crucial. Hotel performance is often found in the literature by comparison with competitors and as evidenced by, among others work of (Robinson, 2006; Cong, Hai, 2015).



Leadership competencies, also in the hotel sector, are the subject of research in many countries, where numerous researchers have come to independent conclusions about the requirements for effective leadership (Brownell, 2008; Chung-Herrera et al., 2003; Kay, Moncarz, 2007). After decades of research, no single set of managerial competencies has been defined that is appropriate for each entity or tailored to economic conditions in conjunction with achieving high hotel performance. As is accepted in the literature for, which is continued by researchers of the area of competence in a similar approach, competencies can include motives, traits, self-image, attitudes or values, knowledge of specific content areas, as well as cognitive, behavioral, or physical skills. Based on a critical analysis of the literature, drawing on the research findings contained therein and the analyses conducted, the following leadership competencies of hotel managers were selected for study: cognitive competencies, functional competencies, social competencies, and meta-competencies. The aim of this study is to investigate the relationship between hotel managers' leadership competencies, such as cognitive competencies, functional competencies, social competencies, and meta-competencies, and high hotel performance. The cognitive objective will be pursued through a qualitative comparative analysis using a fuzzy set (fs/QCA). This method is suitable for analyzing the relationship between the outcome (i.e. hotel performance) and all possible combinations of potential causal conditions (i.e. cognitive, functional, social, and meta competence of hotel CEOs). The fs/QCA method will be used to identify and determine possible combinations of the identified factors.

This paper begins with the theoretical background and development of propositions, followed by an overview of materials and methods. The results are presented and discussed in the next section. The work ends with a summary and conclusions.

## **2. Theoretical background and development of propositions**

Researchers have tried over the years to trace and understand what allows a business manager to excel and succeed. Leaders play a significant role in shaping goals, strategies, and business decisions (Asree et al., 2010). A business manager is a person who can create a vision for an organization or group and protracts to skillfully influence those who are to implement that vision. They must provide three capacities to shape the vision, to inspire, and to influence (Anand, Punia, 2015) and must also develop trusting relationships with subordinates and empower them by recognizing and clarifying their roles in the organization (Martínez-Córcoles et al., 2020). A good business manager focuses on what he or she is like (leadership qualities), what he or she knows (leadership skills and knowledge), and what he or she does (leadership behaviors and attitudes) (Arasli et al., 2020). Being competent, as defined, means having the ability to do what one is supposed to do by having the right knowledge, skills, abilities, and attitudes (Siu, 1998). There are many interpretations and definitions of the concept of

competence. Competence is the ability to do something well and the skills, knowledge, and personal qualities that produce beneficial results (Galvin et al., 2014; Holtkamp et al., 2015). M. Grzeda (2014) in an attempt to reduce conceptual ambiguity, based on a review of many definitions of competence, breaks it down into the following components: skills, knowledge, and attitudes (KSAs), distinguishing it from others using 'abilities', 'behaviors' or 'attitudes' as a third component. Competence can be viewed in two ways, that is: as a trait of the individual related to personal, individual attributes (Zegward, Hodges, 2003), or as traits related to technical skills (Hodges, Burchell, 2003).

Leadership is the combination of knowledge, skills, experience, behaviors, and attitudes to transform an organization or business into a cohesive organism that will compete effectively in the marketplace (Asree et al., 2010). Leadership can be defined as the broadly defined ability to influence others to achieve organizational goals (Arasli et al., 2020). J.F. Williams and M.D. Winston (2004) argues that leadership competencies represent the areas of knowledge and skills that are essential for effective, leaders. Leadership competencies include the abilities, skills, knowledge, and personal qualities possessed by leaders and are associated with three specific leadership styles: (a) intellectual, (b) managerial, and (c) emotional (Galvin et al., 2014). E. Suh et al. (2012) undertook a study to identify key competencies that contribute to the success of future managers in the hospitality industry. The study identified six dimensions of key competencies, namely: (1) hospitality skills, (2) interpersonal skills, (3) supervisory skills, (4) food and beverage management skills, (5) leadership skills, and (6) communication skills. M.J. Dolasinski and J. Reynolds (2019) also undertook research into leadership competencies in relation to achieving success in the hospitality industry. They identified six factors of leadership competencies in hospitality, including soft skills, leadership skills, and interpersonal, organizational, relational, and self-management competencies. J. Winterton et al. (2005) make the following equivalence: knowledge is cognitive competence; skills belong to functional competence, and attitudes are linked with social competence.

Based on a critical analysis of the literature on the subject and in view of the fact that competencies can be assigned to different categories, which depend on their relationship with functional aspects of work, the personality of the individual, psychological predispositions, or the operational ability to perform the professional role, the paper adopted competencies for the analyses in the empirical part with the following division on categories: cognitive competencies, functional competencies, social competencies, and meta-competences. Knowledge-related competencies constitute the cognitive competence category, technical skills the functional competence category, and behaviors and attitudes the social competence category. In addition, following (Briscoe, Hall, 1999), personal abilities to assess and understand a situation at a given point in time constitute the meta competence category.

A rich body of work in the field of management indicates that managers face several challenges, should possess a range of competencies, and acquire many skills, both qualitative and quantitative, to effectively carry out the tasks and functions assigned to them. Years of

research on hospitality management have shown that hotel managers should meet specific requirements in addition to those needed for management in general (Walke, 2004; Rees, Porter, 2008). When analyzing the work of hotel managers, it is not difficult to see that their job is even more complex and demanding, as it also deals with issues of cultural diversity among others.

The hotel industry, where services are provided to a variety of customers with different requirements and emotional states, causes hotel managers to be exposed to high levels of stress and experience complexity in forecasting and decision-making. This requires managers to have additional competencies, related to assessing and understanding the situation at a given point in time (Pirnar, 2014), which competencies are called meta-competencies. Meta competencies (motives and traits) are higher-order personal competencies that refer to the ability to understand a situation, adapt and apply existing competencies or acquire new competencies when needed. Following S.R. Kandula (2006), distinguishing between competencies and meta-competencies, indicates that meta-competencies include: engaging in activities that require functional intelligence, engaging in non-routine and non-programmed tasks, dealing with complex and changing aspects of the environment, thinking analytically and being able to engage in generalized and varied tasks, and being non-specific and being able to lead.

Hotel managers are also expected to have knowledge of norms as rules and practices for different social, geographical, and cultural environments (Pirnar, Genç, 2009). Apart from intercultural communication and the area of multifaceted guest services, there are other aspects of hotel operation that require managers to have specialized knowledge of, for example, accounting, project management, or financing, which are included in the cognitive competencies. Cognitive competencies (knowledge) are related to the conceptual knowledge of the individual. Cognitive competencies enable the individual to approach problem-solving processes by treating each issue as a component of a larger system, rather than as an independent aspect with unrelated consequences (Ackoff, Addison, 2010). Cognitive competencies refer to the ability to think and analyze information and situations, which are an essential part of the hotel management process.

Hotel managers need to have competencies, skills, and familiar with various types of techniques in the following areas: benchmarking, marketing, interviewing, purchasing processes, interpersonal skills, creativity, assessing the fit between potential candidates and the requirements of the position, technical competence, ethics, planning, flexible programming, quality management, safety and security management, e-tourism applications and legislation, i.e. issues included in functional competence (Shariff et al., 2014; Kay, Russette, 2000; Suh et al., 2012).

Functional competencies (skills) refer to an individual's technical skills related to the job. These include, depending on the position, interviewing and selection skills and assessing the fit between potential candidates and the position and the organization, responsibility for implementing quality standards in the organization, crisis management skills, IT (computer) skills, and financial analysis and cost control, among others (Suh et al., 2012; Kay, 2007).

In addition, the nature of the hospitality industry causes hotel managers to be expected to have social skills and competencies, manifested by, among other things: acting and adapting appropriately to different situations, being able to cooperate with others, and adopting attitudes appropriate to the situation (Clarke, Chen, 2007). Social competence (attitudes and behaviors) is related to an individual's interpersonal attitudes and behaviors and their ability to interact effectively with others. Social competence is the ability to recognize and understand the emotions of others and to use such information to perform better (Emmerling, Boyatzis, 2012). The importance of having social skills by managers in today's dynamic business environment is very high. Social competence refers to the ability to understand other people's concerns, feelings, and emotional states, build and maintain positive relationships, and behave appropriately in social interactions. This is important also because a hotel manager has to deal with so many different people from different backgrounds and cultures.

It has been recognized that the leadership competencies of managers are critical factors for business success (Asree et al., 2010; Clarke, 2010), and business success in the hotel industry analyzed means high hotel performance. Business success in the hospitality industry is expressed by hotel performance, which can be assessed and measured using various indicators and metrics. Hotel performance can be measured using three dimensions: (1) efficiency, including occupancy, average room rate, and sales growth per room; (2) productivity, including return on investment (ROI) and profit margin; and (3) adaptability, including the number of new services or products, introduced successfully and the percentage of sales derived from new services or products (Phillips, 1996). The occupancy rate is important in that it indicates whether a hotel is attracting customers, which is directly related to the quality of services provided or prices offered, and to the success of a hotel.

For achieving a successful end result, in this case, hotel performance, a manager needs to possess and apply various competencies and capabilities, such as flexibility, cognitive competence, creativity, hard-mindedness, motivational skills, social competence, technological knowledge, functional competence, communication skills, personal skills, language skills, leadership qualities, among others, finished with tremendous effort and energy (Bossid, 2011; Suh et al., 2012). Furthermore, in their study, A. Van and J. Ernst (2005) mentioned that for effective and efficient results it is important not only to get things done but to get the right things done, which requires not only social skills but also project skills and knowledge management capabilities.

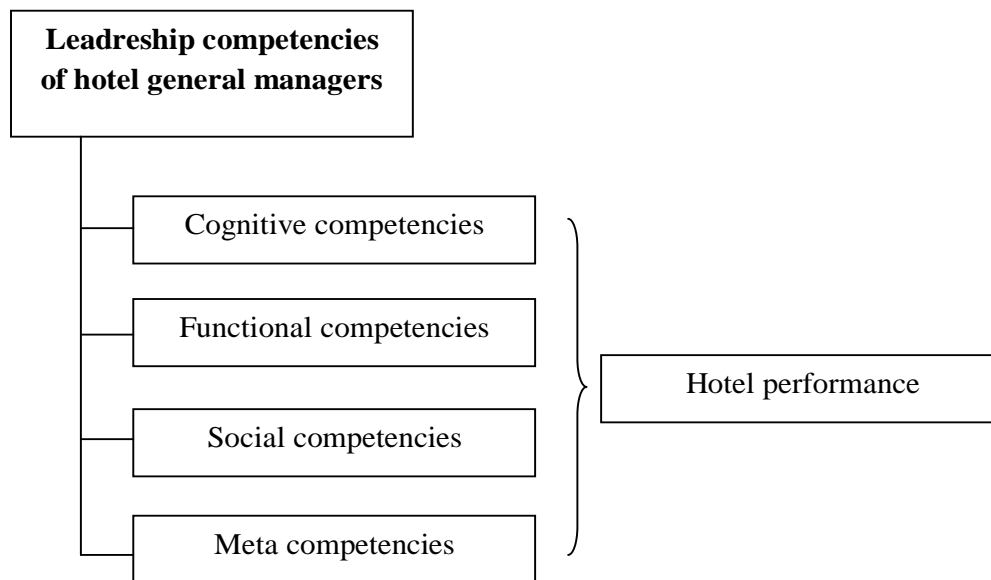
Based on a review of the literature on hotel manager competencies, which identifies a range of skills, motives, behaviors, knowledge, and other attributes associated with the achievement of positive results by these managers and, consequently, with hotel performance, this study divides competencies into four categories. These include cognitive competencies, functional competencies, social competencies, and meta-competencies. On the basis of the theoretical background, the following propositions can be made:

*Proposition 1. Cognitive, social, functional, and meta-competencies of hotel managers lead to hotel performance.*

*Proposition 2. Various combinations of cognitive, social, functional and meta-competencies of hotel managers lead to high hotel performance.*

### 3. Materials and methods

This study identified which configurations of leadership competencies are conducive to the high performance of hotels. Leadership competencies consisted of cognitive, functional, social, and meta-competencies (illustrated in Figure 1).



**Figure 1.** Diagram of the research model.

Source: own study.

The sample for this study was collected in the last quarter of 2022 and the first quarter of 2023. The sample consists of 157 managers from 23 hotels with 3-, 4- and 5-star ratings. The hotels are located on Baltic Sea Coast the area with the largest tourist reception in Poland. The questionnaires were completed individually. A designated person visited 23 hotels in order to explain the characteristics and instructions for filling in the questionnaires and to dispel any questions that arose during the completion of the questionnaire. Table 1 summarizes the main sample characteristics.

**Table 1.**  
*Characteristics of the research sample*

Category		Statistic
Hotel level	Hotel rating	3 stars (43,5%)
		4 stars (30,4%)
		5 stars (26,1%)
	Hotel age	< 5 years (30,4%)
		6-10 years (43,5%)
		> 11 years (26,1%)
Respondent level	Gender	Female (41,5%)
		Male (58,5%)
	Education	Higher (61%)
		Secondary (24%)
		Other education backgrounds (15%)
	Age	< 30 (28%)
		31-45 (46%)
		> 46 (26%)
	Position	Manager: reception manager, director of the bar and restaurant, chef, housekeeping manager, and entertainment manager (76%)
		CEO (24%)
	Working experience of respondents	3-5 years (35,4%)
		6-10 (54,4%)
More than 10 years (10,2%)		

Source: own study.

The questionnaire that was applied in this study covered leadership competencies like cognitive, functional, social, and meta-competencies and the outcome variable – hotel performance compared to competitors. The items adopted in this research were selected from prior studies. All scales followed a five-point Likert format. Cognitive competencies are measured using eight items and include issues relating to decision-making, strategic thinking, critical thinking, and analytical skills. Technical competencies that help in performing concrete activities for running day-to-day business operations were grouped under functional competencies. Functional competencies are measured by twelve items and refer to job-specific skills such as revenue management skills, employee performance appraisal skills, and IT skills. Interpersonal competencies that are useful in establishing and maintaining relationships with others were categorized as social competencies. Social competencies are measured by nine items and relate to skills such as effective communication, teamwork orientation, and developing and coaching others. Finally, meta-competencies included overarching personal competencies such as self-awareness, self-management, and achievement orientation which enable an individual to understand, monitor, and manage their own performance. Meta competencies are measured by thirteen items and refer to abilities that underpin the development of other competencies, as well as intrinsic personality traits. All variables relating to leadership competencies were developed from the research of (Bharwani, Talib, 2017) as well as the work of (Lenehan, 2000; Chung-Herrera et al., 2003; Testa, Sipe, 2012; Jeou-Shyan et al., 2011). The performance of hotels in this study is presented by comparison to competitors and is based on the work of (Robinson, 2005; Cong, Hai, 2015). The performance is measured by eight items. Details of the scale are in Appendix 1.

The sample data were analyzed using fuzzy set qualitative comparative analysis (fs/QCA). Fs/QCA is an empirical method based on Boolean algebra that allows a configurational examination of the causal relation between a group of antecedent conditions and related outcome (Ragin, 1989; Ragin, 2000). This methodology offers a set-theoretical approach to causality analysis as regards conditions and outcome (Ragin, 2008). This method acknowledges that different combinations might explain the outcome; in other words, different combinations of attributions can explain the same outcome. Analyses using qualitative comparative analysis (QCA) methods have been successfully performed in numerous studies in the social sciences e.g. (Kwiotkowska, 2018; 2022; Kwiotkowska, Gębczyńska, 2021; Gębczyńska, 2021; 2022).

The measurement scales used in this type of analysis do not have to be specifically designed for fs/QCA. By calibrating the original variables, any continuous variable can be transformed into another continuous variable that ranges from 0 to 1. Each calibrated value can then be interpreted as the degree of membership to a set, where 0 represents full non-membership and 1 represents full membership. The fs/QCA 3.0 software was used to conduct the analysis in this study.

Fs/QCA was used to test our research propositions by evaluating the degree of influence of the four leadership competencies on hotel performance. We sought to understand whether leaders (i.e., hotel managers) should focus on the four competencies or whether any one competency is of particular relevance. The descriptive statistics for the initial data provide a better understanding of the methodology. The statistics for the four conditions and the outcome are reported in Table 2 based on the scores assigned by respondents.

**Table 2.**

*Descriptive data for the conditions and outcome*

Conditions and outcome	Valid N	Mean	Standard Deviation	Minimum	Maximum
Cognitive competencies	157	3.14	0.63	1.30	5.00
Functional competencies	157	3.93	0.72	1.50	5.00
Social competencies	157	3.12	0.93	1.20	4.00
Meta competencies	157	3.18	0.63	1.30	4.00
Hotel performance	157	3.72	0.91	1.50	5.00

Source: own study.

Before preparing for fs/QCA, we validated the scales and dimensions used in this study. The internal consistency measure of Cronbach's alpha was used to verify the reliability of each dimension of the scale. The evaluation of the scales showed that all Cronbach's alpha values were above 0.70 (Nunnally, 1978).

## 4. Results

In this study, five factors were analyzed. The four leadership competencies (cognitive, functional, social, and meta) were used as antecedent conditions, and hotel performance was used as the outcome.

Each of these quantitative variables was calibrated to determine the degree of membership to previously defined sets. We identified key dimensions and interpreted them as a set in which cases could have different degrees of membership. In fs/QCA, each continuous variable is transformed through a process of calibration into a categorical variable (i.e., a fuzzy set) that is used to indicate the degree of membership of a case to that set. These sets are shown in Table 3.

**Table 3.**  
*Definitions of set*

Conditions/Outcome		Set Membership
Outcome	Hotel performance	High hotel performance
Antecedent condition	Cognitive competencies	Managers with high cognitive competencies
Antecedent condition	Functional competencies	Managers with high functional competencies
Antecedent condition	Social competencies	Managers with high social competencies
Antecedent condition	Meta competencies	Managers with high meta competencies

Source: own study.

Calibration requires setting three anchor points that define full set membership of a case in a set, full non-membership, as well as the point of maximum ambiguity between membership and non-membership. These anchor points need to be theoretically motivated and built on substantive criteria external to the data (Ragin, 2008). By convention, fuzzy-set membership scores range between 0 (full non-membership) and 1 (full membership), with 0.5 denoting the threshold between set membership and non-membership (Ragin, 2008). Raw data are usually transformed into set membership scores by the so-called "direct method", using a logistic function in order to fit data in between the three qualitative anchors (Ragin, 2008; Schneider, Wagemann, 2012). Because our data were based on Likert scales and as we sought to capture with our sets the distinct presence of leadership competencies, and performance in a case, we put the 0.5 threshold for all sets at 3.5; that is, higher than the "neutral" Likert-scale value of 3. We used 5 as a value for full membership and 1 for full non-membership, and we employed the transformation function in the fs/QCA 2.5 software package using the log odds of full membership to transform our original interval scale variables into continuous fuzzy membership scores (Ragin, 2008; Fiss, 2011).



#### 4.1. Analysis of individually necessary conditions

In accordance with the QCA literature, we used fs/QCA to test whether any of our four conditions (cognitive, functional, social, and meta-competencies) could be considered individually necessary for the outcome (high hotel performance). A high threshold for the assessment of the consistency of necessity is required to reduce the likelihood of logical contradictions and to avoid pitfalls of hidden or false necessary conditions (Schneider, Wagemann, 2012). The resulting consistency scores for the necessity of the three individual conditions or their negation (see Table 4) did not allow us to consider any of the conditions as individually necessary for high performance.

**Table 4.**

*Analysis of individual necessity of conditions for high firm performance*

Conditions	High hotel performance	
	Consistency	Coverage
Cognitive competencies	0.51	0.48
~ Cognitive competencies	0.54	0.52
Functional competencies	0.63	0.42
~ Functional competencies	0.68	0.55
Social competencies	0.45	0.49
~ Social competencies	0.68	0.50
Meta competencies	0.64	0.47
~ Meta competencies	0.73	0.53

Note: ~ logical negation - the absence of conditions.

Source: own study.

#### 4.2. Analysis of sufficient configurations of conditions

To identify combinations of conditions that are logically sufficient for the presence of the outcome, the next step involves the construction of so-called truth tables, which represent in their rows all logically possible combinations of conditions. The truth table has  $2^k$  configurations or rows, where  $k$  is the number of conditions (Ragin et al., 2004). In our case, the number of conditions is  $2^4 = 16$ . According to Ragin et al. (2004), the value 1 for each configuration indicates that the score of the calibrated variable is greater than or equal to 0.5 and the value 0 indicates that the score of the calibrated variable is lower than 0.5. The consistency of each configuration is shown based on the relation of the subset with the outcome. Because the sample size was relatively low, configurations with a single case were eliminated. The next step was to select a consistency threshold to distinguish causal combinations that were subsets of the outcome from those that were not. According to Ragin (2008)], values below 0.75 in this column generally indicate substantial inconsistency. We selected 0.85 as the consistency threshold. We assigned the value 1 to the outcome (high hotel performance) if the consistency of a given configuration exceeded the 0.85 threshold. Otherwise, the value 0 was assigned (Table 5).

**Table 5.**  
*Truth table for high hotel performance*

Row	Conditions				Number of cases	Raw consistency	PRI consistency	Outcome High performance
	Cognitive competencies	Functional competencies	Social competencies	Meta competencies				
1	1	1	1	0	23	0.94	0.86	1
2	1	1	0	1	31	0.92	0.84	1
3	0	1	1	1	13	0.90	0.77	1
4	1	0	1	1	11	0.95	0.87	1
5	1	1	0	0	15	0.77	0.62	0
6	0	0	1	1	10	0.78	0.69	0
7	1	1	0	0	13	0.68	0.93	0
8	1	0	1	0	12	0.65	0.21	0

Note: PRI, Proportional reduction in consistency.

Source: own study.

The resulting intermediate solution consists of three combinations that are sufficient to high hotel performance. The complex and parsimonious solutions can be viewed as the two extremes of a single complexity–parsimony continuum. As evidenced by Ragin et al. (2004) "An optimal intermediate solution can be obtained by removing individual causal conditions that are inconsistent with existing knowledge from combinations in the complex solution, while maintaining the subset relation with the most parsimonious solution". These intermediate solutions use only a subset of the simplifying assumptions that are used in the most parsimonious solution. Table 6 summarizes our three solutions. In line with previous QCA studies, these solutions can be interpreted as alternative paths associated with the outcome (high hotel performance).

**Table 6.**  
*Intermediate solutions leading to high hotel performance*

Solutions	Sets	Raw Coverage	Unique Coverage	Consistency
S1	Cognitive competencies*Social competencies	0.59	0.10	0.90
S2	Cognitive competencies*Functional competencies*~ Meta competencies	0.54	0.09	0.85
S3	Functional competencies*Social competencies*Meta competencies	0.55	0.05	0.86
Overall solution coverage: 0.64.				
Overall solution consistency: 0.88.				
Note: * logical AND; ~logical negation.				

Source: own study.

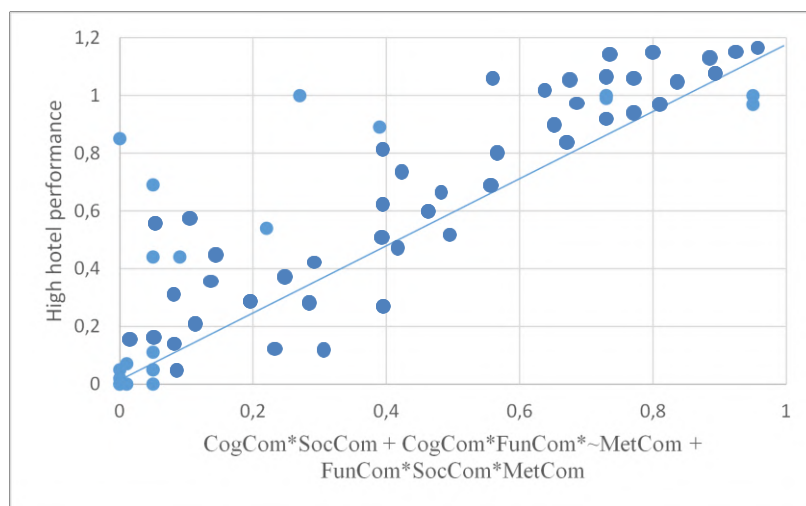
The final solution can be expressed as follows:

Cognitive competencies \* Social competencies + Cognitive competencies \* Functional competencies \* ~ Meta competencies + Functional competencies \* Social competencies \* Meta competencies

Note: \* logical AND; + logical OR

The three combinations shown in Table 6 are sufficient to high hotel performance in 88% of cases. These combinations cover 64% of cases. The combination (S1) of high cognitive competencies and high social competencies leads to high hotel performance compared to competitors. Similarly, the combination (S3) of high functional competencies, high social competencies, and high meta competencies also leads to high hotel performance. There is also a third configuration (S2) leading to high hotel performance that combines high cognitive competence and high functional competencies and, rather surprisingly, low meta-competencies. Functional and meta-competencies in solution S1, social competencies in solution S2, and cognitive competencies in solution S3 represent so-called "do not care" conditions (Fiss, 2011) or conditions whose presence or absence does not matter for the outcome.

Figure 2 represents the consistency and coverage of the solution on a scatter plot of the solution against the result. A combination (set) for which all calibrated scores are systematically less than or equal to the scores of the outcome (upper triangle) is said to be a subset of the outcome with high consistency. The cases (departments) that are below the diagonal are inconsistent with the outcome. Those that are above the diagonal are consistent.



**Figure 2.** Plot of “high hotel performance” against “Cognitive competencies \* Social competencies + Cognitive competencies \* Functional competencies \* ~ Meta competencies + Functional competencies \* Social competencies \* Meta competencies”.

Source: own study.

As C.C. Ragin (2000) points out in the sufficiency analysis, the membership scores of the outcome should be compared not only with the score of each individual condition but also with the scores of all possible causal expressions. If all cases are above the diagonal, it means that the membership scores of the outcome are consistently greater than the causal configuration's membership scores. Therefore, a causal expression is a subset of the outcome is the set-theoretic way of expressing sufficiency. The top corner above the diagonal represents the cases that are most consistent with the solution. The top corner below the diagonal, on the other hand, represents the cases that are most inconsistent with the solution. Given the numerous representation of cases in the upper corner above the diagonal and their very limited number in

the corner below the diagonal, it can be concluded that there are no serious inconsistencies in the solution.

Our final stage of the analysis was a series of robustness checks. The discussion on appropriate robustness tests of QCA analyses is not yet well developed in published empirical studies of QCA in management (Wagemann, Buche, 2016). Measures proposed in the methodological literature to assess the robustness of QCA results include (1) analyses for the absence of the outcome, (2) different calibration thresholds, and (3) varying consistency thresholds (e.g. Schneider, Wagemann, 2012).

Our solution, in the absence of the outcome, indicated one configuration, which is presented in Table 7.

**Table 7.**  
*Intermediate solutions leading to low hotel performance*

Solutions	Sets	Raw Coverage	Unique Coverage	Consistency
S2	~Cognitive competencies * ~Functional competencies * ~Meta competencies	0.61	0.07	0.83
Overall solution coverage: 0.61				
Overall solution consistency: 0.83				
Note: * logical AND; ~logical negation.				

Source: own study.

With a coverage of 61% and a consistency of 83%, the combination of low cognitive, functional and social competencies is sufficient for low hotel performance. It is worth noting that although the social competencies of hotel managers are important for achieving high hotel performance, they are not relevant for low hotel performance.

## 5. Discussion and conclusions

The purpose of this study was to investigate the relationship between leadership competencies of hotel managers, such as cognitive, functional, social, and meta-competencies, and high hotel performance. The size of the research sample included 157 managers from 23 hotels with 3-, 4- and 5-star ratings located on the Baltic Sea Coast in Poland. We addressed our research aims using fs/QCA. This method is suitable to analyze the relationships between an outcome (i.e., hotel performance) and all possible combinations of potential causal conditions (i.e., cognitive, functional, social, and meta-competencies of hotel managers). The fs/QCA method was used to identify the possible combinations of these factors.

The analysis identified three configurations leading to high hotel performance in 88% of cases, with a coverage of 70%. Cognitive competencies occur in two configurations: S1 and S2, where high social competencies can be replaced with high functional competencies

in combination with low meta-competencies. These findings are consistent with the views of (Asree et al., 2010) who report a positive impact of cognitive competencies on the organization. A cognitive competency is an ability to think or analyse information and situations that leads to or causes effective or superior performance of the organization. In the S1 configuration, high hotel performance is achieved when, in addition to high cognitive competencies, leaders also have high social competencies. Social competencies are the ability to recognize and understand the emotions of others, as well as use such information in order to achieve superior performance (Emmerling, Boyatzis, 2012). High performance can be achieved by hotels with a configuration in which high cognitive competencies of hotel managers combined with high functional competencies and low meta-competencies are present. Competence can be a source of competitive advantage for an organization because, in an organization where the competence approach is neglected, the desired level of performance cannot be achieved (Hill, Jones, 2015). Functional competencies (skills) refer to an individual's job-specific technical skills. As research indicates (Masoud, 2013) there is a significant impact of functional competence on company performance.

Finally, when meta-competencies are combined with high cognitive and functional competencies, they lead to high hotel performance despite their low levels. On the other hand, when combined with high social and functional competencies, they also lead to high hotel performance, but this time also their level is high.

While several studies of competencies in the hospitality industry have been conducted, the competencies of the CEO in the hospitality industry have been marginalized. The manager of the hotel industry should have a number of competencies allowing him to achieve success in the form of high hotel performance. The meta-competencies of the manager of the hotel industry constitute an area that is not understood empirically to a large extent. As our research results show, their level depends on a specific context. Sometimes a high level of these meta-competencies is desirable, while in others a low level constitutes a significant contribution of the research carried out. These findings confirm Proposition 1 that cognitive, social, functional, and meta-competencies of hotel managers lead to hotel performance and Proposition 2 that various combinations of different competencies of hotel managers lead to high hotel performance.

It is worth noting that the alternative to having high cognitive competencies is the S2 configuration, which combines the high remaining three competencies of leaders, i.e. functional, social, and meta-competencies. This finding indicates that regardless of whether the cognitive competencies are high or non-binding if the other three conditions hold (the remaining three competencies are high), managers will contribute to the high hotel performance. This result is consistent with the findings of the research area. Each combination has a coverage of between 59% and 55%.

In conclusion, as indicated by the results of the conducted empirical research, the combination of high cognitive competencies and high social competencies is sufficient for high hotel performance. The same outcome is achieved with high functional, social, and meta-competencies or with high cognitive and functional competencies and low meta-competencies. No single condition is alone sufficient to guarantee high hotel performance. The existence of alternative configurations indicates that hotels may follow alternative paths to achieve high performance (as measured against competitors) in conjunction with the different combinations of leadership competencies of their top managers. Focusing on just one competence (i.e. cognitive, functional, social, and meta) is insufficient to achieve high performance. Each leadership competence must be analyzed in combination with at least one more to allow the hotel to achieve its performance objectives.

Unlike quantitative estimation techniques, fs/QCA is not symmetric. Therefore, we studied which combinations of leadership competencies lead to low hotel performance. The combination of low cognitive, functional and social competencies is sufficient for low hotel performance. Notably, although the social competencies of hotel managers are important for achieving high hotel performance, they are not relevant for low hotel performance.

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## Appendix

**Table 1.**

*Variable questionnaires regarding leadership competencies and hotel performance*

<b>Variables of the leadership competencies questionnaire</b> (Bharwani, Talib, 2017; Lenehan, 2000; Chung-Herrera et al., 2003; Testa, Sipe, 2012; Jeou-Shyan et al., 2011)	
Cognitive competencies	1. Ability to scan the business environment and anticipate emerging opportunities and challenges
	2. Ability to make well-informed, effective, and timely decisions
	3. Ability to develop new insights into situations, question conventional approaches and design and implement new or cutting edge initiatives
	4. Ability to gather relevant information and business intelligence required for decision-making
	5. Ability to establish a systematic course of action to ensure the accomplishment of specific objectives by setting priorities, goals and timetables
	6. Ability to reach well-reasoned conclusions and solutions, grounded in logic, on the basis of observation, interpretation, inference, analysis and evaluation
	7. Ability to take calculated risks to achieve organizational goals
	8. Ability to deal with change, articulate a compelling change vision, manage the change process
Functional competencies	9. Attentiveness and willingness to deal with guest requests, complaints, and problems promptly
	10. Ability to understand and keep abreast of business trends that affect the organization and its stakeholders
	11. Ability to understand customers' perception of product value and optimize product availability and price within each customer segment to maximize revenue
	12. Ability to assess potential candidates' job-fit and organization-fit based on their knowledge, skills, and personality
	13. Promotion of a strong internal culture of quality with the ultimate responsibility for implementing quality standards within the organization.
	14. Ability to develop and use criteria for ensuring the optimal use of available resources
	15. Ability to maintain calm in the midst of chaos and handle the pressures of a crisis through multitasking and delegation
	16. Ability to implement employee performance management systems to align employee performance with performance targets
	17. Ability to effectively engage with internal and external stakeholders, i.e. employees, management, and shareholders by appropriately managing their expectations
	18. Computer literacy skills and knowledge of operations management systems such as hotel property management systems
	19. Ability to monitor expenditures and utilise cost-benefit analysis to vet financial plans and decisions
	20. Knowledge of statutory requirements related to the establishment and operation of hotels such as licenses, permissions and other legal compliances
Social competencies	21. Ability to express oneself clearly to get the message across succinctly and effectively
	22. Knowledge about diverse cultures and intrinsic desire and ability to engage in cross-cultural encounters
	23. Ability to develop and maintain contacts, partnerships and alliances through a personalised approach
	24. Ability to negotiate differences in a calm, non-defensive manner and resolve matters by devising creative resolutions to problems
	25. Ability to co-ordinate the efforts of team members and work effectively to advance the collective goals
	26. Ability to reduce discrimination and promote equal opportunity for all regardless of race, gender, lifestyle or disability
	27. Ability to create conducive ambience at the workplace by inspiring and empowering others to take purposeful action

	28. Ability to listen to and understand spoken and unspoken concerns and thoughts of others
	29. Ability to guide others to develop and contribute to the organisation by providing constructive feedback and offering formal and informal learning opportunities
Meta competencies	30. Ability to remain calm and confident in face of provocation and adversity
	31. Passion for work, driven by motivations other than money or status, such as genuine hospitality towards guests
	32. Belief in one's abilities to handle routine as well as challenging tasks and work situations
	33. Ability to regulate rational and emotional operations of the mind in a balanced way and think before acting
	34. Ability to navigate complex, sensitive situations with internal and external stakeholders with tact and savvy
	35. Ability to manage one's time through self-discipline, controlling interruptions, setting priorities, and meeting deadlines
	36. Propensity to act in an honest and trustworthy manner based on moral conviction to do the right thing
	37. Ability to change behavioral style or method of approach as appropriate to meet the needs of the situation
	38. Mental strength to persistently pursue long-term goals despite occasional failure or adversity
	39. Commitment to personal and professional development and the drive to update one's knowledge and skills
<b>Variables of the hotel performance questionnaire</b> (Robinson, 2005; Cong, Hai, 2015)	
Performance compared to competitors	40. Our company achieve more success than our competitors
	41. In general, our revenue is higher the direct competitor's one
	42. Our larger market share is larger than the direct competitor's one
	43. Our profit is higher than the direct competitor's one
	44. Our profit margin is higher than the direct competitor's one
	45. Our rate of return on investment is higher than the direct competitor's
	46. Our customer loyalty is higher than the direct competitor's one

## ENERGY SELF-SUFFICIENCY OF A MUNICIPAL COMPANY IN A CIRCULAR ECONOMY – CASE STUDY

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**Purpose:** Energy self-sufficiency of a municipal company in a circular economy refers to the ability of the company to meet its own energy needs through the use of renewable energy sources and efficient energy technologies. The closed loop economy, also known as the circular economy, is about minimising waste by maximising the use and reprocessing of raw materials and energy.

**Design/methodology/approach:** The paper provides a detailed analysis of the energy self-sufficiency of Przedsiębiorstwo Wodociągów i Kanalizacji sp. z o.o. based in Rybnik, in the production of heat and electricity from biogas produced at a sewage treatment plant.

**Findings:** Collected over the period 2013-2022, the data of the analysed company allows us to conclude that in the process of wastewater treatment, the biogas burned for the needs of the wastewater treatment plant in Rybnik-Orzepowice makes it self-sufficient in terms of thermal needs. In turn, the production of electricity from cogeneration covers 43% of the electricity demand. A deeper analysis of the amount of biogas produced showed the need to build a new generator to produce electricity, which will result in the analysed company being self-sufficient in energy.

Biogas plants at municipal wastewater treatment plants bring many environmental and economic benefits, such as:

- Reducing greenhouse gas emissions by avoiding the release of methane into the atmosphere and replacing fossil fuels with biogas.
- Saving the cost of operating the treatment plant by reducing the consumption of grid electricity and heat and fossil fuels, and reducing the amount of waste to be landfilled or disposed of.

**Originality/value:** Energy self-sufficiency for a municipal company not only contributes to environmental protection by reducing greenhouse gas emissions, but can also result in financial savings by reducing the cost of purchasing energy from external sources. Furthermore, these actions can set an example for other businesses and communities, encouraging them to make similar investments in renewable energy and efficient energy technologies.

**Keywords:** wastewater treatment plant, biogas, heat and power, cogeneration, circular economy.

## **1. Introduction**

### **1.1. Municipal wastewater treatment plants as a source of raw materials and renewable energy**

Wastewater treatment plants play a key role in environmental protection by removing pollutants contained in incoming wastewater. According to the Central Statistical Office, there were 3260 municipal wastewater treatment plants in Poland in 2022. The proportion of the population using wastewater treatment plants was 75%, with approximately 95% in urban areas and 47% in rural areas (Bocheński, 2016, pp. 403-406).

Changing economic and environmental needs and the development of new technologies are now also treating wastewater treatment facilities as a source of raw materials and renewable energy with many economic and ecological benefits.

The production of electricity and heat and fuel from biogas produced by sewage sludge digestion is currently a technology that is widely used at many facilities, and efforts are being made to optimise this process as much as possible in order to achieve energy independence (Fukas-Płonka, Zielewicz-Madej, 2000, pp. 37-48) and even to sell heat, electricity and fuel, e.g. to power means of transport (Grzesik, 2005; Krupa, 2015, pp. 101-112).

The sewage sludge that is produced in wastewater treatment plants during the treatment process, which was previously a nuisance, has gained a new perspective as a substrate that is a valuable raw material rather than waste. The ashes left over after sewage sludge incineration are used to produce construction materials. Incineration of dried sewage sludge provides additional energy. Sewage sludge is a source of the nutrient elements - nitrogen and phosphorus. At present, the most implemented uses for sewage sludge are the production of fertiliser preparations or plant aids, which are a very attractive alternative to very expensive artificial fertilisers. Due to the limited supply of phosphorus in the environment, which is a non-renewable resource and of key importance for the development of life and agricultural production, recovery of this element from sewage sludge is increasingly being carried out (Prusek, Tytko, 2018, pp. 16-17).

The separation from wastewater of fertiliser products containing nitrogen, phosphorus or potassium that can be used to fertilise plants is included in the Strategy for dealing with municipal sewage sludge for 2019-2022 developed by the Ministry of the Environment (Skoczko, Piekutin, Barszczewska, 2016).

### **1.2. Process of biogas formation - methane digestion - course and significance**

Methane digestion - is the microbiological process of decomposition of organic matter under anaerobic conditions with the production of a mixture of gases of which methane is the main component. Records have been found that biogas was used as early as the 10th century BC to heat water baths in Assyria, and in 1776 Alexander Volta demonstrated that gas extracted

from bottom sediments burns. The development of knowledge about methane digestion began with the development of microbiology in the 1930s. Today, methane digestion has found its way into various industries (Wawrzyniak, 2007, pp. 39-46).

In wastewater treatment technology, methane digestion is used as an effective method to stabilise the sludge generated during the wastewater treatment process in order to reduce the content of organic compounds in the sludge, thereby reducing the rotability and removing pathogens. This stabilisation reduces the volume of sludge generated, eliminates odours and increases the potential for further use (Dyrektywa 2003/30/WE...).

The end product is biogas, which, as defined by European Union Directive 2003/30/EU, is 'a gaseous fuel produced from biomass and/or the biodegradable fraction of waste' and is a valuable energy resource (<https://www.gov.pl/attachment/...>).

### **1.3. Biogas from wastewater treatment plants as a source of renewable energy**

At most large and medium-sized treatment plants, the sludge generated is subjected to anaerobic stabilisation. Methane digestion is the primary process used in sludge treatment and is, to date, the most economical and environmentally friendly form of utilising the residues from the wastewater treatment process. The waste product of this process is biogas, which is a mixture of gases, mainly methane and carbon dioxide, as well as small amounts of other gases such as hydrogen, carbon monoxide, nitrogen or hydrogen sulphide (<https://stat.gov.pl>).

Biogas is recognised as a renewable RES energy source, i.e.: one whose use for the production of heat and electricity does not involve a long-term deficit of raw material, and its resources in the form of sludge available as biomass in the wastewater treatment process are readily renewable (<https://www.teraz-srodowisko.pl/...>).

Biogas can be used as a source of renewable energy to produce heat and electricity or to power vehicles. Biogas plants at municipal wastewater treatment plants bring many environmental and economic benefits (<https://pl.wikipedia.org/...>; <https://wysokienapiecie.pl/...>) which include:

- Reducing greenhouse gas emissions by avoiding atmospheric methane emissions and replacing fossil fuels with biogas.
- Improving wastewater quality by stabilising sludge and reducing organic waste.
- Saving the cost of operating the treatment plant by reducing the consumption of grid electricity and heat and fossil fuels, and reducing the amount of waste to be landfilled or disposed of.
- Creating new jobs and income for local communities through the sale of surplus biogas or energy derived from it.

The number of biogas plants at municipal wastewater treatment plants in Poland is difficult to determine, as there is no uniform register of such installations. However, based on various sources, it can be estimated that there are around 300 (Krupa, 2015, pp. 101-112).

## 2. Biogas production at the Rybnik-Orzepowice wastewater treatment plant

### 2.1. Characteristics of the Rybnik-Orzepowice wastewater treatment plant together with a synthetic description of the technology used

The sewage treatment plant in Rybnik-Orzepowice is a mechanical-biological treatment plant with removal of nitrogen and phosphorus compounds by biological means. The treatment plant has been equipped to chemically support phosphorus removal. The designed capacity of the facility is 27 500 m<sup>3</sup>/d. The biological treatment stage uses the flow- sequential activated sludge process BIODENIPHO®, with a preliminary anaerobic chamber and a phase sequence in the reactors, adapted to the biological removal of nitrogen and phosphorus. The treatment plant also includes a process line for sludge treatment. Provision is made for sludge stabilisation by methane digestion, final dewatering and hygienisation. The biogas produced by the digestion process is combusted in a cogeneration unit with an electrical power in a cogenerator with an electrical output of 192kW and a thermal output of 232kW, as well as two gas boilers with an output of 320 kW each. Excess biogas produced is burned in a flare.

### 2.2. Biogas production at the Rybnik-Orzepowice Sewage Treatment Plant

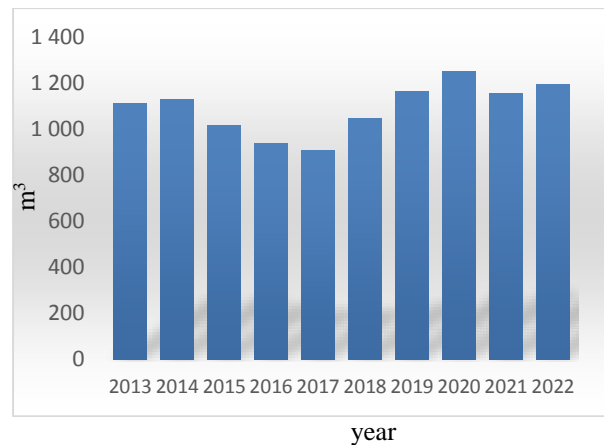
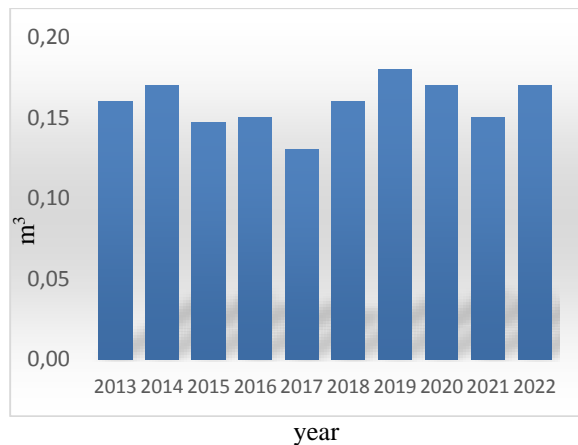
The anaerobic stabilisation process in separate closed digesters (SCD) produces biogas, which has been used to produce electricity and heat since 2012. On a daily basis, the Sewage Treatment Plant in Rybnik-Orzepowice produces approximately 3000 m<sup>3</sup> of biogas. On average, about 0.16 m<sup>3</sup> of biogas is generated from 1 m<sup>3</sup> of sewage flowing into the treatment plant (Table 1) and (Fig. 1-2).

**Table 1.**

*Waste water intake and biogas production*

Year	Amount of incoming wastewater [m <sup>3</sup> ]	Biogas production [m <sup>3</sup> ]	Average biogas production from 1 m <sup>3</sup> wastewater
2013	6 805 430	1 112 200	0,16
2014	6 540 800	1 132 272	0,17
2015	5 938 820	1 017 258	0,17
2016	6 400 050	939 083	0,15
2017	7 223 900	906 740	0,13
2018	6 380 780	1 046 217	0,16
2019	6 537 300	1 165 582	0,18
2020	7 172 100	1 249 509	0,17
2021	7 506 770	1 155 194	0,15
2022	6 951 530	1 197 007	0,17

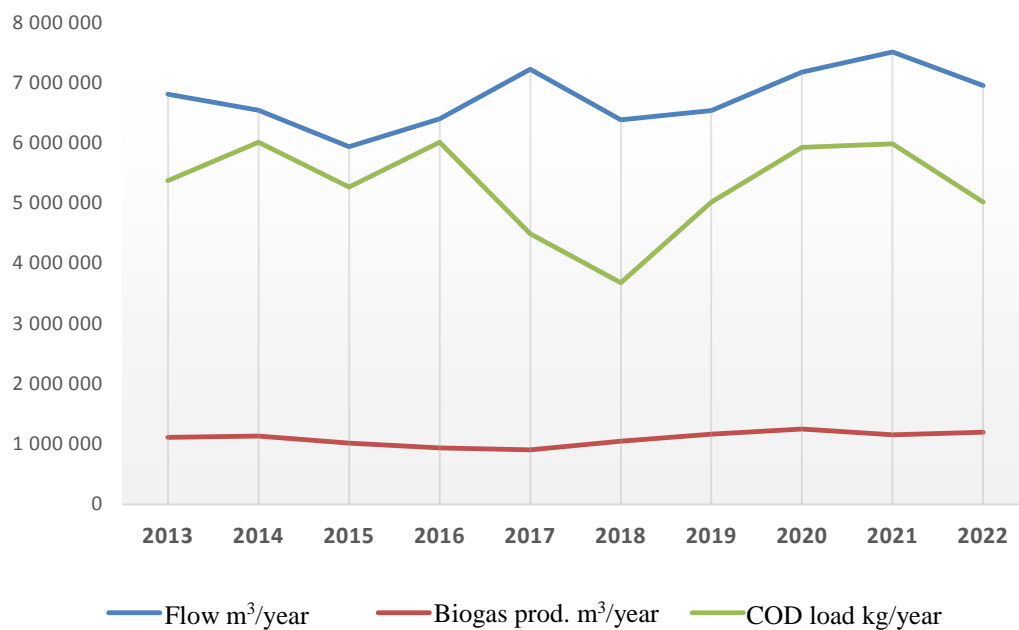




**Figure 1.** Biogas production thousand m<sup>3</sup>/year.

**Figure 2.** Average biogas production from 1 m<sup>3</sup> wastewater

An analysis of the quantity and quality of wastewater carried out between 2013 and 2022 showed that biogas production remained constant despite the varying flow and pollutant load.



**Figure 3.** Diagram of the dependence of biogas production on the quantity and quality of incoming wastewater.

The chemical oxygen demand (COD) load was used for the analysis (Fig. 3).

### 3. Characteristics of biogas and its use

#### 3.1. Composition and quality of biogas produced at the Rybnik-Orzepowice sewage treatment plant

The biogas produced during the digestion process at the SCD is captured, then purified by removing water vapour in subsequent condensate wells and hydrogen sulphide in a turf ore bed

desulphuriser. Biogas produced at the Rybnik-Orzepowice wastewater treatment plant is characterised by relatively stable parameters and contains an average of approx. 64% methane, 35% carbon dioxide and 0.002% hydrogen sulphide. The calorific value of biogas produced from sewage sludge is approximately 23 MJ/m<sup>3</sup>.

**Table 2.**

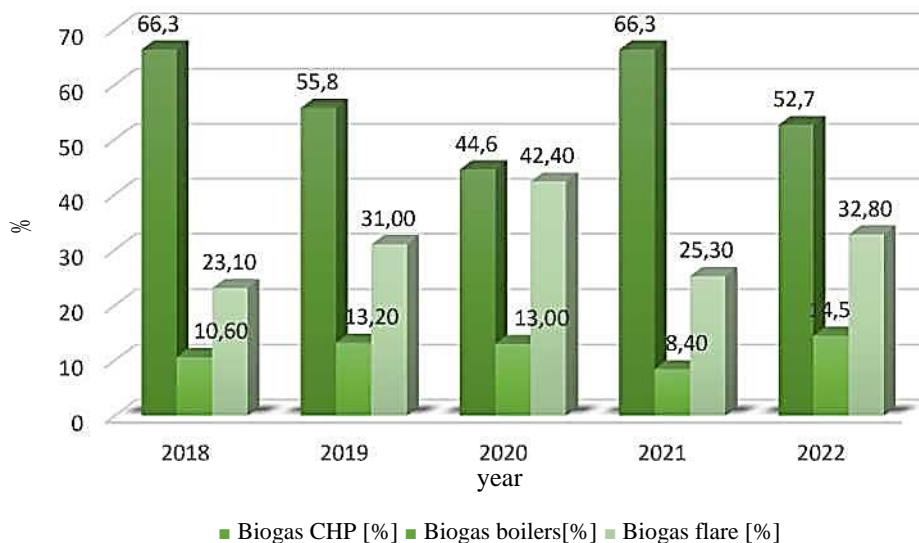
*Biogas composition and quality tested after desulphurisation, upstream of the cogeneration unit*

Parameter	Unit	2018	2019	Year 2020	2021	2022
Relative humidity	%	63	60.4	50.8	47.6	43.3
Methane CH <sub>4</sub>	vol. %	65.9	65.2	63.7	65	60.7
Carbon dioxide CO <sub>2</sub>	vol. %	34.1	34.8	32.8	35	37.8
Oxygen O <sub>2</sub>	vol. %	<0.1	<0.1	<0.1	<0.1	<1
Carbon monoxide CO	vol. %	<0.0001	0.0005	0.0005	0.001	0.0018
Hydrogen sulphide H <sub>2</sub> S	ppm	6	6	12	27	46
Hydrogen sulphide H <sub>2</sub> S	%	0.0006	0.0006	0.0012	0.0027	0.0046
Hydrogen sulphide H <sub>2</sub> S	mg/m <sup>3</sup>	9	9.2	18.47	41.36	70.8
Hydrogen H <sub>2</sub>	%obj.	<0.1	<0.1	<0.1	<0.1	0.0074
Sum of Siloxanes	mg/m <sup>3</sup> CH <sub>4</sub>	6.86	0.2	0.16	0.05	0.77
Ammonia NH <sub>3</sub>	mg/m <sup>3</sup>	1.04	0.67	1.43	1.12	0.01
Calorific value of biogas	kJ/m <sup>3</sup>	23655	23400	22900	23300	21800

The biogas extracted to ensure a stable supply to the cogeneration unit is stored in a 550 m<sup>3</sup> three-layer membrane tank.

### 3.2. Biogas utilisation.

Biogas produced at the Rybnik wastewater treatment plant, assuming there are no unforeseen breakdowns of the cogeneration unit or other conditions preventing energy production, is used at 75%. The structure of gas consumption by individual units of the energy and heat production system, i.e.: CHP unit, gas boilers and flares varies from year to year (figure 4).

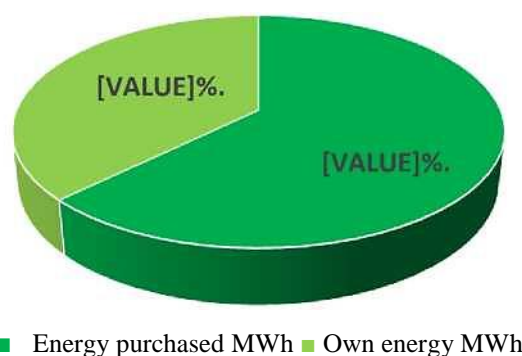


**Figure 4.** Utilisation structure of the produced biogas in the individual units of the cogeneration system.

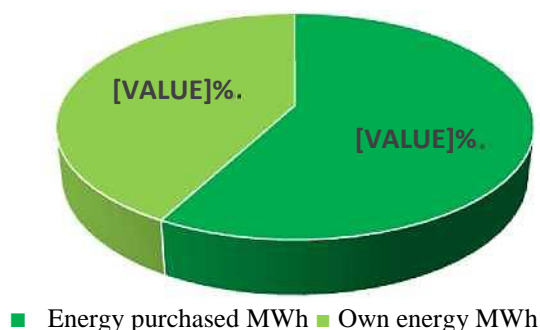
This is influenced by a number of factors, of which the main ones are inspections and maintenance of the CHP unit, the aforementioned breakdowns, as well as the heat demand used to heat the process facilities, the administration building and the production of domestic hot water (DHW).

#### 4. Electricity production

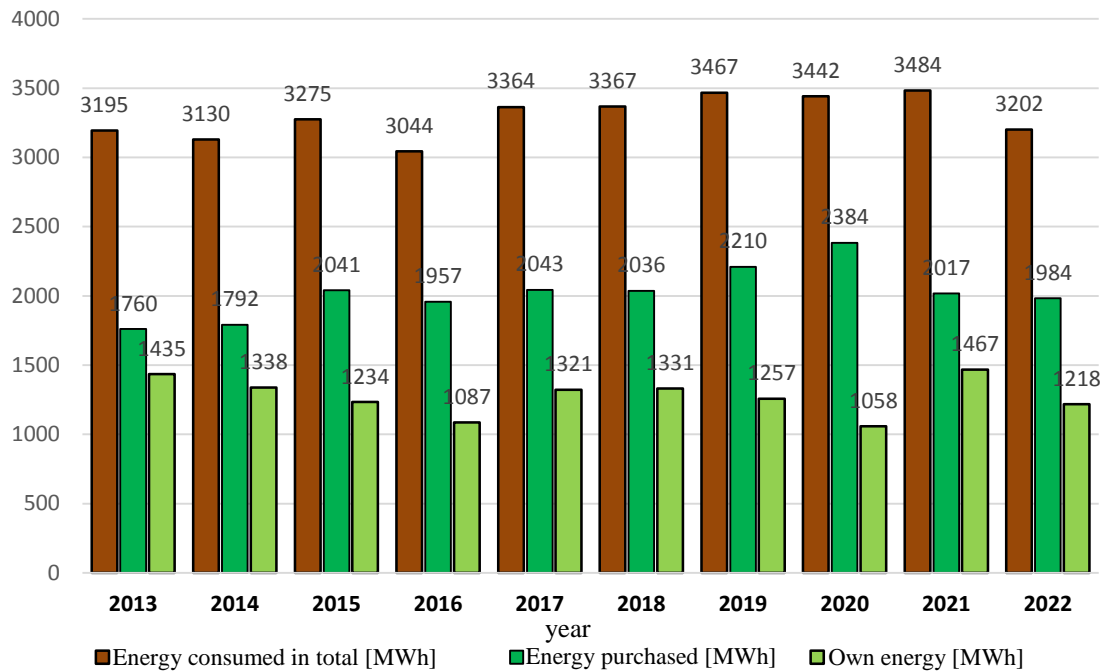
The demand for electricity at the Rybnik-Orzepowice wastewater treatment plant is at a level of approximately 3400 MWh per year. Annual production of green electricity from the biogas generated at the Rybnik-Orzepowice WWTP (data for 2021) is at a level of 1467 MWh. 96 % of the electricity produced is used for the plant's own needs. The part of the energy that cannot be consumed due to technical conditions is sold to the TAURON network, which accounts for approximately 4% of the total energy produced. From the production of electricity PWiK Sp. z o.o. obtains certificates of origin for energy from renewable sources. The current production of electricity at the Rybnik-Orzepowice sewage treatment plant covers approx. 40% of the plant's total demand for electricity.



**Figure 5.** Electricity demand coverage of the Sewage Treatment Plant in Rybnik-Orzepowice from its own sources - average for 2018-2022.



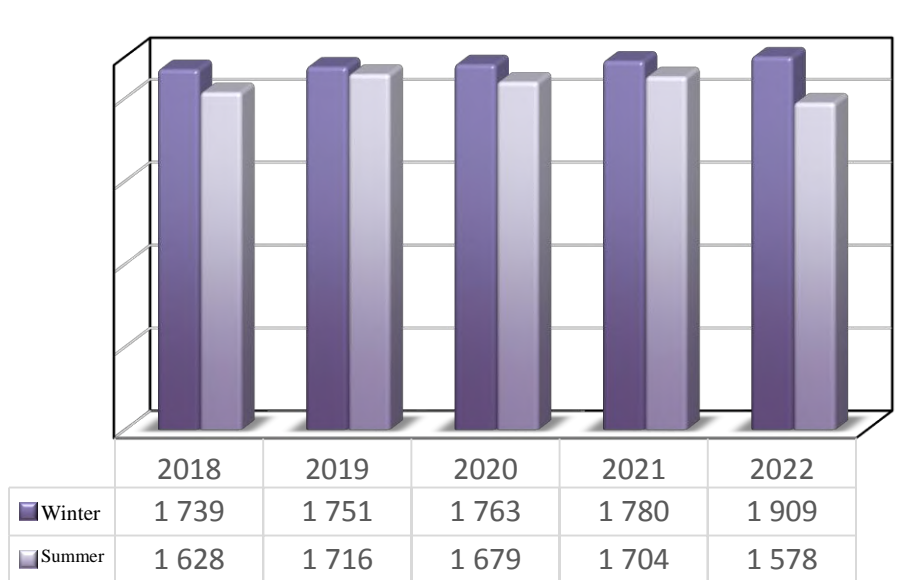
**Figure 6.** Coverage of electricity demand of the Sewage Treatment Plant in Rybnik-Orzepowice from its own sources - year 2021.



**Figure 7.** Structure of energy consumption [MWh] at the Rybnik-Orzepowice treatment plant.

Since, as previously shown, biogas production remains relatively constant, the amount of electricity production is mainly determined by the standstill of the CHP unit due to breakdowns or maintenance and repair work.

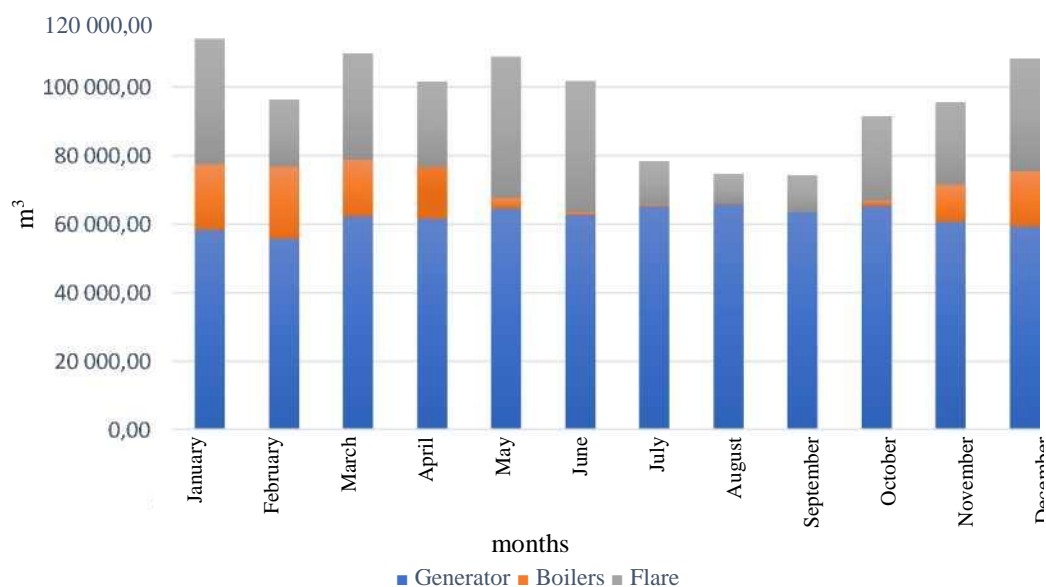
Biogas production and energy demand fluctuates throughout the year and shows variability depending on the seasons. This is mainly related to the outside temperature and the length of the day. In summer, electricity consumption at the Rybnik-Orzepowice wastewater treatment plant is lower by 10% than in the winter months Fig. 8.



**Figure 8.** Electricity consumption [MWh] in summer (April to September) and winter (October to March) at the Rybnik-Orzepowice WWTP.

## 5. Combined heat and power energy

The production of electricity in the cogeneration system is accompanied by the production of thermal energy. The heat from the CHP unit is used to heat the process buildings including heating the digestion process in the SCD. It provides heat for the administrative building of the treatment plant, and is also used to produce DHW supplied to the staff baths. The heat demand during winter periods is higher Fig. 10. therefore, heat production from the generator is often insufficient and must be compensated by high-efficiency biogas boilers. In 2021, when the generator was operating without failure Fig. 11, 105,000 m<sup>3</sup> of biogas was burned on the boilers to provide sufficient heat for the facility.



**Figure 10.** Biogas consumption [m<sup>3</sup>] at individual facilities.

The combined heat and power production system at the sewage treatment plant in Rybnik-Orzepowice does not have metering of the generated heat energy, therefore the amount of heat generated is determined based on calculations (Table 2).

**Table 3.**

*Calculated thermal energy production from biogas combustion*

Year	COGENERATOR		GAS BOILERS	
	Biogas consumption m <sup>3</sup> /year	Heat energy production MJ/year	Biogas consumption m <sup>3</sup> /year	Heat energy production MJ/year
2018	695 076	8 070 070	109 869	2 365 040
2019	650 323	7 550 445	154 762	3 331 407
2020	546 412	6 344 007	165 371	3 559 776
2021	774 042	8 673 382	104 564	2 250 845
2022	630 701	7 322 628	172 978	3 723 524

In Poland, to produce 1 MWh of electricity, it is necessary to burn approx. 144 kilograms of hard coal with a calorific value of approximately 25 MJ/kg. It is worth remembering, however, that the amount of coal needed to produce 1 MWh depends on the efficiency of the

boiler, as well as the calorific value of the coal. The lower the calorific value, the more coal needs to be burned. In view of this, in a nutshell, it can be said that the production of approximately 1 400 MWh/year of electricity from biogas cogeneration saves about 200 tonnes of coal, not including the losses associated with the transmission and transfer of electricity. In addition, the production of heat for preheating sludge as well as rooms and DHW heating is estimated to save around 300 tonnes of coal per year.

## 6. Summary and conclusions

Analysis of the data shows that the biogas produced in the sewage treatment process and burned for the needs of the sewage treatment plant in Rybnik-Orzepowice makes it self-sufficient in terms of heat needs. In turn, the production of electricity from cogeneration covers the plant's electricity needs by 43%. The biogas burned represents approximately 30% of production, which argues for the addition of a second 40-50kW engine. The installation of an additional unit would make it possible to utilise biogas to a much greater extent - perhaps even entirely. An analysis of the heat demand of the treatment plant showed that, especially in winter, it is necessary to run a gas-fired boiler plant for additional heat production. An additional CHP unit, despite the lower thermal efficiency of the generator, would make it possible to provide sufficient heat without having to run the boilers. This, in turn, would free up an additional biogas stream that could be used to produce electricity. Since it is estimated that the supply of a smaller engine involves a high unit investment cost and subsequently an operating cost, an investment decision would have to be made to install a generator with the same capacity as the current one, i.e.: 190 kW and 231 kW thermal output. There are many arguments in favour of such a solution for the Rybnik-Orzepowice WWTP, i.e.:

- ✓ Use of the entire available biogas stream.
- ✓ Covering the deficit in heat demand from CHP in the winter months.
- ✓ The ability to continuously produce energy despite the failure of one of the units or ongoing maintenance activities.
- ✓ Increasing the production of renewable energy for own consumption to around 70% of current consumption.

Not insignificant for the application of the 190 kW CHP variant is the ongoing extension of the sewage network in the Chwałęcice-Stodoły districts, which will result in an additional sewage load flowing into the treatment plant, thereby increasing the amount of sludge generated and biogas production.

Furthermore, in view of the climate policy of the European Union and Poland, which aims to make electricity generation independent of fossil fuels, the construction of a third closed SCD, together with a gas storage tank, should also be included in the forthcoming investment

plans. This will secure the reliability of the reception of sludge generated at the sewage treatment plant and enable the lengthening of the digestion process, thus increasing biogas and energy production and reducing the amount of sludge generated.

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## MANAGEMENT OF INVESTMENT ACTIVITIES AND DEVELOPMENT POTENTIAL OF MUNICIPAL GOVERNMENTS IN THE SILESIAN AND GREATER POLAND VOIVODESHIP IN CRISIS CONDITIONS

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**Purpose:** Managing local governments' investment and development activities is a complex problem, conditioned by the appropriate financial potential and the involvement of many entities. The article's main aim is a comparative analysis and assessment of the investment and development potential of municipal governments in the Silesian and Greater Poland Voivodeships in the conditions of the crisis resulting from the COVID-19 pandemic.

**Design/methodology/approach:** The article undertakes research based on the indicator analysis of the budget management of municipal governments, which was extended with a multi-criteria analysis of TOPSIS linear ordering. Determining financial condition classes allowed us to indicate whether the COVID-19 pandemic influenced the surveyed entities' development potential and investment activities.

**Findings:** The indicator analysis of the budgetary management of municipal governments allowed for a comparative determination of the development potential of municipal governments in two voivodeships and to assess their investment activities in 2019-2021. Research has shown that 2020 and the onset of the COVID-19 pandemic resulted in a slowdown in investment activity and a very large increase in the self-financing rate. The municipalities of the Silesian and Greater Poland Voivodeships were characterized by high investment and financial potential, although the use of the investment potential decreased dramatically.

**Research and limitations/implications:** The research results can be used for further exploration in the field of managing investment activities and the financial potential of local governments.

**Practical and social implications:** The research results can help increase the awareness of the local community about the process of managing investment activities and the financial potential of municipal governments.

**Originality/value:** The article contributes to expanding the research topic in the field of managing the investment and development potential of municipal governments in crisis conditions, based on single- and multi-criteria analysis methods.

**Keywords:** financial and development potential, investment activities, local governments.

**Category of the paper:** Empirical research paper.

## 1. Introduction

Financial management in local government units mainly involves taking both strategic and development activities. An integral element is access to reliable information, as management cannot be intuitive. To implement the assigned tasks and rationally manage financial resources, ratio analysis becomes important. In times of crisis, the role of efficient decision-making increases, especially in the use of investment and development potential, self-financing opportunities, and obtaining debt capital. Due to uncertainty and major environmental perturbations, local governments should use appropriate tools and techniques to improve the budgeting process for public tasks.

The financial management of territorial division entities is considered a rather complex process, as it not only involves decision-making and several actions by the legislative and executive bodies but is also a process aimed at maximizing economic and social results to meet planned goals, both strategic and current. Kornberger-Sokołowska (2012) stresses that the level of income and the allocation of money are primarily based on the qualitative and quantitative needs of the local community. Drywa et al. (2014) indicate that funds are the basis for the performance of tasks by municipalities. Their amount also depends on the municipality's economic, social, and political development. Lewis and Oosterman (2011) argue that the implementation of investment projects by local government units (LGUs) affects the strengthening of their investment activity, which is important for any country, as it positively affects its development.

The COVID-19 pandemic has forced LGUs to use creative and untested economic development strategies (Johnson et al., 2022). Afonso (2021) stressed the importance of understanding how government agencies were responding to the challenges of the COVID-19 pandemic and how municipalities used their economic development tools to combat the crisis. The pandemic period, as Malinowska-Misiąg (2022) concluded, was a time of intensifying unfavourable systemic trends in the finance of Polish LGUs. For another year in a row, the financial independence of local government units has decreased, and the pool of funds with the status of own revenues has increased, which, unfortunately, is related to specific expenses. Ofiarska (2021, p. 139) note that the effects of the COVID-19 pandemic in the form of a reduction in LGU's own revenues and the related reduction in their expenditure, including capital expenditure, were the decisive factor for the introduction of extraordinary and temporary mechanisms to minimise this negative phenomenon from 2020. One such solution is the Government Fund for Local Investment, separated from the state-dedicated fund - the COVID-19 Counteracting Fund. Szolno-Koguc (2022, p. 547) notes that the creation of the COVID-19 Counteracting Fund resulted in the exclusion of some finances of a public nature from the general pool, intended primarily for tasks related to health care during the COVID-19 pandemic.

Therefore, the goal of the research undertaken in this article is to present a theoretical and practical approach to the management of investment activities and development potential of local government units based on the indicator analysis of budget implementation reports and the TOPSIS multi-criteria method of municipalities in the Silesian and Greater Poland Voivodeships in the conditions of the crisis caused by the pandemic. COVID-19. The period covered by the research covers the years 2019-2021.

## 2. Literature review

The pandemic and the ensuing recession caused a huge burden on state and local government budgets (Tracy et al., 2020). Responses to COVID-19 in various countries only exacerbated existing socioeconomic inequalities and, as expected, not all federal, state, or local responses had a positive effect on all segments of society (Li et al., 2022). With the challenges of the pandemic, governments around the world established various mechanisms to facilitate responses to the pandemic and ensure state functioning (Patrzalek, Gałeczka, 2022). At the same time, most EU countries saw a change in the structure of local government spending by increasing the share of spending on health care, social protection, and economic affairs. Franek (2022, p. 55) conducted research that indicated that local government finances in EU countries did not suffer significant effects of the pandemic, but this was mainly because the main source of funding for additional tasks and covering shortfalls in tax revenues were transfers from the government sector. Auerbach et al. (2021) indicated that the pandemic temporarily contributed to budget deficits, but had little impact on long-term budget forecasts. For state and local governments, the unusual nature of the recession was emphasized: focusing on job losses among low-wage workers, and the unprecedented growth and expansion of unemployment insurance benefits and business loans. Among other researchers, Grand and Loualiche (2020) found that local governments were facing large revenue losses and increased expenses due to the COVID-19 crisis. They also documented the causal relationships between the fiscal pressures caused by COVID-19 and layoffs of state and local government employees.

Malinowska-Misiąg (2022) concludes that the financial situation of individual LGUs varied greatly in the first year of the pandemic, which turned out to be better for LGUs than initially expected. The negative effects of the pandemic were particularly noticeable in urban municipalities and towns with powiat status, and least pronounced in rural municipalities. Mackiewicz et al. (2022) assessed the economic impact of the pandemic from the standpoint of the local finances of LGUs in the Mazovia region of Poland and provided evidence that the characteristics of urban and rural LGUs affect not only their resilience to the pandemic but also influence their strategies and actions performed in response to the crisis. The lockdown and reduced economic activity have had an impact on local government budget revenues. Chernick

et al. (2020) predicted large variations between cities, depending on differences in income structure and fiscal health due to the recession. According to the authors, the hardest-hit cities faced revenue losses of 15% or more at the beginning of the pandemic. The comparison of revenue pressures with cost pressures caused by the coronavirus conducted by these authors revealed that many cities would experience large revenue shortfalls and high additional costs in the coming years. Furthermore, Kańduła and Przybylska (2021) conducted a study showing that the initial response of Polish municipalities to the pandemic crisis varied by administrative type, amount of current per capita income, and population. However, correlations between applied income and expenditure instruments and the above factors were rather weak.

Patrzalek et al. (2022) examined how the pandemic affected the finances of LGUs in 2020-2021. Their scientific investigations also focused on indicating whether it was possible to distinguish the types of units where the impact was greater or lesser, and whether and how pandemic-related regulations affected the fiscal relationship between the state and local governments. Their research confirmed that the economic impact of the COVID-19 crisis varies from region to region and that financial solutions dedicated to LGUs and making local government fiscal rules more flexible helped maintain the potential of the local economic base.

The analysis of the literature on the subject based on the triangulation method allowed us to outline the following research questions:

- Has the COVID-19 pandemic affected the investment and development potential of urban, urban-rural, and rural municipalities in the Silesian and Greater Poland Voivodeships?
- Did municipalities accumulate financial resources and limit the use of debt capital during the crisis?
- Which municipalities in the Silesian and Greater Poland Voivodeships ranked best in terms of the TOPSIS synthetic measure?
- How did the COVID-19 pandemic affect the classification of municipalities in the Silesian and Greater Poland Voivodeships in terms of financial development potential in 2019-2021?

### 3. Methods

The assessment of the financial condition, investment, and development activities of local governments is most often carried out concerning traditional tools and methods based on financial analysis. The Ministry of Finance in Poland monitors three groups of indicators: budget (WB1-WB11), per capita (L1-L5), and liabilities according to debt titles (WZ1-WZ7), which together with the calculation formulas are presented in the table. 1. based on the presented indicators, it is possible to assess, statically and dynamically, inter alia, investment

activity, investment and development potential, use of investment potential, and sources of financing, including the self-financing possibilities of local governments.

**Table 1.**

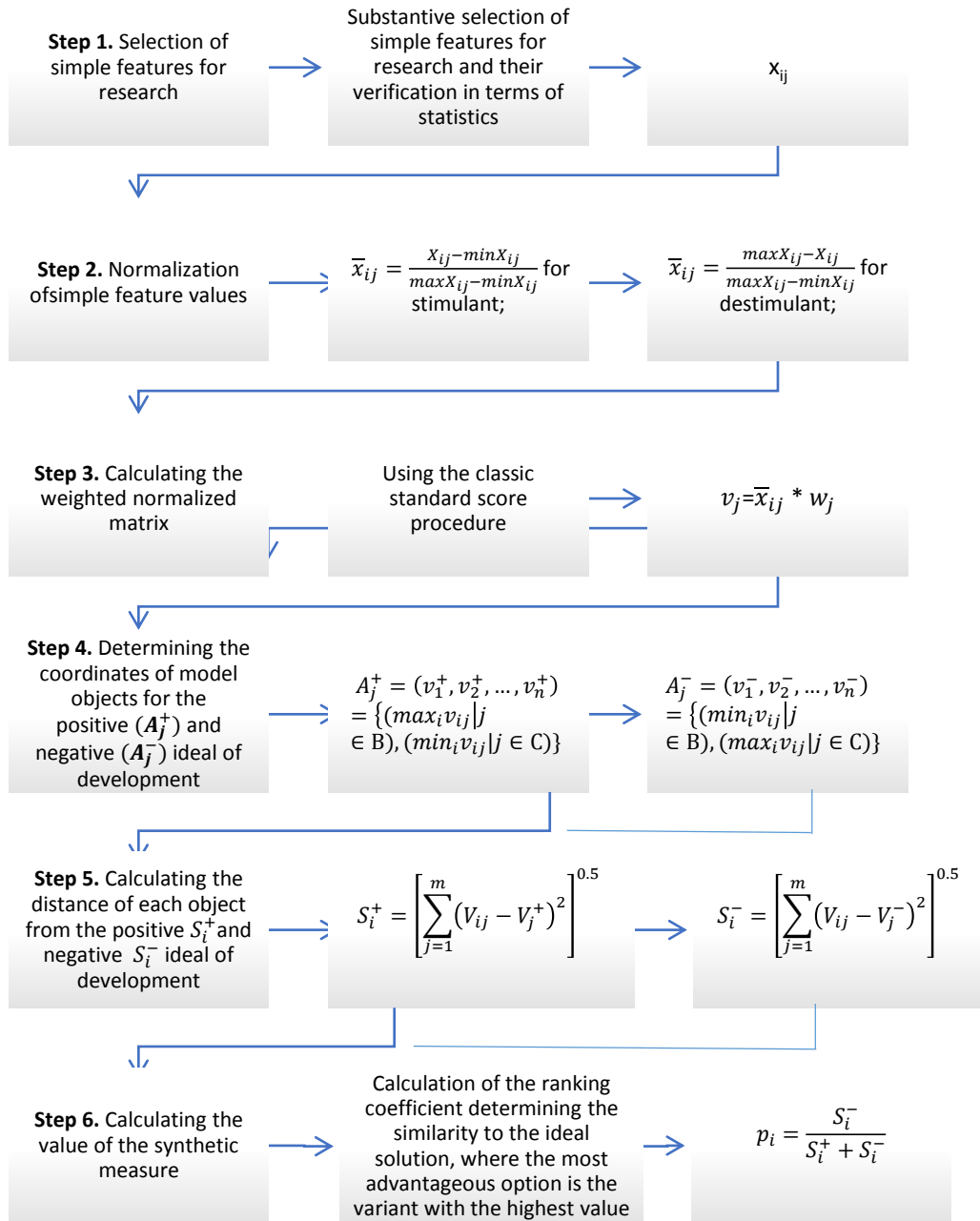
*Indicators for monitoring the financial condition of local governments in Poland*

Indicators name	Calculation formula
Share of current income in total income	$WB1 = Db/Do$
Share of current transfers in current income	$WB2 = Tb/Db$
Share of operating surplus in current income	$WB3 = No/Db$
Share of capital expenditure in total expenditure	$WB4 = Wm/Wo$
The burden of current expenditures on wages and salary derivatives	$WB5 = Ww/Wb$
Share of operating surplus and income from the sale of assets in total income	$WB6 = (No + Sm)/Do$
Share of operating surplus and property income in capital expenditure (Self-financing ratio)	$WB7 = (No + Dm)/Wm$
Development potential for property expenditures and capital repayments	$WB9 = (Pbzwr + (Do - Wb))/Wm + Rs$
Investment potential for property expenditures	$WB10 = (Pbzwr + (Do - Wb - Rs))/Wm$
Utilization of investment potential	$WB11 = Wm/(Pbzwr + (Do - Wb - Rs))$
Current transfers per capita	$WL1 = Tb/L$
Operating surplus per capita	$WL2 = No/L$
Total liabilities per capita	$WL3 = Zo/L$
Development potential per capita	$WL4 = (Pbzwr + (Do - Wb))/L$
Investment potential per capita	$WL5 = (Pbzwr + (Do - Wb - Rs))/L$
Share of total liabilities in total income	$WZ1 = Wo/L$
The burden of total income on debt service	$WZ3 = Wm/L$
The burden of current income on debt service	$WZ5 = (Rs + O)/(Db - Dbd)$

\* Designations in formulas: *L* - number of residents of local government units; *Db* - current income; *Dm* - property income; *Sm* - income from the sale of property; *Tb* - current transfers - income from general subsidies and subsidies and funds allocated for current purposes; *Wo* - total expenses; *Wm* - capital expenditure; *Wb* - current expenses; *Ww* - expenditure on remuneration and remuneration derivatives, excluding remuneration financed or co-financed by EU funds; *Zo* - Total liabilities according to debt titles; *O* - debt servicing expenses, including interest on credits and loans; *Rs* - repayment of capital instalments on loans and credits taken out; *No* - operating surplus; *Pbzwr* - budget revenues excluding credits, loans, securities issues; *Dbd* - current income from subsidies and funds allocated for current purposes.

Source: Own elaboration based on: Wskaźniki do oceny sytuacji finansowej jednostek samorządu terytorialnego w latach 2019-2021. Retrieved from: <https://www.gov.pl/web/finanse/wskazniki-do-oceny-sytuacji-finansowej-jst-w-latach-2019---2021>, 7.09.2023.

To assess the investment activity and development potential of 370 municipalities (excluding cities with powiat status) located in two bordering voivodeships: Silesia (148 municipalities) and Greater Poland (222 municipalities), univariate and multivariate analyses were carried out using the TOPSIS method in 2019–2021 (period of the COVID-19 pandemic), to obtain the value of a synthetic measure of the level of investment activity and development potential of the surveyed entities. The designated classes of financial development potential were the basis for a comparative analysis of the assessed municipalities. Fig. 1 shows the stages of the TOPSIS method along with the description and individual formulas, and Fig. 2 shows the ranking of the classes of the calculated synthetic measure.



Where:  $x_{ij}$  – the value of the  $j$ -th trait in the  $i$ -th object (municipalities);  $v_j$  – indicator value in the weighted normalized matrix;  $w$  – indicator weight;  $V$  – coefficient of variation of a single indicator;  $\bar{x}_{ij}$  – normalised values of the  $j$ -th trait in the  $i$ -th object;  $A_j^+$  - the positive ideal value;  $A_j^-$  - the negative ideal value;  $S_i^+$  – euclidean distance from the ideal value;  $S_i^-$  - euclidean distance from the anti-ideal value.

**Figure 1.** Stages of determining the TOPSIS synthetic value.

Source: Own elaboration based on Wysocki (2020), Kozera, Wysocki (2016), Kacprzak (2018), Behzadian et al. (2012), Pietrzak (2016), Azizi (2017), Wołoszyn et al. (2021).

According to research conducted by Głowicka-Wołoszyn et al. (2018), based on the calculated TOPSIS synthetic indicator, four typological classes can be selected to define the financial development potential of municipal governments, based on the mean ( $\bar{p}_i$ ) and standard deviation ( $s_{pi}$ ) of the synthetic indicator ( $pi$ ). The grading formulas for individual classes are presented in Table 2. The best result is shown in class 4, and the weakest in class 1.

**Table 2.***Typological classes of measures of the synthetic TOPSIS method*

Class I (high)	Class II (medium-high)	Class III (medium-low)	Class IV (low)
$p_i \geq \bar{p}_i + s_{pi}$	$\bar{p}_i - s_{pi} \leq p_i < \bar{p}_i$	$\bar{p}_i - s_{pi} \leq p_i < \bar{p}_i$	$p_i < \bar{p}_i - s_{pi}$

Source: Own elaboration based on Głowicka-Wołoszyn et al. (2018); Wołoszyn, Wysocki (2016).

The TOPSIS method (Technique for Order Performance by Similarity to Ideal Solution) is one of the most frequently used multi-criteria decision-making methods (Çelikkilek, Tüysüz, 2020). Among others, Pandey et al. (2023) made an effort to review various studies that have used the TOPSIS method or developed extensions to it. The authors performed an extensive review of the subject literature: articles published by Elsevier, Springer, Wiley, Taylor and Francis, and others from 1981 to the first quarter of 2023, relating to various types of TOPSIS methods, their extensions and applications, as well as the latest trends in various research fields. Based on their findings, they observed that the number of articles using the TOPSIS method and its extensions has increased exponentially in recent years. The popularity of this method in the research conducted influenced the decision to use it in this study, although it was decided to choose the classic TOPSIS approach.

## 4. Results

The research was conducted for 370 municipalities ( $n = 370$ ) from the Silesian and Greater Poland Voivodeships in 2019-2021. These are regions with a large number of inhabitants and a high degree of industrialization. The main goal of the research undertaken is to assess the investment and financial potential of the surveyed entities in the conditions of the crisis caused by the COVID-19 pandemic. Due to its implementation, the financial indicators monitored by the Ministry of Finance in Poland for 45 urban municipalities (excluding cities with powiat status), 118 urban-rural municipalities, and 207 rural communes were first assessed. In total, 370 municipalities were subjected to the study including 15 urban municipalities in the Greater Poland Voivodeship, 30 in the Silesian Voivodeship; and 96 urban-rural municipalities in the Greater Poland Voivodeship and 22 in the Silesian Voivodeship, as well as 111 rural municipalities in the Greater Poland Voivodeship and 96 in Silesian Voivodeship. The results of the examined indicators are presented in Tables 3 and 4.

**Table 3.**

*Budget, per capita, and liabilities indicators of municipal governments in the Greater Poland Voivodeship in 2019-2021*

Indicator name	Rural municipalities			Urban-rural municipalities			Urban municipalities		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
WB1 [%]	93.0	91.0	90.9	94.2	92.4	92.1	92.2	93.3	94.6
WB2 [%]	61.9	63.0	61.5	58.7	60.7	59.6	49.2	51.6	51.3
WB3 [%]	10.2	10.1	12.3	9.3	9.0	10.9	7.2	5.7	11.0
WB4 [%]	15.6	14.0	14.2	13.3	13.0	12.6	13.6	9.8	10.8
WB5 [%]	36.7	35.7	36.8	36.0	34.9	35.7	37.2	36.0	37.2
WB6 [%]	9.9	9.8	12.0	9.7	9.1	11.4	8.1	6.9	11.6
WB7 [%]	134.6	177.0	177.9	124.1	145.9	176.0	145.0	139.4	182.7
WB9 [%]	131.4	180.4	218.1	123.9	152.0	199.2	140.3	164.0	203.7
WB10 [%]	148.1	210.5	248.6	130.7	169.0	229.1	162.3	187.0	244.4
WB11 [%]	99.9	64.9	46.7	98.7	73.5	54.1	90.4	67.3	49.6
WL1 [zlotys/per capita]	3,080.7	3,409.5	3,607.9	2,830.1	3,167.9	3,352.6	2,306.3	2,615.6	2,922.8
WL2 [zlotys/per capita]	529.5	574.2	767.8	460.2	478.7	626.9	339.9	289.1	635.7
WL3 [zlotys/per capita]	1,075.0	1,105.9	1,056.0	1,197.8	1,229.2	1,207.9	988.4	1,067.2	1,027.7
WL4 [zlotys/per capita]	1,262.7	1,587.6	2,144.0	1,018.1	1,269.4	1,682.4	939.7	973.8	1,502.6
WL5 [zlotys/per capita]	1,044.4	1,389.4	1,954.7	824.0	1,084.5	1,506.1	803.2	828.5	1,323.8
WZ1 [%]	19.5	17.8	15.7	23.3	21.5	19.8	19.4	19.4	17.3
WZ2 [%]	4.5	3.6	3.1	4.4	3.7	3.2	3.1	3.0	3.2
WZ5 [%]	7.5	6.4	5.2	7.1	6.4	5.3	4.8	4.8	4.9

Source: Own elaboration.

Urban and urban-rural municipalities in the Greater Poland Voivodeship were characterized by a decreasing share of current income in total income (WB1) in the years 2019-2021, and the opposite trend was observed in urban municipalities (an increase from 92.2-94.6%). In the case of municipalities in the Silesian Voivodeship, a progression of property income is visible, current income decreased except for urban municipalities in 2021. The increase in current transfers is especially visible in 2020, which was characterized by an escalation of the COVID-19 pandemic and clear support from government funds under the Road Fund Local Government Funds (FDS) (currently Government Road Development Fund - RFRD). The fund is an instrument to support the implementation of tasks on roads managed by local government units. It aims to accelerate the creation of modern and safe road infrastructure at the local level, constituting an important element of the proper functioning and development of the economy and contributing to improving the standard of living of citizens. In 2019, 6 billion zlotys was allocated for the construction of local roads from the FDS, while in 2020 it was 3.2 billion zlotys. The limit for co-financing tasks carried out by local governments of the Greater Poland Voivodeship was 376.9 billion zlotys in 2019, and 228.7 billion zlotys in 2021; while local



government units from the Silesian Voivodeship in 2019 (234.4 billion zlotys), and in 2021 (140.6 billion zlotys). It can therefore be concluded that greater co-financing for current tasks in the field of road infrastructure went to the LGUs of the Greater Poland Voivodeship. This thesis is also confirmed by the higher level of WB1 and WB2 indicators. Taking into account the situation related to the COVID-19 epidemic and the need to take action to protect the road transport sector, financial support provided under the FDS was one of the important elements of combating the effects of the economic crisis and stimulating economic activity.

**Table 4.**

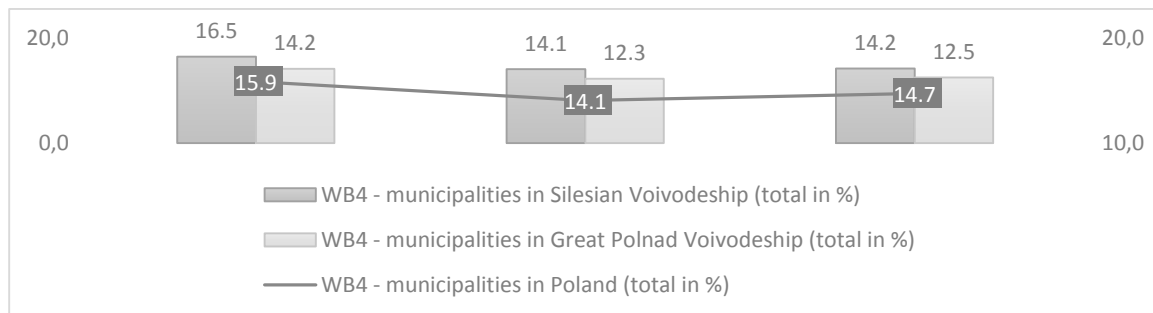
*Budget, per capita, and liabilities indicators of municipal governments in the Silesian Voivodeship in 2019-2021*

Indicator name	Rural municipalities			Urban-rural municipalities			Urban municipalities		
	2019	2020	2021	2019	2020	2021	2019	2020	2021
WB1 [%]	91.3	88.9	88.3	91.7	89.4	87.8	92.0	88.6	90.6
WB2 [%]	56.3	57.9	57.2	54.4	56.6	56.0	42.7	46.4	45.8
WB3 [%]	10.5	9.5	11.7	8.1	7.8	10.5	7.7	4.7	9.5
WB4 [%]	17.3	14.5	14.4	16.1	14.1	14.9	16.1	13.7	13.4
WB5 [%]	40.0	38.1	39.0	38.6	36.7	37.6	38.9	37.5	38.6
WB6 [%]	10.2	9.1	11.1	8.4	7.7	10.4	9.0	6.0	11.0
WB7 [%]	142.6	178.3	226.8	108.9	143.8	184.2	103.0	128.3	157.6
WB9 [%]	147.5	212.4	269.4	121.1	149.7	204.0	121.4	157.5	211.5
WB10 [%]	160.9	238.9	322.9	126.6	159.3	237.3	127.6	168.0	235.2
WB11 [%]	86.4	147.4	-5.1	96.8	74.9	48.5	91.6	75.6	51.7
WL1 [PLN/per capita]	2,646.6	2,970.9	3,223.7	2,404.6	2,742.1	3,005.4	1,971.1	2,281.4	2,546.0
WL2 [PLN/per capita]	509.6	492.4	670.0	362.3	377.8	571.9	367.5	231.3	533.3
WL3 [PLN/per capita]	996.0	1,040.8	1,009.0	965.9	1,026.6	976.1	1,043.8	1,116.6	1,144.2
WL4 [PLN/per capita]	1,422.7	1,694.5	2,375.2	1,067.7	1,275.3	1,935.7	1,163.7	1,312.4	1,777.5
WL5 [PLN/per capita]	1,259.3	1,549.7	2,196.9	893.1	1,119.2	1,780.3	1,011.0	1,166.7	1,652.2
WZ1 [%]	19.3	17.8	15.4	20.3	19.1	15.8	20.7	19.9	18.3
WZ2 [%]	3.7	2.9	3.1	4.1	3.3	2.8	3.5	3.0	2.3
WZ5 [%]	5.9	4.9	5.0	6.5	5.5	4.5	5.1	4.9	3.6

Source: Own elaboration.

The outbreak of the COVID-19 pandemic also affected the level of operating surplus, with the surveyed municipalities recording the lowest share in total income (WB3) in 2020. It should also be emphasized that the lowest level of the examined measure in 2020 was recorded in urban communes (in the Silesian Voivodeship, 4.7%, and in the Greater Poland Voivodeship, 5.7%, respectively). Fig. 2 illustrates the share of capital expenditure in total expenditure (WB4). The list of communes in the studied voivodeships was compared to the value of

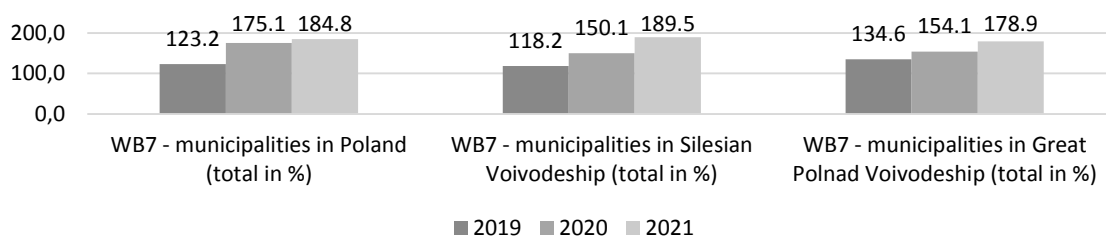
communes in total in Poland. It can be concluded that municipalities in Poland during the outbreak of the COVID-19 pandemic recorded a slowdown in investment activity on average from 15.9% in 2019 to 14.1% in 2020. The highest value of the examined measure was recorded in the municipalities of the province of Silesia, although in their case the indicator decreased from 16.5% to approximately 14% in 2020-2021. In turn, the investment activity of municipalities in Greater Poland was characterized by a regression from 14.2% in 2019 to over 12% in 2020-2021. This confirms the thesis that the investment activity of the surveyed municipalities slowed down during the COVID-19 pandemic.



**Figure 2.** Share of capital expenditure in total expenditure of municipalities in Poland in 2019-2021.

Source: Own elaboration.

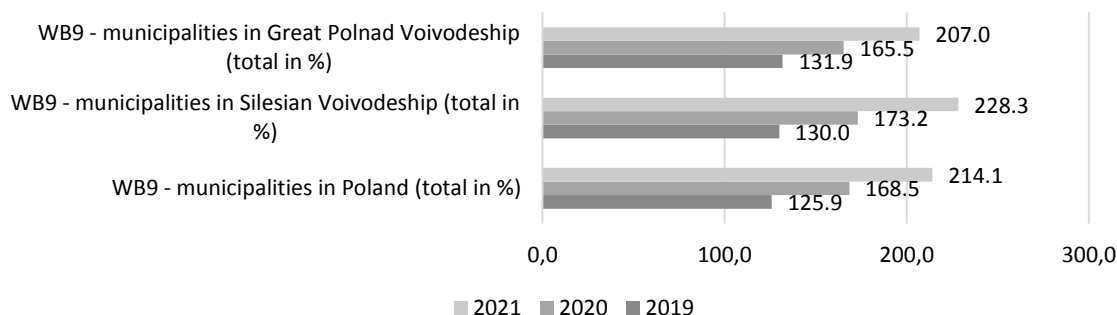
The slowdown in investment activity and a very cautious investment policy increased the level of self-financing of the examined communes (Fig. 3), which did not differ significantly from the average value for all communes in Poland. The years 2019-2021 were also characterized by a regression of debt ratios according to debt titles (WZ1, WZ2, and WZ5), although the communes of the Silesia and Greater Poland Voivodeship generated much lower values compared to municipalities in Poland in general.



**Figure 3.** Share of operating surplus and property income in capital expenditure (self-financing ratio) of municipalities in Poland in 2019-2021.

Source: Own elaboration.

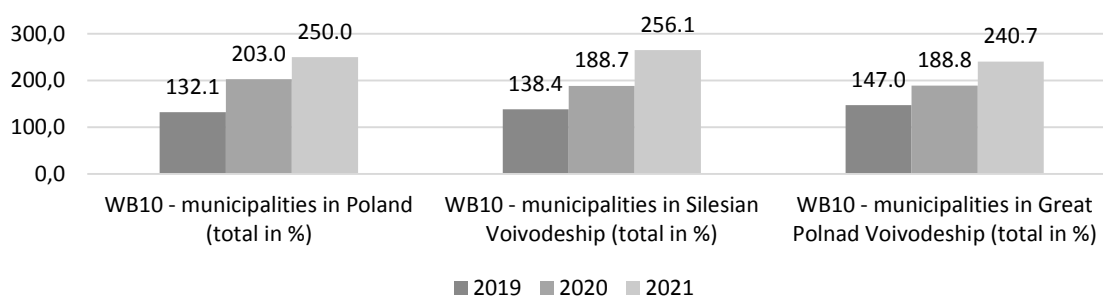
Figure 4 compares the development potential in terms of capital expenditure and capital repayments of the surveyed municipalities in 2019-2021. It can be noticed that the WB9 indicator is characterized by a large progression, for municipalities in general it is an increase of 75.1%, for municipalities in the Silesian Voivodeship by 98.3%, and in the Greater Poland Voivodeship by 88.2%.



**Figure 4.** Development potential about property expenditures and capital repayments of municipalities in Poland in 2019-2021.

Source: Own elaboration.

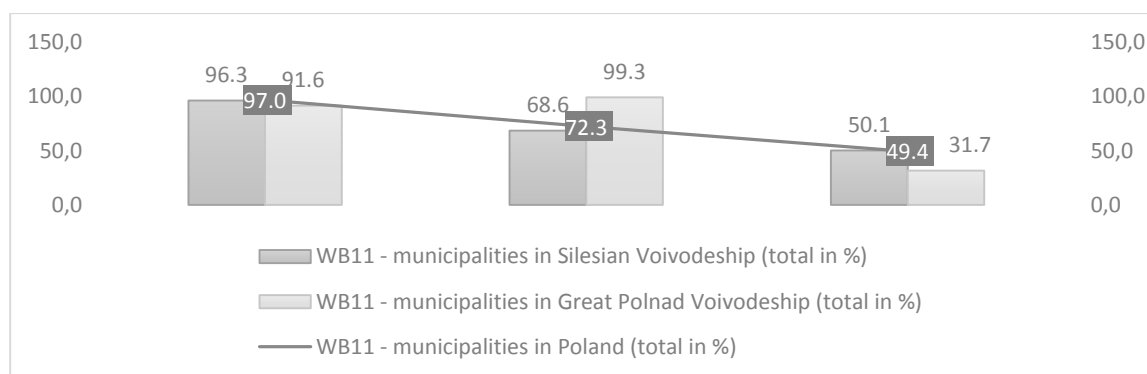
A similar escalation can be seen in the case of the next measure WB10. Investment potential in property expenditures of municipalities in Poland increased from 132.1% to 250.3% in 2019-2021. The highest value of the indicator in 2021 was recorded by the communes of the Silesian Voivodeship 265.1%, while about the total number of communes in Poland, communes of the Voivodeship Greater Poland Voivodeship with an investment potential of 240.7%. Such high values of indicators confirm great possibilities in the field of active investment policy, unfortunately, another indicator WB11 proves that the use of this potential was relatively low during the COVID-19 pandemic.



**Figure 5.** Investment potential about property expenditures of municipalities in Poland in 2019-2021.

Source: Own elaboration.

Municipalities in total in Poland reached the ceiling of 96.3% of the use of investment potential in 2019, and in the following years there was a significant decline, first to 72.3% in 2020, and then 49.4% in 2021. This proves the thesis about half the capacity to pursue an active investment policy in times of crisis. Interestingly, the communes of the province in 2020, Greater Poland Voivodeship had 99.3% of the opportunities to use the investment potential, but in 2021 only 31.7%. Municipalities of the province of Silesia were characterized by a slightly lower level of the examined measure compared to municipalities in Poland in general.



**Figure 6.** Utilization of investment potential by municipalities in Poland in 2019-2021.

Source: Own elaboration.

The analysis of budget indicators and liabilities allows for a general assessment of the management of the investment and development potential of the examined municipalities. To determine development classes and classify individual municipalities into them, research was carried out using the TOPSIS linear ordering measure. Table 5 presents the highest values of the synthetic indicator and the names of municipalities that achieved its highest level.

**Table 5.**

*A synthetic measure of the financial development potential of municipalities with 1st position in voivodeship based on the TOPSIS method in 2019-2021*

Type of local government unit and location in the voivodeship		Pi – municipalities with 1st position			Ranking – municipalities with 1st position		
		2019	2020	2021	2019	2020	2021
Silesian Voivodeship	rural municipalities	0.5818	0.7466	0.9904	Ornontowice	Brenna	Milówka
	urban-rural municipalities	0.6450	0.6537	0.5551	Sośnicowice	Kuźnia Raciborska	Sośnicowice
	urban municipalities	0.8095	0.6160	0.7460	Knurów		
Greater Poland Voivodeship	rural municipalities	0.6233	0.6294	0.7357	Baranów		
	urban-rural municipalities	0.6606	0.6572	0.6800	Sieraków	Stęszew	
	urban municipalities	0.6570	0.6809	0.6641	Chodzież		Obrzycko

Source: Own elaboration.

Based on the data presented in Table 5, it can be concluded that, firstly, in the Silesian Voivodeship during the entire period under study, the leader in terms of financial possibilities and development was the urban commune of Knurów, and in the Silesian Voivodeship the rural commune of Baranów was the leader. However, it should be noted that the escalation of the COVID-19 pandemic resulted in much lower values of the synthetic measure than in the first year of the analysis. The rural communes of Ornontowice (2019), Brenna (2020), Milówka (2021) also recorded high scores; urban-rural Sośnicowice (2019, 2021), Kuźnica Raciborska (2020), Sieraków (2019), Stęszew (2020-2021), as well as urban Chodzież (2019-2020) and Obrzycko (2021). Table 7 presents average values for positive and negative ideal and synthetic measures ( $P_i$ ) of the financial development potential of LGUs based on the TOPSIS method in

2019-2021. A very low average value of the synthetic indicator was recorded by the surveyed communes in 2020, in particular rural communes in Silesia ( $P_i = 0.189$ ), although in 2021 this is the highest level among the presented results ( $P_i = 0.963$ ). Although the COVID-19 pandemic has had a huge impact on the investment activities of local governments in Territories, in the case of municipalities in the Silesian and Greater Poland Voivodeships, a significant improvement in the synthetic measure of the financial development potential of the assessed units in 2021 is visible.

**Table 7.**

*The positive ( $S_i^+$ ) and negative ( $S_i^-$ ) ideal and synthetic measure ( $P_i$ ) of the financial development potential of LGUs based on the TOPSIS method in 2019-2021 - average value*

Type of local government unit and location in the voivodeship		positive $S_i^+$ ideal			negative $S_i^-$ ideal			Pi		
		2019	2020	2021	2019	2020	2021	2019	2020	2021
Silesian Voivodeship	rural municipalities	0.184	0.425	0.041	0.143	0.100	1.078	0.435	0.189	0.963
	urban-rural municipalities	0.158	0.148	0.174	0.152	0.164	0.138	0.489	0.525	0.440
	urban municipalities	0.171	0.180	0.166	0.135	0.116	0.132	0.441	0.389	0.442
Greater Poland Voivodeship	rural municipalities	0.175	0.169	0.131	0.131	0.136	0.191	0.427	0.444	0.592
	urban-rural municipalities	0.152	0.154	0.142	0.138	0.136	0.162	0.473	0.469	0.533
	urban municipalities	0.197	0.182	0.160	0.106	0.113	0.144	0.345	0.380	0.472

Source: Own elaboration.

The synthetic value of the financial development potential of municipalities in the Silesian and Greater Poland Voivodeship based on the TOPSIS method allowed us to further classify the assessed units into four classes, as shown in the data in Table 8.

**Table 8.**

*Class of the financial development potential of municipalities in the Silesian and Greater Poland Voivodeship based on the TOPSIS method in 2019-2021*

Specification		number of municipalities in the Silesian Voivodeship			number of municipalities in the Greater Poland Voivodeship		
		rural municipalities	urban municipalities	urban-rural municipalities	rural municipalities	urban municipalities	urban-rural municipalities
class 1	2019	18	4	4	17	18	2
	2020	1	3	4	17	17	2
	2021	0	4	3	14	19	3
class 2	2019	32	10	7	40	22	4
	2020	38	9	10	33	28	4
	2021	95	8	13	44	38	3
class 3	2019	30	2	15	35	37	7
	2020	56	6	12	47	36	8
	2021	0	6	9	46	27	7
class 4	2019	16	6	4	19	19	2
	2020	1	4	4	14	15	1
	2021	1	4	5	7	12	2

Source: Own elaboration.

In the case of rural communes in the province of Silesia, the largest number of them (32 communes) in 2019 is concentrated in class 2, and 30 communes in class 3, although 16 are characterized by the highest, fourth class of financial development potential. In 2020, only one commune was qualified for class four, 56 communes for class two, and 38 communes for class three. In turn, in 2021, no rural commune was classified in class three, and as many as 95 were in class two. The situation is different in the Wielkopolskie Voivodeship, the largest number of communes are classified two and three. It should also be noted that of the 19 rural communes from class four recorded in 2019, there were only 7 of them in 2021. A similar trend characterizes urban communes in the years examined.

## 5. Discussion

Evaluating investment activity and development potential, especially under conditions of a pandemic crisis, is a complex phenomenon, determined by the choice of appropriate measures and techniques of ratio analysis. Multi-criteria analysis is one of the most widely used in the management process by both public and commercial entities (Çelikkilek, Tüysüz, 2020). The aim of the research undertaken by Kozera et al. (2017) among others, was to conduct a comparative analysis of the results obtained by serial ordering of objects and identification of their development types using the TOPSIS method in two approaches: classical and positional. The proposed approaches are presented using the example of the construction of a synthetic measure and the identification of types of financial self-sufficiency in rural municipalities in the Greater Poland region in 2013. Research using the TOPSIS technique as a tool for a comprehensive evaluation of local governments in Slovakia was conducted by Vavrek and Pukała (2019), who used eight criteria and calculated their weights based on Fuller's triangle method and 25 experts. The authors noted that the use of this method is contingent on the choice of specific indicators and their proper monitoring. In their study, Malinowski and Smoluk-Sikorska (2020) also used the TOPSIS approach to measure the standard of living of residents and the financial capabilities of 380 poviats. Furthermore, Łuczak and Just (2020) proposed a new methodological approach to the construction of a synthetic measure in the assessment of complex economic phenomena of local government units. Their study aimed to demonstrate the application potential of the positional MEF-TOPSIS method. The approach proposed by the authors is used to assess the financial self-sufficiency of Polish municipalities in 2016. The paper also compares the results of applications of the positional MEF-TOPSIS method and the classical and positional TOPSIS methods.

The TOPSIS method was also used in the investigations presented in this paper to determine a synthetic measure in municipalities from two different macro-regions. Kozera et al. (2021) studied local investment projects of rural municipalities and their expansion due to, among other

things, obtaining EU funding in 2007-2018, and their research showed that the most pro-investment municipalities are those in the southern and eastern macro-regions, while those that invest the least are located in the northwestern and northern macroregions. In the present study, municipalities from the Silesian Voivodeship (southern macroregion) and the Greater Poland Voivodeship (northwestern macroregion) were selected. The research included univariate and multivariate analyses using the TOPSIS method to obtain synthetic values for a measure of the level of financial development potential and investment activity of municipalities of three types: rural, urban-rural, and urban. The authors' research showed that the apparent slowdown in investment activity came in 2020, which in Poland saw the spread of the COVID-19 pandemic and its effects on economic activity and development. This is illustrated, among other things, by the WB4 index, which was much higher for municipalities in Silesia than those in Greater Poland. In contrast, the units from the Northwest macroregion were characterized by slightly lower investment potential (WB10), similar development potential (WB9), and level of self-financing (WB7), despite government support for infrastructure investment.

As emphasized by Malinowska-Misiąg (2022), this support was intended to counteract the socio-economic impact of COVID-19 but the distribution of funds indicates that this was not a priority in making the allocation. The most funds (3.1 billion zlotys) went to rural municipalities, while urban-rural municipalities, towns with powiat status, and powiats received support at a comparable level (1.9-2.0 billion zlotys). The distribution of funds has aroused a lot of emotion and controversy, as evidenced both by numerous media reports and the huge number of parliamentary interpellations and questions. These issues were also the subject of many expert reports, which indicated that the distribution of funds was not based on substantive but political criteria (Malinowska-Misiąg, 2022, p. 59). Similar conclusions were presented by such authors as Rudka and Kocemba (2021); Flis and Swianiewicz (2021a; 2021b); Sześciło et al. (2021).

Based on the WB11 index, it can be concluded that the municipalities of Greater Poland voivodeship in 2020 used the investment potential in more than 99% (68.6% in the Silesian Voivodeship), with this percentage declining in 2021 to only 31.7% (50.1% in Silesia). The average value of the synthetic index ( $P_i$ ) decreased significantly in the municipalities of both Silesia and Greater Poland. The pandemic had an impact on the classification of the financial development potential of the LGUs studied, with most municipalities reaching the range defined for classes 2 or 3. Unfortunately, few units were characterized by very high financial and investment potential (class 4).

## 6. Conclusion

The comparisons and classification of communes into individual classes presented in this article using the classic TOPSIS approach prove that the financial development potential of communes in the studied Silesian and Greater Poland voivodeships is medium-low and medium-high. The research also confirms the thesis about the impact of the COVID-19 pandemic on the slowdown in the investment activity of municipalities, the weakening of their financial condition in 2020, and especially the lower use of the investment potential. The communes pursued a cautious investment policy, relying on transfer funds intended primarily for road infrastructure, engaging less foreign capital, and accumulating high financial surpluses.

To conclude, based on the research conducted, it can be indicated:

- The research showed that the apparent slowdown in investment activity of municipalities came in 2020, which in Poland saw the spread of the COVID-19 pandemic and its effects on economic activity and development.
- The municipalities recorded an average slowdown in investment activity from 15.9% in 2019 to 14.1% in 2020 (the highest value of the examined measure was recorded in the municipalities of Silesia).
- The outbreak of the COVID-19 pandemic affected the level of operating surplus (the lowest level of the examined measure WB3 in 2020 was recorded in urban communes, in the Silesian Voivodeship, 4.7%, and in the Greater Poland Voivodeship, 5.7%, respectively).
- Investment potential in property expenditures of municipalities in Poland increased from 132.1% to 250.3% in 2019-2021. The highest value of the indicator in 2021 was recorded by the communes of the Silesian Voivodeship (265.1%).
- High values of indicators confirm great possibilities in the field of active investment policy and prove that the use of this potential was relatively low during the COVID-19 pandemic.
- The average value of the synthetic index (Pi) (TOPSIS method) decreased significantly in the municipalities of both Silesia and Greater Poland. Few units were characterized by very high financial and investment potential (class 4).
- The pandemic COVID-19 had an impact on the classification of the financial development potential of the municipalities studied, with most of them reaching the range defined for classes 2 or 3.

Further research in this area should include a multi-criteria analysis of the entire population of communes in Poland, along with the correlation of the examined indicators and the assessment of the strength of their dependence. On this basis, the TOPSIS synthetic indicator and its classification classes can be visualized on cartograms, enabling monitoring of the



financial development and investment potential of local government units, which should have a positive impact on their management process, but also due to the large information value of the measure, especially from an important point of view. the perspective of residents, but also business entities.

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## THE EXPERIENCE OF POLISH ORGANIZATIONS UNDER HUMANITARIAN AID

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**Purpose:** Evaluation of the experience and operational preparedness of Polish entities involved in humanitarian aid.

**Design/methodology/approach:** The research was carried out using a diagnostic survey method, with PAPI (paper and pencil interview) and CAPI (computer-assisted personal interview) survey techniques. The survey included organizations involved in humanitarian relief activities, represented by individuals working in managerial positions with long years of work experience.

**Findings:** The organizations surveyed do not have significant experience in organizing and implementing humanitarian activities, but among them many have participated in international humanitarian operations. The organizations provide a positive assessment of their stock strategies and the resources required to secure the distribution process during humanitarian aid.

**Originality/value:** The results of research can be addressed to those involved in public crisis management, both local authorities and public entities as well as blue light organizations and non-governmental organizations.

**Keywords:** humanitarian aid, humanitarian logistics, crisis situations, crisis management, hazards.

**Category of the paper:** research paper.

### 1. Introduction

Events don't always unfold as expected – in a crisis situation, this is a generally accepted rule. Humanitarian operations are dynamic, requiring participating organizations to exhibit flexibility in delivering effective assistance and protection, often within a matter of days or even hours. Thomas and Kopczak (2005) and Hovhannessian (2012) conclude that the main challenges in humanitarian aid can be caused by a lack of ability to recognise the importance of logistics, a shortage or absence of staff, underutilization of technology, insufficient institutional learning, and the need for improved cooperation and experience.

Crisis situations are characterized by many unpredictable factors, including time pressures, lack of information and the complexity of logistical processes (Marzantowicz, 2015). In such a turbulent environment, organizations need to manage their resources efficiently, including developing the necessary skills and experience of staff. In the PWN dictionary, experience is explained as:

- a set of knowledge and skills acquired based on observations and personal experiences,
- an event, especially an unpleasant one, that has an impact on someone's life,
- inducing or reproducing a phenomenon under artificial conditions,
- in philosophy: the entirety of the process of perceiving reality or the totality of perceived facts.

Experience is "the spontaneous cognition of something that exists; the result of the act of cognition, expressed in empirical judgments (judgments, sentences); a psychological state resulting from acts of experience" (Krapiec, 2001, p. 673). Experience is associated with conscious activity of obtaining information about an object through its direct apprehension, as well as the cognitive result of this activity, formulated in the form of an empirical judgment or sentence; colloquially - experiencing, going through something, or undergoing trials and their consequences (such as knowledge and skills), as well as participation in something (Filipowicz, 2012, p. 45).

Learning through experience (experiential learning) is reflected through various formulations that capture its essence and specificity, such as "window to the real world" or "bridge to the real world" (Chen, Shen, 2012, p. 30). It is emphasized that learning through acquiring experience is highly effective. Therefore, the concept of David Kolb's experiential learning deserves special attention, emphasizing that first, the learner must be provided with an opportunity for direct experience so that they can draw conclusions from it and relate it to theory, which will help them better understand it (Łaguna, 2008, p. 40).

Rescue operations require experienced individuals, and these professionals are urgently needed to improve the overall execution of operations (Rifai, 2018). The experience of these individuals does not bring material benefits, but through them it is possible to protect human lives and reduce the suffering of those affected (Rifai, 2018). Therefore, there is a need to develop the issue of operational preparedness of humanitarian actors and to assess their experiences in humanitarian operations. This will be achieved by seeking answers to the following research questions:

1. What international humanitarian operations have Polish organizations been involved in?
2. Do Polish organizations have experience in organizing humanitarian activities?
3. Do legal regulations allow for effortless cooperation with international entities during humanitarian actions?
4. How do respondents assess the competences of management bodies?

5. How do respondents assess the level of training for humanitarian operations?
6. What are the stock strategies securing the distribution processes of relief items?
7. Is the allocation of resources for humanitarian aid operations adequate?

The answer to the above research questions is based on surveys conducted in 2021 using PAPI and CAPI in Poland.

## 2. The importance of humanitarian aid

Humanitarian aid (Latin *humanitas* - humanity, human, humane - humane, humane) refers to any action aimed at saving lives, alleviating human suffering, providing adequate material conditions (medicines, food, resources, water), temporary shelter and security. Activities also include the reconstruction of damaged infrastructure to facilitate the arrival of aid and prevent the deterioration of living conditions (Bonilla, 2011).

Humanitarian aid has traditionally included support for the reconstruction of infrastructure. Unfortunately, today's reality shows that sometimes post-conflict or post-disaster emergency interventions do not include measures to restore the area to its pre-disaster state, thus failing to put people back on a development path and instead placing them in a maintenance structure (Walker, Hein, Russ, Bertleff, Caspersz, 2010).

Weiss (2013), author of the provocative book *Humanitarian Business*, discusses this very aspect of humanitarian aid in more detail. However, as Grzebyk and Mikos-Skuza (2016) rightly point out, the accusation that a humanitarian aid industry has emerged cannot undermine the idea of humanitarianism and solidarity with those in need. For a century and a half, the humanitarian sector has been a symbol of empathy, selflessness and often heroism. This image still holds true today. One only has to think of humanitarian workers and volunteers who have been killed and injured in armed conflicts, as a result of aftershocks from major earthquakes, or infected with difficult-to-treat diseases (Grzebyk, Mikos-Skuza, 2016). In such a situation, humanitarian aid has imperceptibly become part of the so-called 'winning of hearts and minds', which aims at public recognition of military and humanitarian efforts and the achievements, desired outcomes and strategic objectives of a given mission (Fitzsimmons, 2008, p. 340).

International humanitarian law was developed in response to the needs of soldiers wounded on the battlefield. The main sources of international humanitarian law are international custom and treaties. The first multilateral treaty was the Convention for the Amelioration of the Condition of the Wounded and Sick in Armed Forces in the Field, adopted in Geneva in 1864. Since then, there have been more than 100 significant international agreements in this field, the most important of which today are the four Conventions for the Protection of Victims of War, adopted in Geneva in 1949 (Grzebyk, Mikos-Skuza, 2016). They are universal in nature, having been adopted by 196 states, i.e. all sovereign territorial organizations recognised as

states by the international community. In 1977, the Geneva Conventions were supplemented by two additional Protocols, and in 2005 a third Protocol was adopted, dealing with additional protective signs. The protocols also have fairly broad (though not universal) coverage, with 174 states being parties to Additional Protocol I on the protection of victims of international armed conflicts, 168 states having accepted Additional Protocol II - on the protection of victims of non-international armed conflicts - and 72 states being bound by Additional Protocol III (Grzebyk, Mikos-Skuza, 2016). The Geneva Conventions and their Additional Protocols, as well as customary norms, are crucial for defining the legal framework for humanitarian assistance in situations of armed conflict, whether interstate or internal, and for assessing the principle of humanitarian access, which may facilitate or hinder the provision of humanitarian assistance (Grzebyk, Mikos-Skuza, 2016).

The embedding of humanitarian aid in the Polish legal hierarchy is quite complicated. According to Jagielski (2016), next to international law, administrative law is the most authoritative as a determinant of the legal framework for the main aspects of humanitarian aid. In legal-administrative norms, one has to look, for the regulation of legal-material aspects related to the definition of what humanitarian aid is, as well as the establishment of possibilities and conditions for the implementation of such activities (Jagielski, 2016). Administrative law also provides basic references for norms that serve to shape Organizational forms of humanitarian aid. Finally, possible procedures for organizing and providing such aid can be found in legal-administrative regulations (Jagielski, 2016).

Aid is classified as direct, meaning the provision of services and goods to a population in need, or indirect, i.e. that which includes the transport of such goods and personnel, as well as infrastructure support, e.g. road repair, provision of electricity, which are necessary for the effective distribution of aid (United Nations Office for the Coordination of Humanitarian Affairs, 2006). It is also important to remember that the cost of delivering aid should be as low as possible in relation to the cost of the aid itself, in order to get as many goods as possible into the hands of those in need (Drewek, 2013). The role of logistics in humanitarian aid is highly emphasised as it is an essential component of emergency response plans and humanitarian assistance to ensure that the right goods are available in the right location, at the right time and in the right quantity (Iqbal, Mehler I Yildirim, 2007). According to Bujak (2014), logistics plays an increasingly important role not only in economic terms, but mainly in the area of improving the quality of life of societies. The application of logistics is becoming more and more widespread, and opportunities for its use in crisis management and humanitarian aid are increasingly being identified. In general, the following essential undertakings can be distinguished in the process of logistical security of humanitarian action (Kmieciak, 2015):



### 1) Logistics services.

- Specialised services. Mainly transport services. They include evacuation, resupply and transshipment. Includes planning the number of transport resources, taking into account resources obtained from the national economy through relevant contracts or defence benefits.
- Economic and subsistence services. Includes the provision of basic necessities to the civilian population - food, water, clothing, hygiene products, cleaning products, medicines, etc. This category also includes efforts to provide shelter for the affected population. This may be done in holiday resorts, hotels, schools or by accommodation with civilians remaining outside the disaster area.
- Other services. These include services that Nowak (2009, p. 62) describes as: "social assistance, transport of deceased and killed persons, burial services, disposal of solid waste and rubbish, disinfection, deratisation, special treatments for the removal of chemical and radioactive contamination, disposal of dead animals and contaminated food, clothing, medicines".

### 2) Medical services (first aid, qualified first aid, emergency medical operations, medical assistance, qualified medical assistance, specialised medical assistance).

In the humanitarian logistics sector there is a lack of knowledge of logistics and management sciences in general, which would be particularly useful for those responsible for directing humanitarian operations and managing operations during emergencies. The increased demand for Organizational and professional competences is due to the increasing number of disasters, both environmental and civil (Sienkiewicz-Małyjurek, 2014). In addition, standardisation in each field will lead to improved interoperability of humanitarian operations (Paciarotti et al., 2021).

## 3. Research methodology

The aim of this paper is to assess the experience and operational preparedness of Polish organizations providing humanitarian aid. This objective was achieved by analyzing the results of a survey conducted in 2021 using the diagnostic survey method, a PAPI (Paper and Pencil Interview) and CAPI (Computer Assisted Personal Interview) survey technique. The survey questions were prepared on the basis of a critical literature review. The theoretical part presents the importance of humanitarian aid and highlights the role of logistics in these activities. Empirical part based on the survey that utilized a 7-point Likert Scale, allowing respondents to indicate the extent to which they agree or disagree with a given issue: strongly disagree (1), disagree (2), somewhat disagree (3), undecided (4), somewhat agree (5), agree (6), strongly agree (7). Responses were provided by 101 individuals from 75 organizations.

Non-governmental organizations (3.8%) made up the smallest proportion of the survey, as they were unwilling to participate, citing a lack of knowledge in the areas surveyed or a lack of time. In addition, representatives of the crisis management centers of the provincial offices (10.4%) and other units that wished to remain anonymous (23.5%) participated in the survey. The largest group are the units of the State Fire Service (62.3%). The State Fire Service is the leading unit in the national rescue and firefighting system (Bujak, 2014). The State Fire Service is a professional and uniformed formation with specialized equipment (Ciekanowski, Żurawski, 2022, p. 21). In addition, the State Fire Service, as the organizer of National Rescue and Firefighting System, fights fires and other natural disasters and deals with technical and chemical rescue (Dz.U. 1991, No. 88, item 400, art. 2). According to the law in Poland, as in most countries, when a unit of the National Rescue and Firefighting System participates in a rescue operation, its commander is automatically in charge of the rescue operation and thus the commander of all services, including medical services (Ciećkiewicz, 2010, p. 31). In all scenarios, except in cases of terrorist acts falling under police jurisdiction, the ultimate authority lies with the fire commander. In addition, if the commander of the operation designates a danger zone - only State Fire Service rescuers and firefighters operate in this area (Ciećkiewicz, 2010, p. 31).

The study involved individuals with extensive knowledge in crisis management and humanitarian aid: Chief and Deputy Chief - 21.9%; Specialized positions - 14.3%; Commander and Deputy Commander - 13.3%; Manager and Deputy Manager - 8.6%; Commandant and Deputy Commandant - 7.6%; Section Head - 6.7%; Officer and Non-Commissioned Officer - 4.8%; Technician, Senior Technician - 3.8%; Director and Deputy Director- 3.8%; Officer - 3.8%; Inspector, Senior Inspector - 3.8%, others - 7.6%. Furthermore, the average work experience of respondents in organizations engaged in crisis management and humanitarian aid activities is 17 years. The results of the survey were statistically analysed. The measures used for the analyses were dominant, median, first quartile (Q1), third quartile (Q3) and mean. These measures allowed an objective evaluation of the information obtained.

## **4. Results**

### **4.1. Experience in humanitarian operations**

Getting a job in the humanitarian sector is often challenging. Even entry-level positions frequently require several years of experience in the field. Internships and volunteering can provide valuable experience in the humanitarian sector (Li, 2022). One participant shared experience volunteering at a local NGO that worked in refugee support in Africa. The participant told that “the volunteering brought me many skills and knowledge that were

beneficial for me until today, and through the volunteering experience, I expanded my professional network and gained contextual knowledge, which helped me find a job later on in the humanitarian sector” (Li, 2022, p. 29). More than half a million people are estimated to work in humanitarian sector, the majority being locally engaged staff. Increasing the skills, knowledge and experience of leaders and managers of humanitarian responses is a critical need to ensure the most effective recovery in communities as well as use of resources (Clarke, Perreard, Connors, 2019, p. 1665).

Table 1 shows what percentage of Polish organizations have experience in humanitarian operations.

**Table 1.**  
*Participation of Polish organizations in humanitarian aid*

Multiple choice questions (% data)							Position measures					
definitely not (1)	not (2)	rather not (3)	I do not know (4)	rather yes (5)	yes (6)	definitely yes (7)	Q1	Median	Q3	Mode	Standard deviation	Mean
Has your organization participated in international humanitarian actions?												
10,89%	31,68%	5,94%	8,91%	13,86%	13,86%	14,85%	2	4	6	2	2,08	3,84

Source: own research.

The data in table 1 show that the majority of organizations do not participate in international humanitarian actions – 48.51% of negative responses. The dominant is 2 (response: “no”). A group of 8,91% respondents do not have opinion in this area. A group of 42.57% of organizations participated in international humanitarian operations and these organizations pointed out hazards and crisis situations that required multinational intervention and were the source of their experience in international humanitarian actions (Table 2).

**Table 2.**  
*Experience of Polish organizations in humanitarian operations*

Event	Location	Year	Number of responses
Earthquake	Albania	2019	2
	Nepal	2015	3
	Haiti	2010	3
	Sweden	2008	1
	Algeria	2003	1
	Turkey	1999	1
Floods	Montenegro	2010	1
	Germany	2002	1
	Czech Republic	2002	2
	India	2001	1
	Hungary	2000	1
Forest fires	Sweden	2018	5
	Russia (Moscow)	2010	3
Covid-19	International reach	2019-2022	3
War	Lebanon (Beirut)	2020	3
	Afghanistan	2001-2021	1
	Iraq	2003-2011	1
	Balkans	1999	1

Cont. table 2.

<b>Industrial incidents</b> (ammonium nitrate explosion)	Lebanon (Beirut)	2020	3
<b>Tsunami</b>	Sri Lanka	2004	1
	Maldives	2004	1
	Indonesia	2004	1
	Malaysia	2004	1
<b>Illegal migration and border security</b>	Multi-country support - Frontex missions	2004-2021	2

Source: own research.

Furthermore, respondents were asked whether, in their opinion, legal regulations allow for cooperation with international entities during humanitarian actions. The majority of respondents found it difficult to determine their opinion – 54.46% of respondents are undecided. A group of 31.68% of respondents believe that legal regulations enable international cooperation, while 11.88% believe that such conditions have not been established, making cooperation more challenging. In addition, the surveyed organizations expressed opinions regarding the alignment of national procedures with international procedures in the context of delivering humanitarian aid. It turns out that the majority of respondents do not have an opinion on this matter (62.38%). Nearly one-third of the respondents believe that the procedures differ, while 5.94% are of the opinion that the procedures are aligned (Table 3).

**Table 3.**

*Legal regulations and procedures under humanitarian aid*

Multiple choice questions (% data)							Position measures					
definitely not (1)	not (2)	rather not (3)	I do not know (4)	rather yes (5)	yes (6)	definitely yes (7)	Q1	Median	Q3	Mode	Standard deviation	Mean
Do legal regulations allow for free cooperation during humanitarian actions with other international organizations?												
0,99%	3,96%	6,93%	54,46%	21,78%	6,93%	2,97%	4	4	5	4	1,01	4,27
Do the procedures of international organizations in the context of providing humanitarian aid differ from national procedures?												
0,00%	1,98%	3,96%	62,38%	16,83%	11,88%	2,97%	4,00	4,00	5,00	4,00	0,93	4,41

Source: own research.

The next area under examination pertains to the experience of Polish organizations in organizing activities during humanitarian operations (Table 4).

**Table 4.**

*Experience of Polish organizations in organizing activities during humanitarian operations*

Activities	Scope of experience				
	Once a year	Once every 1-2 years	Once every 3 to 5 years	1-3 total actions	Lack of experience
Experience in organizing field kitchens	15,84%	8,91%	10%	17%	49%
Experience in organizing field hospitals	9,90%	10,89%	18%	15%	47%
Experience in accommodation of medical staff	5,94%	15,84%	7%	8%	63%
Experience in search operations	17,82%	8,91%	14%	21%	39%

Source: own research.

The survey shows that Polish organizations have reported a lack of experience in organizing humanitarian activities. Group of 63% of organizations don't have experience in accommodating medical personnel, 49% in organizing field kitchens, 47% in organizing field hospitals and 39% in search operations. Organizations have only some experience in these activities as they participate in them occasionally.

#### 4.2. Organizational competences and training

Respondents were asked whether the management bodies (village head, mayor, city mayor, district governor, governor) have adequate competences in the context of humanitarian aid activities. The most common response was "rather yes", as indicate by the dominant. Group of 13.86% respondents indicate that competences are not sufficient and 11.88% of respondents avoided answering.

Another question concerned interorganizational training. The majority of organizations (42.57%) indicated that training was insufficient, although one in four organizations considered the frequency of training to be adequate. Thus, the extent of interorganizational training in Poland is insufficient, and even if such training takes place, the organizer is the provincial level and the other administrative levels are only participants (NIK, 2017). The results on level of competence and interorganizational training are presented in table 5.

**Table 5.**  
*Competence and interorganizational training*

Multiple choice questions (% data)							Position measures					
definitely not (1)	not (2)	rather not (3)	I do not know (4)	rather yes (5)	yes (6)	definitely yes (7)	Q1	Median	Q3	Mode	Standard deviation	Mean
Do the competencies of governing bodies (Mayor, City Mayor, City President, County Governor, Voivode) in the context of humanitarian aid and crisis management activities are appropriate?												
1,98%	1,98%	9,90%	11,88%	36,63%	35,64%	1,98%	4	5	6	5	1,2	4,94
Are interorganizational training sessions in the field of humanitarian aid and crisis situations are sufficient?												
3,96%	15,84%	22,77%	29,71%	19,80%	6,93%	0,99%	3	4	5	4	1,3	3,7

Source: own research.

The planning and preparation of activities within humanitarian aid require transparent leadership principles. Leadership and decision-making are crucial in crisis management and humanitarian aid, and they are linked to an individual's personality, attitude, and experience. However, they can also be shaped through training, such as simulation exercises (Sobol, Faccincani, Khorram-Manesh, 2017). In recent years, local and state authorities have begun to establish positions for resilience: resilience strategists, resilience planners, and resilience analysts. Research conducted by Ross (2013) provides some guidance on effective interorganizational resilient leadership (Alshayhan, Yusuf, 2021). Resilient leadership encompasses improvisation in identifying solutions; coordinating resources to meet community needs; engaging the community to gain support from key stakeholders; resilience; and an emphasis on long-term solutions. Therefore, resilience-oriented leadership in

interorganizational environments entails several skills and competencies (Alshayhan, Yusuf, 2021): flexibility and adaptability to enable improvisation; coordination; persuasive communication to enhance support and engagement; and strategic thinking.

### **4.3. Inventory and Resource Strategies for Ensuring Efficient Aid Distribution Processes**

Neglecting logistics during humanitarian actions can lead to chaos, for example, a lack of ability to manage humanitarian aid resources (Perry, 2007). Own research indicates that 51.49% of organizations implement a inventory strategy designed to minimize stocks throughout the supply chain. However, the most common response to this question was "I have no opinion" (dominant – 4). Every fifth respondent believes that their organizations do not employ a safety stock minimization strategy.

In addition, 63.37% of respondents say, although mostly without conviction (dominant 5 – “rather yes”), that their organization's inventory strategy is to maintain buffers of cheap but critical stock. Group of 15.84% of organizations do not rely on such a strategy and one in twenty organizations did not express an opinion in this area. According to Kieżun (1998), stockpiling can have a significant impact on operational efficiency.

Regarding the physical resources needed for humanitarian operations, 74.26% of respondents say that the physical resources held by their organization are sufficient, but among these positive responses, the highest number of responses expressed uncertainty (dominant 5 – "rather yes"). Group of 18.81% of organizations consider the level of physical resources to be insufficient. The survey also shows that 55.45% of organizations consider the financial resources available to carry out humanitarian activities to be sufficient, but again the majority of respondents are not sure of their opinion (dominant 5 – "rather yes"). Almost 1/3 of the organizations (30.69%) think that the financial resources are insufficient.

The respondents were asked about the technological equipment of their organizations. It turns out that 87.13% of organizations have technological equipment, while 7.92% don't have it, 4.95% did not express a specific opinion on the matter. Respondents who gave a positive rating to their organization's technological equipment indicated the technological equipment and software they use during humanitarian operations:

- desktops, laptops,
- video equipment,
- video conferencing equipment,
- cameras,
- video screens,
- remote desktops,
- telephones,
- Internet network,

- Zimbra (groupware, email, calendar, database, etc.),
- Cisco (networking, cloud and security solutions),
- Webex (collaboration),
- Teams, Zoom, Skype,
- OneDrive,
- Decision Support System (DSS),
- Electronic Document Management,
- Integrated Information System for County and Municipal Authorities (pl. EWID),
- communication tools.

Besides almost all organizations (95.05%) have an emergency power supply, although 4.95% of organizations do not have an emergency power supply. The results on inventory and resource strategies to secure aid distribution processes and accessibility to emergency power supply are presented in table 6.

**Table 6.**  
*Resources for ensuring efficient aid distribution processes*

Multiple choice questions (% data)							Position measures					
definitely not (1)	not (2)	rather not (3)	I do not know (4)	rather yes (5)	yes (6)	definitely yes (7)	Q1	Median	Q3	Mode	Standard deviation	Mean
Does the inventory strategy in your organization has been developed to minimize stock levels throughout the supply chain?												
0,00%	5,94%	13,86%	28,71%	24,75%	24,76%	1,98%	4	5	6	4	1,22	4,54
Does your organization create inventory buffers based on the principle of maintaining low-cost but critical supplies?												
0,00%	10,89%	4,95%	20,79%	31,69%	28,71%	2,97%	4	5	6	5	1,31	4,71
Do the physical resources held by the organization suffice for the needs of humanitarian aid activities?												
0,99%	5,94%	11,88%	6,93%	33,67%	25,74%	14,85%	4	5	6	5	1,45	5,02
Are the financial resources allocated for conducting activities within humanitarian aid sufficient?												
3,96%	9,90%	16,83%	13,86%	34,66%	15,84%	4,95%	3	5	5	5	1,5	4,32
Does your organization have computer equipment and collaborative work software?												
0,00%	0,00%	7,92%	4,95%	11,88%	51,49%	23,76%	6	6	6	6	1,1	5,78
Does your organization have emergency power supply?												
0,99%	1,98%	1,98%	0,00%	1,98%	27,72%	65,35%	6	7	7	7	1,1	6,44

Source: own research.

## 5. Summary and conclusions

Humanity is the foundation of humanitarianism, and impartiality is a fundamental principle of humanitarian action. To ensure impartiality, humanitarianism must adhere to principles of action such as neutrality (i.e. not taking sides in a conflict) and independence. If humanitarian

actors are not neutral actors in the conflict, it will be very difficult for them to act impartially (Grzebyk, Mikus-Skuza, 2016). We can divide humanitarian aid according to three basic criteria: financial, in-kind and technical. Financial aid usually takes the form of donations, loans or debt relief. It can be given directly to the country in crisis, to people in need, or to national aid agencies. In-kind aid takes the form of goods such as food, water, hygiene items, medicines or clothing, while technical assistance can include the provision of specialised equipment or experts in a range of fields (Ficoń, 2015).

Participation in national and international humanitarian operations provides valuable experience that results in better prepared staff. Own research derived from the feedback received from 101 individuals representing 75 entities shows that organizations involved in international humanitarian operations have identified many countries around the world where they have gained experience, mainly in Europe and Asia. This partly agrees with research Paciarotti et al. (2021), where the most frequently cited geographical regions for gaining experience in humanitarian aid are Africa 71%, Europe 41%, Asia 37% and the Middle East 31%.

In order to effectively carry out the humanitarian aid mission, organizations must operate in an integrated manner, conducting regular exercises and participating in training programs for all blue light organizations and coordinating bodies. Therefore, training positively impacts integration, synergy, and a common language necessary for systematic collaboration.

In addition to interorganizational training programmes, which mainly focus on collaboration between independent organizations, professional training for public authorities dealing with humanitarian aid is another important element. Altshuler and Elran (2014), who analysed training issues in Israel, found that there is no mandatory training programme for emergency and humanitarian managers in local authorities. The researchers emphasise that this type of training is extremely important, as many local emergency managers, as well as officials in the Ministry of Defence, do not have an academic background in emergency management and humanitarian aid (Altshuler, Elran, 2014). In Poland, there is an even greater lack of organizational competence. Following an audit by the Supreme Audit Office (NIK) (2017), it was found that civil protection tasks in the Legnica Starosty were performed by an organizational unit that was essentially unrelated to the crisis management and humanitarian aid – Education and Promotion Department. In the course of the same audit, it was assessed that employees of district and municipal offices entrusted with civil protection tasks were poorly prepared in terms of content, and one of the reasons is the lack of educational and professional experience requirements for persons employed in such positions (Supreme Audit Office, 2017, p. 13).

Altshuler and Elran (2014) state that training programs need to be developed for the public, private, and non-profit sectors, and academic courses should be established. This is because professionalization in the field of crisis management and humanitarian aid is necessary, along with the creation of a structured professional identity in this domain that goes beyond



affiliations with any specific organization. In conclusion, all types of training are needed to increase organizational competence. However, it can be concluded that the most important types of training for humanitarian action are those that build the organizational capacity of the different actors and those that enable joint interorganizational training. As McLachlin and Larson (2011) conclude, relationship building is a key skill in humanitarian aid. Interorganizational training builds trust, is an arena for gaining experience, new knowledge and sharing good practice, and improves the quality and scope of communication.

The final area examined was the stock strategy and level of resources that secure aid distribution processes. When planning distributions, it is necessary to bear in mind the limited nature of all the resources used in humanitarian operations. Both the number of drivers and vehicles and the amount of goods they can carry are limited (Sukany, Stefaniak, 2005). Efficiency, speed and reliability are particularly major in humanitarian operations, so it is important to support this with information systems (Day, Melnyk, Larson, Davis, Whybark, 2012). Efficient use of limited resources requires the use of system-wide data with optimisation models (Day et al., 2012).

Sometimes resources are not properly coordinated and congestion, overstretched forces and equipment become a crisis in themselves (Safarpour, Fooladlou, Safi-Keykaleh, Mousavipour, Pirani, Sahebi, Ghodsi, Farahi-Ashtiani and Dehghani, 2020). For example, during the COVID-19 pandemic, medical companies, foreign institutions and many other organizations donated medical supplies and equipment to hospitals and humanitarian organizations (Chen, 2021). These donors should be classified to manage the distribution of their donations, but most donors provided assistance according to their own preferences (Chen, 2021). Agarwal, Kant and Shankar (2020) highlight the phenomenon of convergence of humanitarian relief items, which only exacerbates bottlenecks in supply chains and hinders the efficient flow of essential items. In addition, humanitarian organizations are not well equipped to deal with surplus humanitarian supplies due to insufficient transport resources, limited loading facilities and low storage capacity. The management of misplanned relief supplies is referred to as a second disaster (Agarwal et al., 2020).

As well as being sent in excess without control, resources can also be stolen. According to research by Maghsoudi and Moshtari (2021), resource theft was a problem during the 2017 Kermanshahz earthquake. Many facilities, such as mosques and schools, were converted into warehouses. A significant number of items were stored in these local warehouses, which were organized on an ad hoc basis and had no security personnel (Maghsoudi, Moshtari, 2021). Warehouses are strategic locations during humanitarian operations (Sedeh, Ardalan, Torabi, Khorasani-Zavareh, Allahbakhshi, 2020). Therefore, it is important to secure them properly and to have an appropriate stock strategy. When managing supply chains configured during humanitarian operations, it is advised, in line with Cankaya, Ekici, and Ozener's (2019) recommendation to strive for the highest possible minimum level of safety stock. Own research shows that more than half of organizations have a stockholding strategy that aims to minimize

stock across the supply chain, and the stockholding strategy of most organizations is to maintain buffers of cheap but critical stock.

Matopoulos, Kovács and Heyes (2014) used secondary data analysis to determine what resources are needed and how these resources evolve in the delivery of humanitarian aid. Based on a resource-based view of organizations, the authors assessed the impact of local resources on the configuration of supply chains. The results indicate that the use of local resources in humanitarian aid has a positive impact on overall supply chain performance. At the same time, it was found that local sourcing is often associated with a number of problems, such as a shortage of local supplies (Matopoulos et al., 2014).

Gavdia (2017) recommends the use of Enterprise Resource Planning systems in humanitarian aid, as they allow the optimisation of material flows and resource use through analytical selection and optimisation models implemented by integrated software with a single database. Another important factor affecting distribution efficiency is the equity of relief distribution (Chen, 2021). Distribution of aid may lead to surpluses in certain affected areas while causing shortages in others. If the distribution of aid is inequitable, downstream events may occur in parts of the affected area (Chen, 2021). As an example, the World Health Organization has made a commitment to extend immunization aid to impoverished nations, aiming to guarantee a fair allocation of COVID-19-related resources.

The own research shows that three out of four respondents claim that the physical resources held by their organization are rather sufficient. This uncertainty, expressed by the respondents, is confirmed by the assessment of the Supreme Audit Office (2017), which, following an inspection, indicated that the equipment of the organizations involved in humanitarian actions and emergencies is incomplete and outdated. Many years of neglect in this area as well as, insufficient funding for the tasks have led to this situation (NIK, 2017). Own research confirms that organizations lack money, with almost one in three organizations believing that financial resources are insufficient.

The own research shows that the organization's technological equipment is adequate. Respondents mentioned laptops and video conferencing equipment among these technologies. The most advanced systems mentioned by respondents were EWID and DSS. At this point, it is crucial to emphasize the necessity for change and to allocate additional resources towards the advancement of humanitarian aid. In view of the growing hazards it is worth considering higher funding, as technology and innovation are associated with high implementation and usage costs (Fox, 2015).

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## THE EFFECTIVENESS OF HARRY BROWN'S PORTFOLIO STRATEGY ON THE POLISH CAPITAL MARKET

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**Purpose:** The theoretical aim of the article is to present the portfolio construction according to Harry Brown's strategy and its modification adapted to the capital market in Poland. The empirical goal is to answer the question whether it is possible to build a profitable Harry Brown portfolio using the available assets of the capital market in Poland in the third decade of the 21st century.

**Design/methodology/approach:** The goal was achieved by using selected quantitative methods, including portfolio methods and Harry Brown's strategy.

**Findings:** A portfolio constructed according to Harry Brown's strategy gives poor results (low or negative rates of return) in the analyzed period.

**Research limitations/implications:** You can build a portfolio based on Polish assets. However, domestic securities should not constitute the majority of a well-diversified and long-term portfolio built with the future in mind. In the analyzed period, the rates of return on passive investments were negative in most cases. The economic recession in the period under review has a negative impact on investment results.

**Practical implications:** Portfolio diversification according to Harry Brown reduces investment risk due to changes in the economic situation.

**Social implications:** The proper selection of assets for the portfolio affects the investment result, thus the well-being of society in the case of individual and collective investments, and the financial results of the company. It is an important element of the functioning of entities in a market economy.

**Originality/value:** The article presents the application of Harry Brown's method in the third decade of the 21st century on the Polish capital market, taking into account selected values. The effectiveness of the investment was examined.

**Keywords:** long-term investing, portfolio method, Markowitz model, Harry Brown method, geographical diversification of investment risk.

**Category of the paper:** research paper.

## 1. Introduction

Investing in finance is a process that involves the current commitment of funds in order to obtain profits later. When investing, you should define your strategy and investment goal and diversify your investments appropriately to minimize the risk of losses. The construction of an effective and profitable investment portfolio is an art that involves the involvement of knowledge, science and experience (Begg et al., 2007; Dorosz, 2014; Głuch, 2020; Partridge, 2022; Petzel, 2021; Stewart, 2019; Taylor, 2009; Wojewoda, 2023).

The theoretical aim of the article is to present the portfolio construction according to Harry Brown's strategy and its modification adapted to the capital market in Poland. The empirical goal is to answer the question whether it is possible to build a profitable Harry Brown portfolio using the available assets of the capital market in Poland in the third decade of the 21st century.

In terms of how to invest money in Poland, low-interest financial products dominate, such as bank deposits, savings accounts and investment funds (Mastalerz-Kodzis; 2014, 2015, 2016). But this is slowly changing. Every year, a Polish investor has more and more investment options, so the choice is becoming more and more difficult. The third decade of the 21st century is a very specific and difficult period, because the market is still feeling the effects of the Covid-19 pandemic and reacting to the armed conflict in eastern Poland. So how will Harry Brown's assumedly stable portfolio behave during this period? Can we expect significant financial benefits from investing in accordance with Brown's guidelines?

## 2. Research methodology

### 2.1. Harry Markowitz's classic portfolio theory

Portfolio theory is a theory of decision-making under risk, based on the diversification technique. It was published by Harry Markowitz in the article *Portfolio Selection* in the *Journal of Finance*. According to the theory, a rational person making a choice should invest capital in accordance with his or her preferences so as to either minimize the variance (the basic measure of risk) at a given expected rate of return, or maximize the rate of return at a given variance (Markowitz, 1952).

The model proposed by Markowitz was groundbreaking, not only from the perspective of investment theory, but also because of its importance for the analysis of choice under risk conditions. It was the first choice model to explicitly introduce a risk parameter and also allude to a trade-off between risk and return. Markowitz denied that the only goal when constructing a portfolio is to maximize the rate of return, because as it increases, the risk increases. Using the portfolio model, you can calculate the most favorable proportion of these two factors.



The second important element contained in Markowitz's theory is related to the concept of diversification and its impact on the expected rate of return and portfolio risk. Markowitz's theory shows that there are a large number of securities portfolios with an assumed income rate, but only one of them offers minimal risk. Similarly, there are a large number of portfolios with an assumed level of risk, but only one has the maximum expected rate of return for this amount of risk.

Therefore, an important term in Markowitz's theory is the so-called an efficient portfolio, i.e. one for which there is no other portfolio with the same expected rate of return and lower risk, and one for which there is no other portfolio with the same risk and a higher expected rate of return. According to Markowitz, the preference of a rational investor is to choose an efficient portfolio. First, using past data can be problematic. The use of the Markowitz method involves the need to estimate future rates of return and standard deviations based on past data. However, there is no guarantee that past data will prove to be accurate for the future. Secondly, the Markowitz method is very sensitive to even small changes in the initial conditions, i.e. to the choice of the period from which the historical data used in the analyzes come from. Sometimes it is enough to shift the period from which the analyzed data comes by a few days to obtain a significantly different portfolio composition.

## **2.2. Harry Brown's passive strategy and its modifications**

### *2.2.1. Classic Harry Brown model - historical outline*

Harry Browne was a financial advisor in the United States in the 20th century. He was looking for an investing style that would be sustainable in the long term. He was developing a strategy based on stability (Browne, 1999; Rowland, Lawson, 2012). This is how he created the Harry Browne Permanent Portfolio. Browne's portfolio was supposed to be a universal portfolio, so it would provide satisfactory results in all market conditions and regardless of the phase of the business cycle. The idea was to divide the portfolio into four equal parts invested in shares, bonds, gold and cash (i.e. bank deposits or treasury bills). The essence of the concept was to accept market rates of return with low transaction costs and moderate risk (understood as relatively low variability of rates of return).

### *2.2.2. Assumptions of the Harry Brown model*

When analyzing the mathematical and statistical forms of investment models, careful attention should be paid to the assumptions regarding the possibility of their application in economic practice. Sometimes, for example, it is necessary to take into account the distributions of return rates of series or analytical forms of trend functions and their adjustment to empirical data. An important feature of investment strategies are the assumptions regarding their matching. Harry Brown's strategy can be used regardless of the economic situation, regardless of the distribution of rates of return of individual portfolio securities. This is a positive feature, it does not limit the application possibilities either to the basis of models or geographically.

### 2.2.3. *The form of the investment model*

According to Brown, this concept is a simple and effective investment method for long-term investments. A portfolio that provides satisfactory results in all market conditions and regardless of the phase of the business cycle. The idea was to divide the portfolio into four equal parts invested in:

- Stocks - the ultimate exponent of prosperity, a time when the standard of living is rising, the economy is growing, business is booming, unemployment is falling, interest rates are low, the financial system is healthy, and credit is easy.
- Long-term bonds - protection against years of deflation. When prices fall and real interest rates are negative, an economic depression can result. But when interest rates fall, bond prices rise, and this effect increases the longer the bond matures.
- Cash - credit expansion slows and the amount of money in circulation shrinks, leaving people and companies with less cash on hand than they expected, which usually leads to an economic recession. Many assets are liquidated, which lowers their price, but the cash portion of the portfolio allows you to reduce overall losses and buy assets at low prices.
- Gold - defense against inflation and currency crises. The amount of money in circulation is greater than the amount needed to purchase available products, so their prices rise. In the face of the loss of value of paper money, gold has an unchangeable value.

What is the philosophy behind this investment strategy? Harry Browne's idea is about preserving the economy. His goal was simple: to create an investment portfolio that would respond well to all economic scenarios. The economy changes in a cyclical way, and depending on what phase of the cycle we are in, one type of financial asset will perform better than another. The idea is to achieve safety and profitability goals at every point in the economic cycle.

Browne therefore includes in his permanent portfolio four types of assets that correspond to the four phases of the economic cycle that he has identified. There is no need for predictability or economic knowledge: it works in any situation. Harry Browne Permanent Portfolio allows you to hedge against any economic scenario.

Harry Browne advised building a Permanent Portfolio through index funds to achieve this diversification. Index funds try to replicate the index, so they are not actively managed (on the contrary, they are passively managed funds) and are characterized by lower costs (which translates directly into higher rates of return). It is well diversified because it combines assets from four different classes. Moreover, it does not require excessive analysis or active management. Therefore, a strategy is constructed that offers stability and security for the investor's assets.

Therefore, you do not need extensive knowledge of economics to build this long-term strategy. It is simply a matter of being exposed to the four phases of the economic cycle (because it is difficult to predict when one phase will end and the next will begin). For this purpose, the proportions corresponding to the four classes of assets that make up the investment

portfolio should be maintained. But what happens when markets oscillate and some assets gain in value while others lose value?

#### 2.2.4. *Model modifications*

Proportions between values change over time and periodic rebalancing is necessary. Harry Browne recommended that those assets which were above 35% and those likely to fall below 15% should be adjusted until they were restored to their proper weight within the overall basket (25%). This is simply a case of selling winning assets and buying those that have lost value (at more attractive prices). Harry Browne Permanent Portfolio is a long-term investment strategy. Harry Browne is one of the key authors within the so-called passive investing or passive management. In the strategies he proposes, his use of gold and cash stands out from the rest because he invests in physical gold as a safe asset - a topic that generates a lot of discussion in the world of wealth management. Its main goal is to protect savings, regardless of the state of the economy and financial markets.

### 2.3. Comparison of assumptions for using the Markowitz and Brown methods

So how can Markowitz's model be compared to Harry Brown's strategy? The Markowitz model, well known in the literature, is an optimization model. Most often, risk is minimized at a fixed rate of return on the portfolio. It may happen that a given security that was taken into account will not be included in the portfolio. Brown's model assumes constant shares of individual assets in the portfolio, which is to ensure its stability in various, unpredictable states of the economy. You can see a completely different approach to portfolio construction here. There are many research works on Markowitz portfolios applied to the Polish capital market, as well as many works on optimal investment strategies using less popular investment methods (Mastalerz-Kodzis, 2014, 2015, 2016; Mastalerz-Kodzis, Pośpiech, 2015; Pośpiech, Mastalerz-Kodzis, 2015). However, there are few publications on Harry Brown's strategy regarding the specificity of the Polish market. Therefore, it was decided to analyze this strategy.

## 3. Research results on the Harry Brown model on the Polish capital market

### 3.1. Theoretical form of the Harry Brown's models using in the work

Let  $x_i$  denote the share of the  $i$ -th asset in the investment portfolio. Harry Browne suggested that the shares of individual securities should not exceed the range of 15-35%. The first asset is shares, the second is long-term bonds, the third is cash (currencies), and the fourth is gold. Let us consider the following models (Table 1) taking into account the share of individual securities in the portfolio.

**Table 1.***Share of individual securities in portfolios*

Value/Model	1	2	3	4	5	6	7	8	9	10
Shares	25%	15%	25%	25%	25%	15%	35%	35%	15%	35%
Long-term bonds	25%	25%	15%	25%	25%	15%	35%	15%	35%	15%
Cash	25%	25%	25%	15%	35%	35%	15%	35%	15%	15%
Gold	25%	35%	35%	35%	15%	35%	15%	15%	35%	35%

Source: own assumptions, original models.

### 3.2. Selection of the research sample, research period, course of research

The research covers the period 01/2022-06/2023. The aim of the research is to check the rate of return on portfolios in specific time periods. Investment periods of six months, one year and one and a half years were considered.

The following were taken into account: the WIG20 index (reflecting the performance of shares), the TBSP index ETF (representing Polish treasury bonds), gold bars (prices in PLN according to the National Bank of Poland) and foreign currencies (the exchange rate of the US dollar against the Polish currency).

The effectiveness of portfolios was analyzed using the annual rate of return. Securities were purchased at the beginning of the analyzed periods and sold after a specified period of time (0.5 year, 1 year, 1.5 year).

### 3.3. Results of empirical analyses on the Polish capital market

Table 2 shows the effectiveness of the investment strategy over specific periods of time, measured by the annual rate of return. The six-month, one-year and one-and-a-half-year investment periods were analyzed successively.

**Table 2.***Annual portfolio returns*

Investment period/ mathematical model	1	2	3	4	5	6	7	8	9	10
01.22-06.22	-0,132	-0,055	-0,069	-0,129	-0,134	<b>0,005</b>	-1,444	-0,148	-0,115	-0,143
07.22-12.22	-0,065	-0,083	-0,044	-0,066	-0,065	-0,061	-0,862	-0,026	-0,105	-0,026
01.23-06.23	0,005	-0,026	-0,007	<b>0,010</b>	-0,001	-0,043	<b>0,137</b>	<b>0,018</b>	-0,009	<b>0,029</b>
01.22-12.22	-0,089	-0,058	-0,049	-0,088	-0,09	-0,019	-1,047	-0,082	-0,097	-0,08
07.22-06.23	-0,008	-0,035	-0,002	-0,003	-0,013	-0,034	-0,294	<b>0,020</b>	-0,036	<b>0,030</b>
01.22-06.23	-0,053	-0,041	-0,029	-0,049	-0,057	-0,022	-0,63	-0,046	-0,06	-0,037

Source: own study based on data taken from: [www.bankier.pl](http://www.bankier.pl), [www.gpw.pl](http://www.gpw.pl), [www.mennica.com.pl](http://www.mennica.com.pl), [www.nbp.pl](http://www.nbp.pl).

### 3.4. Conclusions

Harry Brown's model worked well and gave good results on the American market, during economic stagnation or growth. As shown in the study, however, the European capital market is not safe in times of crisis and unstable geopolitical situation. They can generate even negative annual rates of return.

The Polish capital market operates and is dependent on foreign markets. Taking into account the process of globalization and the question one may ask, to what extent should the portfolio be diversified geographically? How much capital can I invest in Poland so that the portfolio as a whole is resistant to domestic turmoil? One quarter of this problem is solved by gold, which is a global asset. It is also relatively easy to diversify the cash part by investing it in different currencies (USD, CHF, EUR, GBP). ETFs provide exposure to global stock and bond markets. Polish ETFs only complement a diversified portfolio and allow you to use your information advantage over foreign investors on the domestic market.

In the models analyzed in the article using data from the Polish capital market annual rates of return on investments turned out to be very low or even negative. This proves the low effectiveness of the examined investment strategy in the analyzed period. However, it should be remembered that the study area experienced the social, economic and financial effects of the Covid-19 pandemic, and the Russian-Ukrainian conflict also took place.

Moreover, in the analyzed period, significant inflation was recorded in Poland. After taking it into account, the portfolio's effectiveness will be even lower.

So how can we protect ourselves against the unfavorable phenomenon of financial crises, economic turmoil or inflation? This question is difficult to answer. Certainly, passive investing does not generate significant profits, it allows you to "wait out" a difficult period without generating very large losses.

In subsequent research, the author will focus on searching for more effective investment strategies on the Polish capital market, not necessarily based on shares, bonds, precious metals and currencies. It seems that alternative investments can be helpful during significant changes in the economy and may prove profitable in a rapidly changing economic reality. However, it should be remembered that when investing in alternative securities there is also a high risk, do not forget about portfolio diversification.

To conclude, Harry Brown's strategy, which was safe on the American market, turned out to be ineffective on the Polish capital market in times of major changes and crises. This may serve as a warning to investors who rely on conclusions drawn from research on foreign capital markets.

#### **4. Summary**

Searching for effective and low-risk ways of investing is important and timely, especially in the period of significant changes currently taking place in the world.

The portfolio constructed based on Harry Brown's strategy turned out to be a portfolio with low or negative rates of return in the analyzed period. However, it should be emphasized that the examined time period was very specific, both in Poland and in the world. The effects of the

coronavirus pandemic and the Russia-Ukraine conflict negatively affect both global economies and their capital markets. There is a very high risk of failure or even bankruptcy of business and investment activities. Therefore, the search for safe investments in the long term is a current and important problem in the economy, it is an important and necessary element of an efficient and effective management process.

Perhaps constructing a portfolio with a different asset structure or one based on other components from other investment areas would provide better results. The next stage of the analysis will be the search for investment strategies that are resistant to changes in the economic situation, because Harry Brown's idea of constructing such a portfolio certainly deserves the attention of investors avoiding excessive risk. The author also plans to analyze the profitability of alternative investments in both economically stable situations and in times of economic, political and financial crises.

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## BEHAVIORAL FACTORS OF GROWTH OF THE ECONOMY INNOVATIVENESS

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**Purpose:** The aim of the article is to present the impact of behavioral factors on the increase in enterprise innovation, showing the cause and effect relationship between the enterprise's environment and the development of the pro-innovation attitude of its employees.

**Design/methodology/approach:** In the process of preparing the article, desk research and statistical methods were used. As a result of the analysis of sources, it was found that the issues of behavioral aspects of innovation are extremely rarely presented in scientific literature and mainly concern personnel management. Moreover, the basis for pro-innovation attitudes of company employees are behavioral models, social values and priorities created by the external environment. The use of statistical methods allowed to confirm this thesis.

**Findings:** During the research, it was found that the key factors that determine the creation of pro-innovation attitudes of society are the level of democracy in society, the development of civil society and the social responsibility of government institutions. Under the influence of these factors, social values, behavioral models, culture and attitudes of society members are created that contribute to the maximum extent to awareness of the need to transition from an industrial economy to a knowledge-based economy and contribute to the creation of pro-innovation socio-economic conditions.

**Originality/value:** Research results show that one of the key factors in increasing the innovativeness of the economy is the level of democratization of society, shaping civil society and increasing social awareness. It determines the reduction of the "power distance", the effective functioning of power institutions and spheres of socio-economic life, and, above all, the development of the education system, the level of which has a strong correlation with the innovativeness of the economy.

**Keywords:** innovations, behavioral factors, economic development.

**Category of the paper:** Research paper.

## 1. Introduction

A change in the paradigm of socio-economic development towards the creation of a knowledge-based economy (KBE) means a change in the role and importance of specific production factors. A knowledge-based economy means "an economic order in which knowledge, rather than labour, raw materials or capital, is the key resource" (Drucker, 1994). But knowledge itself is not a direct factor of economic development, but is a source of its qualitative changes caused by the use of innovations. Therefore, the innovativeness of the economy is one of the pillars of the knowledge-based economy (Dahlman, Andersson, 2000).

The innovativeness of the Polish economy over the last two decades ranks 3-4 from the bottom in the European Innovation Scoreboard ranking. Reading the scientific literature related to the issues raised leads to the conclusion that a systemic approach to solving the problem of increasing innovation is necessary due to the fact that innovative activity is not only the domain of organizations and enterprises directly related to the implementation of the innovation cycle, but concerns many other spheres of socio-economic life.

Assuming that the source of innovation is a person who has knowledge, his behavior largely determines the success of transforming a new idea into an innovative product. The article concerns behavioral factors of innovation growth, which among many publications related to the problems of economic innovation are presented very modestly, despite their growing role in the conditions of creating the knowledge economy. The vast majority of publications on the behavioral aspects of innovation concern the enterprise level. However, the creativity and innovativeness of enterprise employees are determined by the prior impact of cognitive and behavioral factors occurring in various spheres of socio-economic life - society, education, public policy.

## 2. Methods

According to the approach dominant in the scientific literature, the innovative activity of enterprises is determined, on the one hand, by the impact of the external environment and, on the other hand, by the internal conditions of the company's functioning. The source of innovation in a company is the creativity of its employees, which in turn is based on appropriate pro-innovation attitudes of employees. As we move to a knowledge-based model of economic development, these attitudes play an increasingly important role in increasing the innovativeness of the economy.

In developed countries, there is an increasing emphasis on the role of creativity and innovation in keeping the economy viable and competitive with other major powers. The need for creativity and innovation is emphasized both in business and in government institutions and the public sector (Paulus, 2008, p. 228). Creativity and innovation are closely related. Creativity is an inherent feature of innovation and reflects the ability to combine ideas in a unique way or create an unusual relationship between two ways of doing things. Therefore, it is an innovative approach to work and problem solving (Michalski, 2014). Creativity is divergent thinking, it is a process of creating ideas, not guided by any model. Innovation, on the other hand, is convergent thinking, consisting in selecting, improving, specifying and critically implementing selected ideas into everyday practice (Baruk, 2006). The creativity stage of this process refers to the generation of ideas, and innovation refers to the next stage of implementing ideas towards better procedures, practices or products (Anderson, 2017).

The development of creativity and innovation at the corporate level requires the assurance of specific conditions, which in a simplified way can be presented by the well-known "know - want - can" model (Oksanych, 2021). According to this model, a new idea is transformed into an innovative product when the originator disposes the necessary knowledge, resources for its implementation and is sufficiently motivated. The three pillars of innovation - knowledge, resources and motivation - are interconnected. Motivation determines the intensification of effort to acquire knowledge and obtain resources. Acquiring knowledge helps create appropriate motivation systems and optimize the structure of resources and the efficiency of their use. Having resources at your disposal facilitates employee motivation and expands the possibilities of acquiring knowledge.

In every enterprise, the arrangement of these components of innovation is the result of many conditions. However, it should be remembered that the source of innovation is people, their knowledge, skills, experience, but also behavior. Hence, identifying the role of behavioral factors in stimulating the development of innovation in enterprises has become an important problem, because identifying the mechanisms of influence of these factors on innovative behavior is a boundary condition for the possibility of effectively influencing them (Fryca, 2015).

In the last decade, there has been an increase in interest in the behavioral aspects of innovation at the enterprise level, especially Innovative Work Behavior - IWB (Al-Essa, 2022; Al-Omari, 2019; Soputan, 2022; Yuan, 2017).

However, internal innovation factors are the long-term result of the impact of external factors. For example, the human capital of enterprises, which is the basis of their innovative capital, is created under the influence of knowledge, skills, qualifications and motivation of staff, which are a "product" of external influence. Even those factors that are considered strictly internal (organizational culture, enterprise management system, etc.) are created under the influence of the external environment. Pro-innovation attitudes of managers and their effective actions in the field of innovation are based on certain fundamental foundations of the functioning of society: social values, norms, rules and models of behavior, opinions, customs, culture.

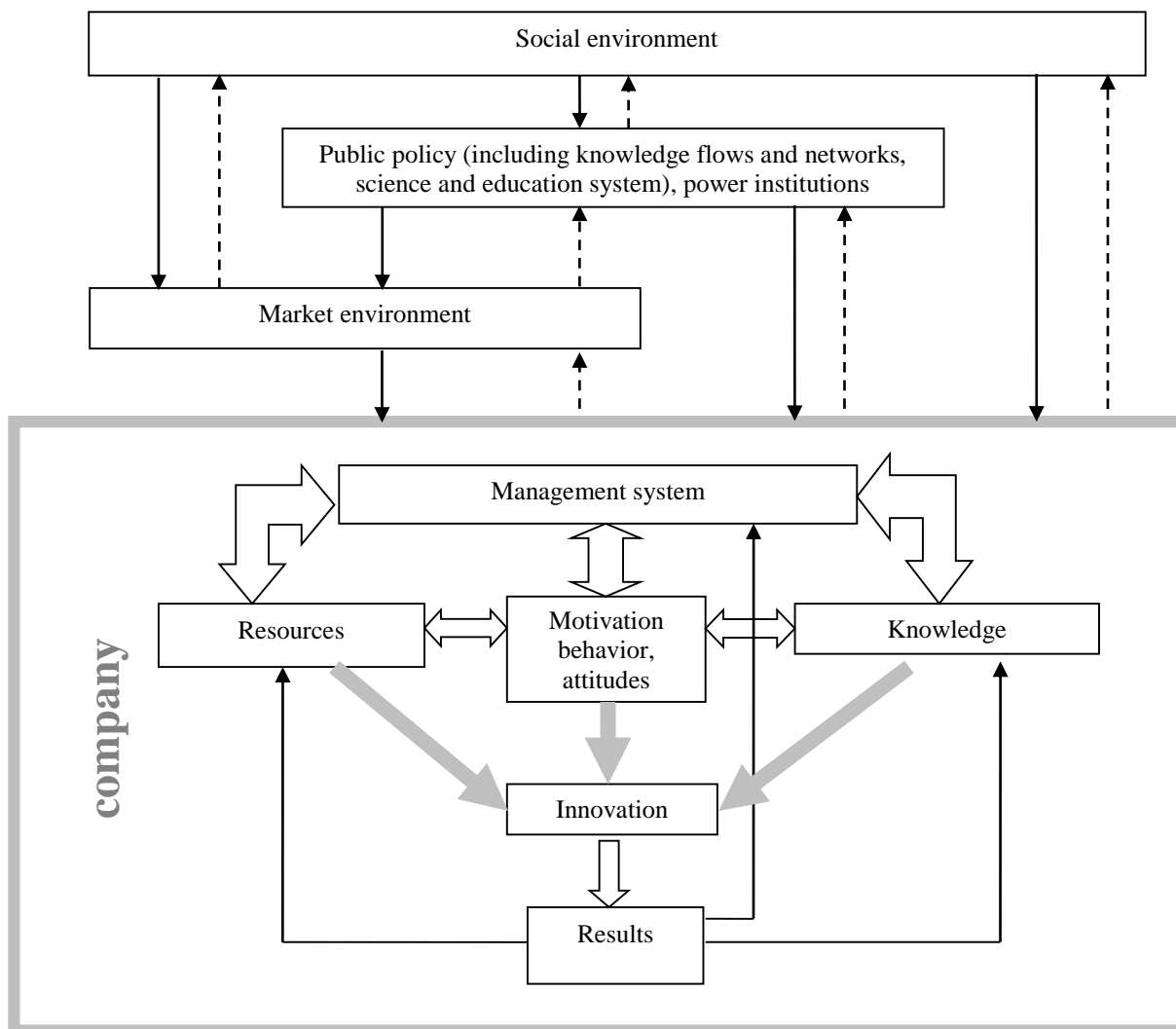
According to the Eurostat classification, the main elements of the external environment for business innovation are: spatial and locational factors, markets, knowledge flows and networks, public policy, society and the natural environment (OSLO Manual, 2018). Reading scientific publications on the researched issues leads to the conclusion about close cause-and-effect relationships between them and to determine the role, above all, of the social environment in shaping the features that form the basis of pro-innovative behavior. W. Makarczyk distinguishes two categories of social environment factors that influence the pace and nature of the process of assimilating innovations - (a) features of the social structure of a given community, conditioning interactions within it; (b) patterns shaping the behavior of community members (Makarczyk, 1971). M. He and J. Lee present a model that assumes that social culture (i.e. individualism, power distance and uncertainty avoidance according to Hofstede's cultural dimension theory) has a direct impact on the structure of small-world networks and individual characteristics (He, Lee, 2020). P. Paulus emphasizes that the social context has a great influence on the innovative behavior of employees (Paulus, 2008).

Many scientists emphasize that economic development is largely determined by values, cultural patterns, social awareness and attitudes, and social factors are one of the key determinants of pro-innovation behavior (Bradley, 2013; Harrison, Huntington, 2003; Hryniewicz, 2004; Mu Tian, 2018; Porter, 2003; Rawlings, 2020).

Therefore, understanding the mechanism of transformation of behavioral models created in society into the creativity and innovativeness of enterprise personnel is a necessary condition for the formation of a national innovation system and the development and implementation of an effective innovation policy. Taking into account the classification of elements of the external business innovation environment adopted in the EU, the concept of such a mechanism can be presented in the form of a diagram in Fig. 1. Solid arrows represent the transfer of behavioral models. Discontinuous arrows indicate feedbacks. This scheme is complemented by the behavioral factors of innovation growth listed in Table 1, their spheres of occurrence and the results of their impact.

Creative and innovative behavior at the enterprise level begins to form at the society level. Therefore, the level of innovation in the economy is a derivative of the level of development of society, which is measured by the level of democracy in society.

A democratic society is characterized by a short power distance, which means social control over the actions of the government and the ability to influence on them. The level of democratization of a society determines its ability to effectively manage key socio-economic processes, because a democratic society is a civil society, which means the responsibility of power institutions and ensuring their sensitivity to changes in society and the economy.



**Figure 1.** Scheme of the influence of behavioral factors on innovative activity.

Source: own study.

**Table1.**

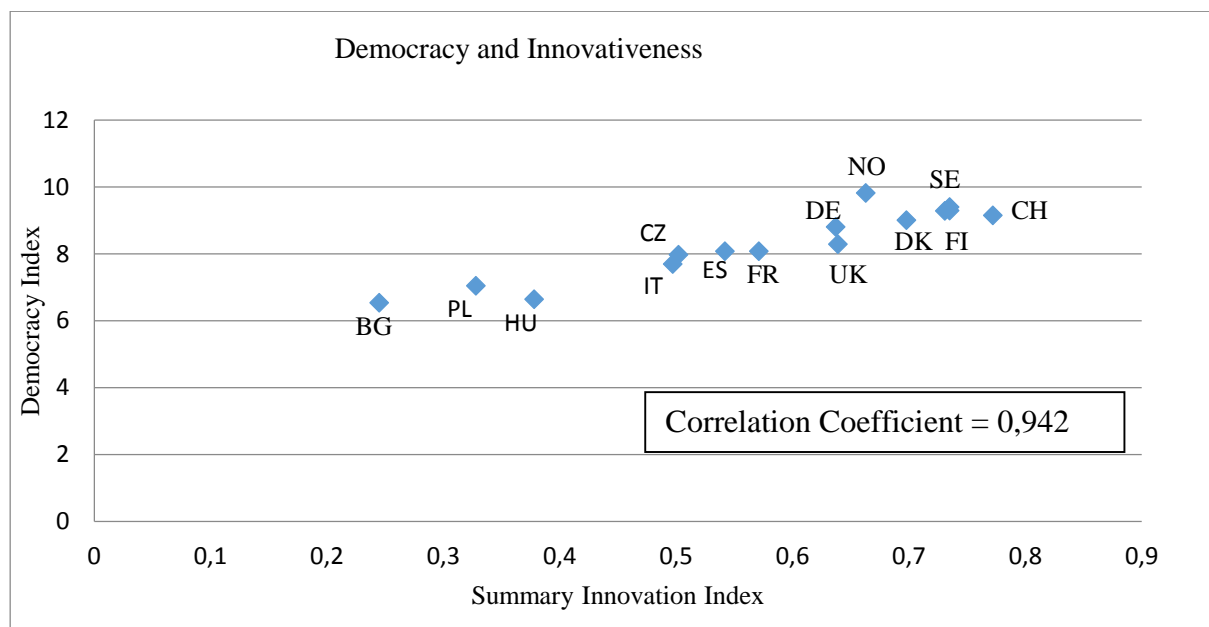
*Behavioral factors, spheres of their occurrence and effects of influence*

<b>Sphere of occurrence</b>	<b>Behavioral factors of innovation</b>	<b>Results of impact</b>
Society, social groups	Cultural and social environment. (social values and norms, behavior models, opinions, principles, social rules). Effectiveness and social responsibility of government institutions (perception of law, especially human rights, property rights, including intellectual property).	Awareness of the need to perceive the law and respect other members of society and social groups, norms and models of behavior accepted by society. Awareness of the possibility of influencing the authorities and social control behind their activities. Creating the attitudes of a member of civil society. Understanding the key problems of society's development and possible directions of solving them.

Cont. table 1.

The spheres of functioning of institutes of power and public policy	Economic policy and economic development model (industrial society, post-industrial economy, knowledge-based economy), innovation policy. Antitrust policy. Efficiency and social responsibility of government institutions (perception of law, especially human rights, property rights, including intellectual property). Education systems, higher education (creating personality, key skills necessary for the knowledge-based economy - learning ability, ability to acquire, systematize and use knowledge, ability to work in a team). Science: financing and efficiency of use.	Awareness of the role and importance of decisions made by the authorities and the responsibility for making them. Attitudes towards science and education: awareness of the need to acquire knowledge and develop the ability to use it. Understanding the relationship between knowledge and standard of life. Development of competences and skills, including the ability to work in a team, present and justify one's own opinions and views.
Market environment	Industry structure: share of high and medium-high technology industry. Innovation model: based mainly on the import (transfer) of innovations or on own (domestic) innovative products. The level of involvement of the economy in cooperation (building cooperation networks) at the international level. Competitive environment.	Awareness of the need for innovation as a key factor in the company's survival on the market and strengthening the company's competitive position.
Company	Innovation culture. Management system (motivation, decision-making, knowledge and information management). Human capital. Knowledge (resources, sources, methods and techniques of use and transfer). Competitive position.	Development of creativity and innovation, willingness and ability to engage in the company's innovative activities, ability to take initiative, understand the need for changes and their acceptance.

Source: own study.

**Figure 2.** Relationships between the level of democracy and innovation.

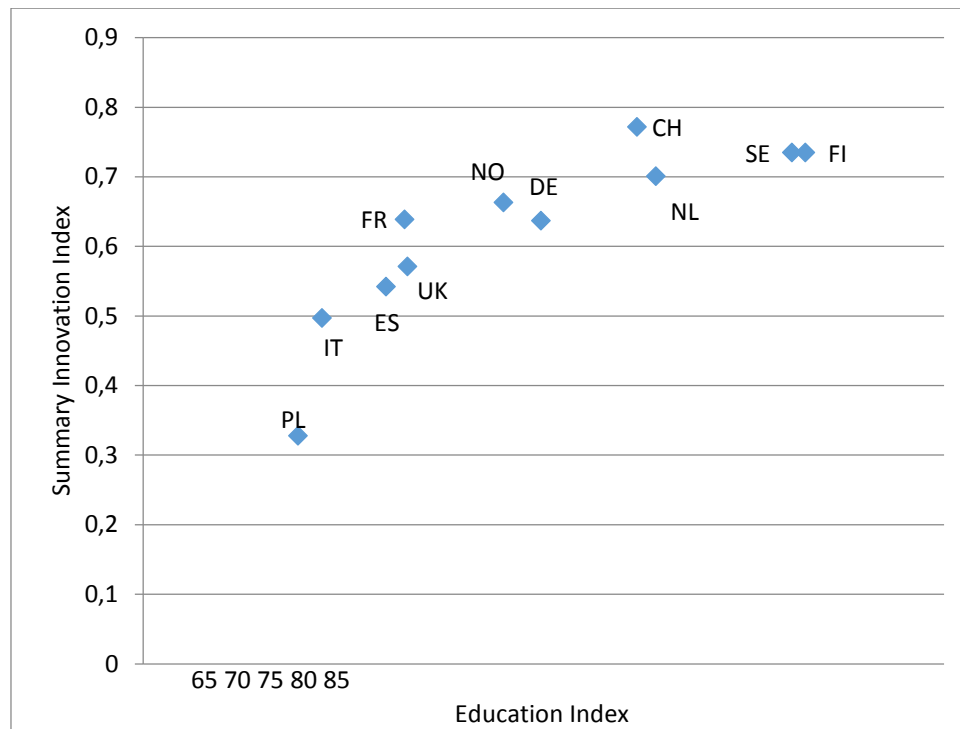
Source: Own study based on (Frontline ..., 2022; European Innovation Scoreboard, 2022).

On the other hand, in a democratic society, social values, attitudes and models of behavior are created that are most needed in the context of emerging challenges in social and economic life. In the conditions of a knowledge-based economy, these include pro-innovation attitudes, creativity, social responsibility, the desire to acquire knowledge and the ability to use it. Therefore, it seems quite logical that there is a high correlation between the level of democracy in society and the innovativeness of the economy, which is characterized by a correlation coefficient of 0.942 (Fig. 2). Countries characterized by a high level of democracy and the development of civil society are among the leaders in innovation.

When analyzing the mechanism of the influence of the macro-environment on the increase in innovativeness of the economy, attention should be paid to the nature of the impact of its elements on the behavior of both society in general and its individual groups, including enterprise personnel. In this respect, the macroenvironment has both direct and indirect influence.

Direct influence creates features, knowledge and skills that make it possible to become aware of the cause-and-effect relationships between the attitudes and actions of society determined by them and the results of these actions. In practice, this means social responsibility for decisions made in society and the optimal selection of strategic goals and priorities. An example would be the situation with the use of fossil fuels. Given the abundance of coal reserves, the optimal solution seems to be the development of energy based on its use, which ensures low energy costs. However, strategically, such a strategy leads to increasingly worse consequences related to environmental pollution (greenhouse effect, increase in disease, deterioration of quality of life, etc.). Society's knowledge and awareness of the long-term effects of such a strategy determine the choice of an alternative strategy, providing for the development of "green" energy, which is a more effective solution from the point of view of sustainable development. This choice encourages society to engage in innovative activities in order to seek more and more effective solutions within the adopted strategy.

The indirect impact of the macroenvironment on pro-innovation behavior of both societies in general and its individual groups is reflected in the formation of appropriate environment and conditions in the key spheres of social and economic life to support innovation, primarily in education, scientific and research and development activities, highly technological branches of the economy, innovative infrastructure. Such influence triggers market mechanisms for increasing innovation and ensures the creation of innovative attitudes and appropriate behavior of managers and staff of enterprises and organizations.



**Figure 3.** Relationships between the quality of education and the level of innovation.

Source: own study.

A greater level of democratization of society is ensured by greater effectiveness of decisions made in shaping a pro-innovation system of state institutions due to the greater responsibility of the authorities to society and greater influence of society on the authorities.

This thesis is confirmed by the relationship between the level of democracy in society and the level of quality of education (fig. 3). The correlation coefficient between them is 0.807.

### 3. Discussion

Pro-innovative behavior of employees is determined primarily by external factors. The culture of society, the level of its democratization and the education system play a particularly important role. They determine innovation policy and a pro-innovation market environment.

The degree of democratization of society, on the one hand, determines the creation of innovation-friendly attitudes of its members (creativity, independence of views, ability to critically analyze socio-economic processes), on the other hand, it ensures feedback in relations with power institutions, its flexibility understood as the ability of power to quick and appropriate response to changes in society and the economy. Since the development of civil society covers all spheres of its functioning, the correlation between the degree of democratization of society and the level (quality) of education seems quite logical.



In turn, the quality of the education system determines the understanding of the importance of innovation for socio-economic development and creates appropriate pro-innovation attitudes of society and its members directly involved in innovative activities.

However, the mere willingness to conduct this activity, i.e. motivation, does not ensure an increase in the innovativeness of the economy. Assuming that innovation is based on three pillars - knowledge, motivation and resources, motivation must be supplemented with an effective system for acquiring, transfer and use of knowledge and appropriate resources (primarily financial). If the motivation to conduct innovative activities is created at the enterprise level with the appropriate quality of human capital (which is largely determined by the influence of the external environment), knowledge and resources depend on the effectiveness of the innovation policy. However, it would be a mistake to assume that such policies do not depend on behavioral factors. Decisions in power institutions are made by people whose attitudes are the result of the influence of the same factors that determine the pro-innovation attitudes of managers and employees of enterprises - that is, the democratization (freedom) of society and the level (quality) of the education system.

The authorities' awareness of the need to create economic conditions conducive to innovation is based, on the one hand, on their knowledge, competences and skills as a product of education, and on the other hand, on taking into account the information coming from the participants of the innovation process, starting from scientific and research institutions. development and ending with consumers of innovative products. The result of such awareness must be involvement in activities that would result in the creation of an effective innovation policy that provides access to knowledge and appropriate resources necessary to support activities at every stage of the innovation cycle.

It is worth noting that all pillars of the "knowledge - motivation - resources" model ("know - want - can") are closely interconnected. Access and use of knowledge while providing resources necessary for acquiring new knowledge and its transfer, as well as for transforming knowledge into innovative products, facilitate the increase in motivation. Society's motivation in pro-innovation activities, while providing appropriate resources, allows for the development of science and the acquisition of new knowledge. Finally, the high motivation for innovative activity in a society that has significant knowledge (including knowledge about the necessary effects of increasing the innovativeness of the economy on society) largely determines the allocation of the necessary resources for it.

The study of behavioral factors of innovation, especially the areas of their occurrence and mechanisms of influence, requires an interdisciplinary approach, because in addition to issues relating to the field of management and economics, it also concerns sociology and psychology. Based on the current state of innovation of the Polish economy, research in this direction should cover issues related to:

- creation of civil society and its impact on the efficiency of management,
- creating effective innovative policy in Poland and the social responsibility of the authorities for the effects of its implementation,
- development of the education and science system to meet the challenges of the Knowledge Economy,
- financial, organizational and legal support for innovative activities.

With a fairly wide range of research issues related to the problem of increasing innovation and creating a knowledge-based economy, their common denominator is behavioral factors, because in every field of activity, in one way or another, related to innovation, there is always a person, his attitudes and behavior.

#### 4. Results

The source of innovation is a new idea, an idea generated by the human intellect. The effectiveness of innovation depends on how effectively each stage of the innovation cycle will be implemented - from the creation of an idea to the commercialization of an innovative product, which is ultimately determined by behavioral factors. Most scientific publications focus on the problem of IWB and analyze the behavior of personnel of enterprises and organizations as part of innovative activities. However, this behavior and attitudes are determined by external factors. Even when it comes to the so-called "internal" behavioral factors (e.g. employee motivation, willingness to engage in innovative activities, initiative, etc.), they are always based on external, "deeply rooted" determinants (e.g. culture, education, social values).

Therefore, creating an effective innovation policy needs to take into account not only the "technical" aspects of economic innovation (science, infrastructure development, financing), but above all those aspects of socio-economic development that create pro-innovation attitudes of society, based on the development of appropriate qualifications and skills of people involved in innovative activities.

The behavioral factors of innovation can be presented in the form of a model presenting four levels - the level of society, the level of public policy, the level of the company's market environment and the corporate level. Each subsequent level builds on the previous one.

As we move to a higher level (from social to corporate), the nature of the factors of the next level is influenced by the factors from the previous level.

Therefore, it can be concluded that the innovativeness of the economy is a derivative of the degree of development of civil society and the development of government and public policy institutes, including the science education system. They determine the cognitive and behavioral

mechanisms of creativity and innovation both at the enterprise level and in society. Detailing the elements of these mechanisms and understanding the principles of their functioning seem to be quite a current and prospective direction of research. Combined with the growing interest of scientists and practitioners in the issues of IWB, this research will ensure the creation of effective innovative policy and contribute to a noticeable increase in the innovativeness of the Polish economy.

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## TESTING THE NEW PRO-INNOVATIVE SERVICE FOR ENTERPRISES OF MATERIALS PROCESSING INDUSTRY

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**Purpose:** The paper presents the process of testing pro-innovative service Monitor of Innovative Organization Development (MIOD) tailored for enterprises of material processing industry.

**Design/methodology/approach:** In the process of new service testing practical verification of the concept were used. Created service prototype were realized fully in four enterprises. In the process of designing service an eclectic approach were used – various methods were implemented, corresponding to design research approach (Faste&Faste, 2012). The paper contributes to area of service design, service management and innovation management because the the main purpose of the service is to support innovation in enterprises.

**Findings:** In the paper two important findings were presented: the roadmap of pro-innovative service commercialization and the results of the MIOD service testing.

**Research limitations/implications:** The designed pro-innovative service is devoted to enterprises of materials processing industry only. The testing process was limited to only four enterprises of this sector operating in śląskie region, Poland. However the service could be adopted to be delivered to the enterprises of other sectors. General observations could be expanded to other business services.

**Practical implications:** The verified prototype of pro-innovative service is the main results of the project entitled *A Network of Regional Specialist Observatories in the Process of Entrepreneurial Discovery in Śląskie Voivodeship (SO RIS II)*. The service could be used by regional business environment institutions.

**Originality/value:** The approach to service design is new in the paper. Moreover the observation form testing the service prototype are quite valuable. Presented knowledge could be interesting for service designers (practitioners) as well as scientists exploring and evaluating services.

**Keywords:** service design, pro-innovative services, innovation management, innovation policy.

**Category of the paper:** technical paper.

## 1. Introduction

Nowadays nobody neglects the fact the innovations are the gate towards competitiveness for every kind of enterprises. Innovations not only bring benefits for business but they contribute to social development and improve the situation on the labour market. Governments and regional administration support the innovativeness of enterprises using different measures (financially, fiscally, organizationally or by offering places for developing new ideas). This is in contradiction to so-called Chicago School paradigm for promoting competitiveness and innovation which created a belief in the free market to maximize innovation and productivity (Trott, 2017). Delivering knowledge about innovation management in the form of tailored services is one of the method fostering innovation management used worldwide. Innovation support services or in other words pro-innovative services are designed for enterprises to help them on different stages of innovation process.

In the project entitled *A Network of Regional Specialist Observatories in the Process of Entrepreneurial Discovery in Śląskie Voivodeship*<sup>1</sup> one of the most important objective was the development of the offer of the network. The general idea was to develop new, valuable services for regional enterprises in the area of innovation management. The service called Monitor of Innovative Organization Development (MIOD) was designed and tested as the result of the project. In the paper the process of designing one of the services is described as well as the results of testing the pro-innovative service is presented.

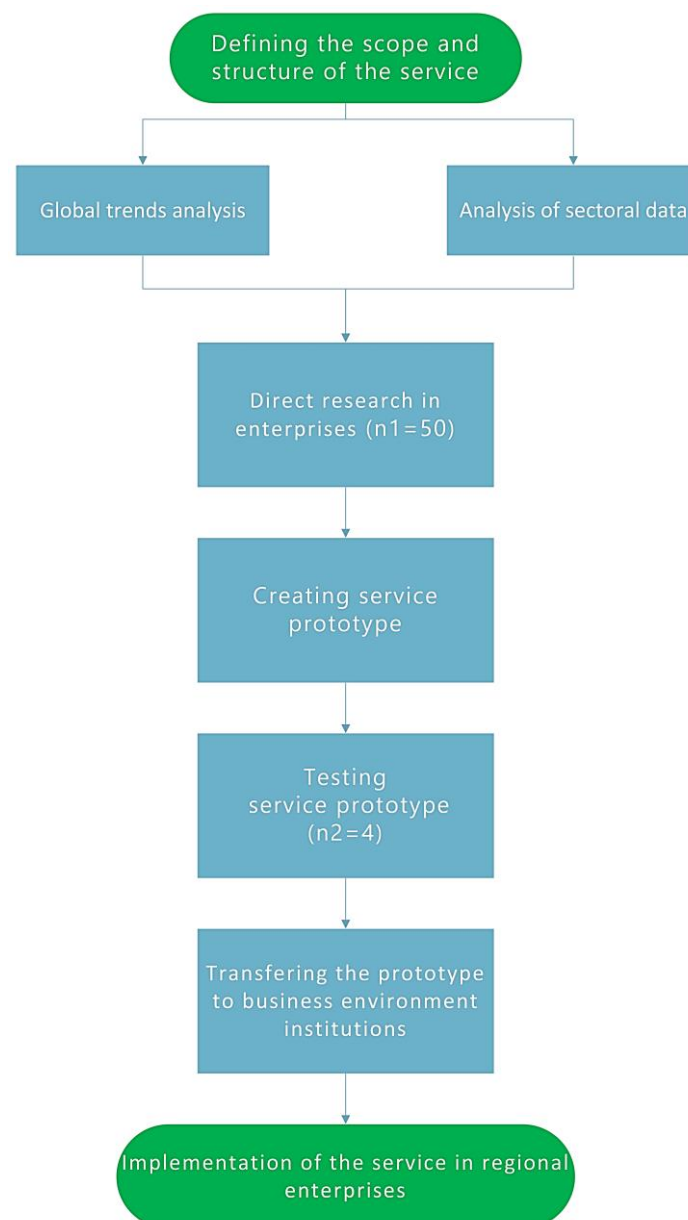
## 2. Methods – service design

Service design is specific because of characteristics of services like Intangibility, Inseparability, Variability, and Perishability (Kotler, Keller, 2007). Trott (2017) also emphasized the service characteristics in the process of creating services (new service innovation). The author adopts after Scheuing and Johnson (1989) service innovation process – a sequential model of creation of new services. The model has three main stages: idea generation, evaluation and realization. The stages corresponding to traditional new product development process, however the activities on each stage are typical for services. Moreover the concurrent service development models were presented by the author, including cycle model that enables the parallelization of the activities. Like New Product Development (NPD) models, New Service Development (NSD) models are derived from the process models that

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<sup>1</sup> The project was conducted from 2020 to 2023 and co-financed by the European Union under the European Regional Development Fund and state budget. The regional Marshall Office was the leader of the project, while eleven regional institutions constitute the project consortium.

initially were created for the development of manufactured products especially on consumer markets (Fitzsimmons, Fitzsimmons, 2000). Business sector requires new types of tailored services delivering knowledge about new products (innovation). Den Hertog (2002) calls this services Knowledge-intensive business services (KIBS), identifying five basic service innovation patterns. Aslesen and Isaksen (2007) expand this concept of services and shows the role of knowledge-intensive service activities (KISA) and verifies this two approaches by studying the use of knowledge-intensive services in two Norwegian industries (aquaculture and software industry). In Canadian economy and ICT sector the role of KIBS is investigated by Doloreux and Frigon (2019).



**Figure 1.** Roadmap of the new pro-innovative service commercialization.

Source: own elaboration – result of the SO RIS II project.

In Poland, there are examples of innovation support services under the general name of innovation audit, with a diverse range of content (Olko, 2017). Positive and negative experiences of the implementation of these services between 2010 and 2015 were used in the development of the new service.

Two methods were considered during the phase of designing the service: Quality Function Deployment (QFD) and SERVQUAL. The QFD is the approach and set of tools used to effectively define customer requirements and convert them into detailed engineering specifications and plans to produce the products and services that fulfil those requirements (Ćwiklicki, 2017). Chan and Wu (2002) on the basis of wide literature review shows that QFD is widely used in designing services, including business services. The second considered method SERVQUAL is used particularly to evaluate services. According to the work of Parasuraman, Zeithaml and Berry (1991) the general service quality consists of five parameters: tangibility, reliability, responsiveness, assurance and empathy. In this areas clients perceive gaps between their expectations and realization.

Eventually considered approaches (QFD, SERVQUAL) were not fully implemented in the process of service design. The team assumed that designed service must be based on direct research addressed to enterprises in śląskie region representing materials processing industry. The scope of the research was the same as the problems raised in the designed service.

The entire process of service commercialization is presented on fig. 1. The team started with determining the scope and structure of the service. The following assumptions were made at this stage:

- the service should be short and simple for the enterprise, not involving a large number of company personnel,
- the feedback should refer to global trends within the technological area of materials production and processing, but also to regional policies that support the business sector,
- the service should meet the needs of small and medium-sized enterprises covering the areas of market, organization of innovation, intellectual property and innovation financing.

In the next stage, a parallel analysis of global trends and a sector analysis was conducted. Both analyses were focused on the materials production and processing sector. Global trends analysis shows that following challenges should be undertaken in the service:

- Industry 4.0 – how the enterprise is prepared to the challenges of Industry 4.0? What activities the enterprise can undertake to cooperate with other businesses more advanced in Industry 4.0 solutions?
- circular economy – How the enterprise is currently meeting the challenge of a circular economy? In which areas to take action to realize the idea of a circular economy?



- Sustainable development - What are the areas of sustainability closest to the company? What sustainable innovation actions to take in accordance with the essence of the ISO 56000 series standards?
- Corporate Social Responsibility (CSR) - What are the enterprise's current CSR strengths? What actions can be taken to improve the enterprise's social responsibility according to ISO 26 000 series standards?

It was assumed that the essence of the service is the identification of business model changes related to the organization's innovation orientation - corresponding to the concept of business model innovation (Afuah, 2018). During the development of the service prototype, it was decided that the main issue would be the development of an innovation capability model tailored to regional (śląskie region) and industry specifics (manufacturing and materials processing sector). According to the OSLO Manual (2018), a company's attainment of competitive advantage is based in the long term on the development of a model for generating innovation, that is, the ability to create new products (product innovation) or new processes (business process innovation). Among the theoretical concepts relating to the general model of innovation creation by companies, it is important to point out:

1. The concept of the New House of Innovation (Prahalad, Krishnanan, 2008) covering four areas: enterprise technical architecture (including IT systems and software), co-created but personalized customer value leveraging experience, access to global resources and talent, flexible and resilient business processes with focused analytics, and enterprise social architecture.
2. Business Model Innovation (Massa, ucci, 2014; Afuah, 2018, Brzóska, 2014) explaining how innovations affect the business model.
3. Inventory of organizational innovativeness (Tang, 1998) – resource-based view on organizational innovativeness.
4. Model of innovation capability (Lawson and Samson 2001) extended by Machnik-Słomka (2020), where innovation capability is understood as *a multidimensional capability that highly integrates various capabilities ensuring an appropriate level of continuous management of the process of creating and implementing innovations that meet the needs of stakeholders in order to achieve the expected effects and competitive advantage.*

### 3. Results

As a result of the design process the prototype of the service called Monitor of Innovative Organization Development (MIOD) was obtained, consisted of:

1. Service provision manual – general manual describing how the service should be provided (procedure and all activities comprising the service).
2. Form of collecting information – form for collecting information about the enterprise, the basis for preparing the report for enterprise. The form consists of 30 questions and fits on 10 pages.
3. Report template – the template of report for the enterprise showing how the content of the report should look like.

**Table 1.***Structure and content of the MIOD service*

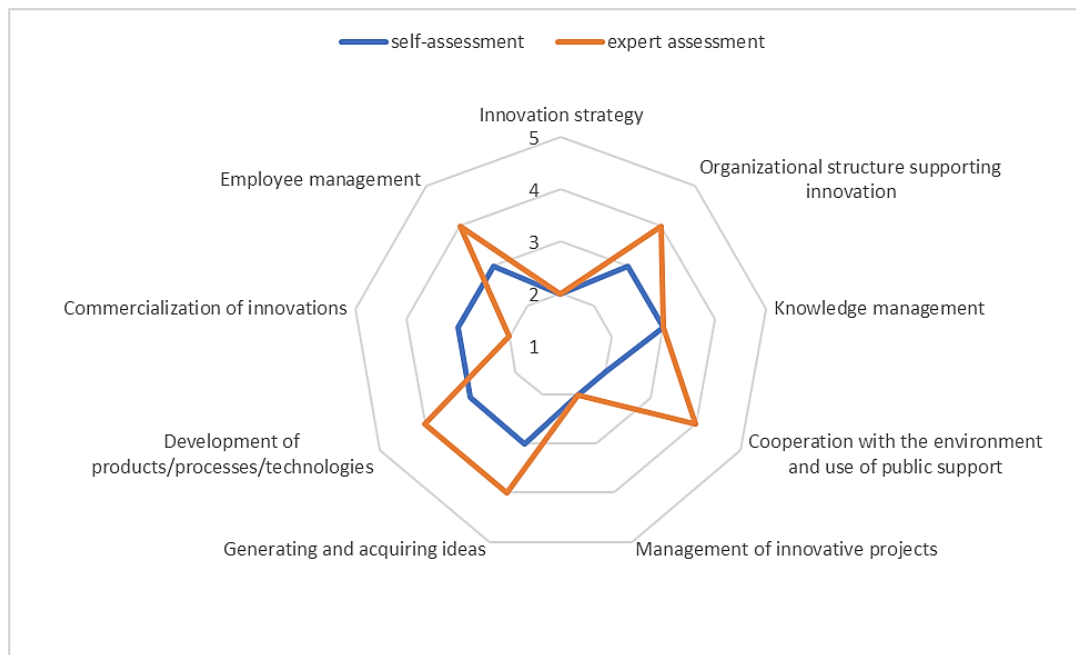
No	Section	Problems - questions
I	Basic data	Company name, addresses, contacts
II	General characteristics of the company	1. company size 2. dominant area of activity (NACE) 3. percentage of revenue allocated to innovation 4. implemented standards
III	Innovation management practice	5. type of implemented innovation 6. sources of financing innovation
IV	Enterprise strategy and business model	7. areas of enterprise activity directly linked with innovation 8. areas of enterprise activity that should be linked with innovation 9. innovation and strategy change 10. innovation and business model change 11. innovation and performance 12. used strategic measures of innovation 13. strategic measures of innovation that should be used
V	Organizational structure	14. organizational unit responsible for research, development and innovation 15. plans about organizational unit responsible for research, development and innovation
VI	Knowledge management	16. knowledge management instruments 17. project management system 18. using a project management system for innovation 19. using a risk mapping 20. areas of risk mapping 21. risk assessment – factors
VII	Employees	22. employee development in innovation 23. detailed areas of employee development in innovation
VIII	The needs and expectations of the enterprise, cooperation with the environment	24. used tax reliefs for innovation 25. cooperation with other entities in innovation 26. expected public support (innovation)
IX	Self-assessment of innovation management	27. Self-assessment of innovation in eight areas

Source: own elaboration.

The MIOD service is focused on practice of innovation management, strategy and business model, organizational structure, knowledge management, employees, needs and expectations of the enterprise, cooperation with the environment. The full characteristics of the service, related to the questions in the form are presented in Table 1. The idea for the service was to collect data during the first visit to the enterprise using a created form. Then, based on the collected data, a report for the company is prepared. To prepare the report external information are used:

- global patent activity and scientific activity (scholarly works) for the specific keywords representing enterprise specialisation derived from lens.org,
- information about the turnover representing enterprise specialisation (according to NACE) for Poland and other selected European countries derived from Eurostat.

The last question in the form referred to the self-assessment of innovation management in the enterprise. This information is used to prepare a visualization of the innovation management assessment, an example of which is presented in Fig. 2.



**Figure 2.** An example of self-assessment and expert assessment in MIOD report for the enterprise.

Source: MIOD final report for one of the enterprises.

The prototype was tested in  $n_2 = 4$  selected enterprises located in the śląskie voivodship. The characteristics of companies where the MIOD was tested is presented in Table 2. After completing the service enterprise representatives were asked about their overall assessment of the service. The following closed-ended questions were asked with Likert-scale responses:

1. After implementing the Monitor for Innovative Organizational Development service in our company, we evaluate it as: (definitely not useful) — (definitely useful) – assessment of service suitability.
2. Are you satisfied with the cooperation during the service? – assessment of satisfaction with cooperation.
3. Did the service meet your expectations? – assessment of fulfilment of expectations.
4. Would you recommend the service to other companies in the industry? – recommendation of the service to other companies in the industry.

**Table 2.***Characteristics of the enterprises in which the MIOD service were tested*

Enterprise id	Size	Organizational form	location	specialization
P1	medium size enterprise	joint stock company	Gliwice	production of cold-drawn of wire, nails and special nails (collated nails, nails for thermal insulation)
P2	small enterprise	limited liability company	Zabrze	production of ceiling support netting for the mining industry
P3	small enterprise	limited liability company	Paniówki	manufacture of components for transformers and electric motors
P4	microenterprise – spin out	limited liability company	Katowice	production of metal matrix composites, consultancy services – material technologies

Source: own elaboration.

Figure 3 presents the average values of the assessment - the results of answers for the above closed questions. As we can see, the overall assessment of the service was very positive. Moreover, the following open-ended questions were asked to determine the usefulness of individual elements of the MIOD service:

- What issues are most useful in the activities of your company?
- What issues are the least useful in the activities of your company?
- What issues regarding the innovative development of the enterprise were not addressed?

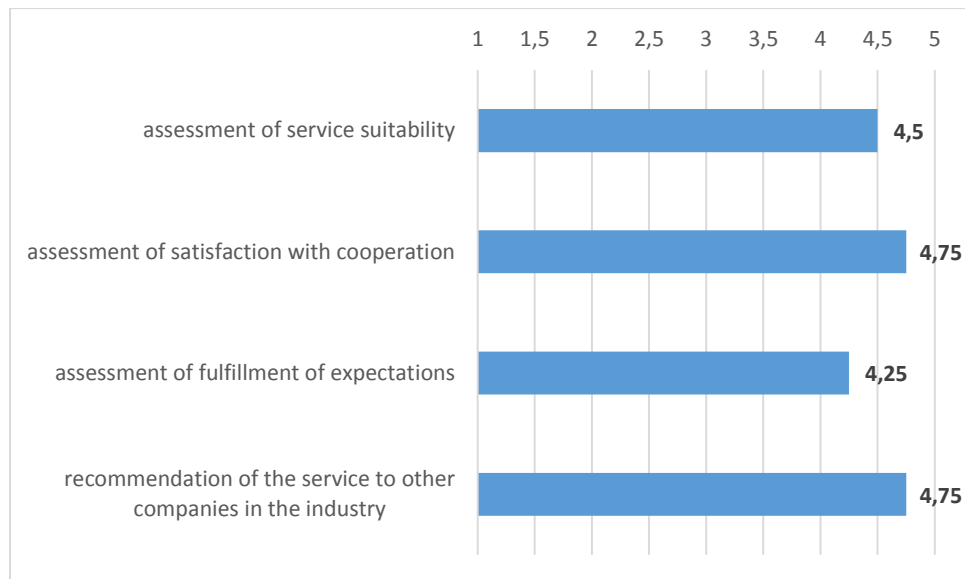
Participants of the tests indicated the following most useful issues implemented as part of the MIOD service:

- analysis of the market situation, innovation management assessment (P1)
- processes automation and robotization (P2),
- innovation management and innovation management system (P3),
- market analysis (P4).

Only one participant (P3) indicated the issues that were least useful in the company's operations and it was Industry 4.0. The rest of the participants did not indicate any issues that was least useful in the activities of his company. Also only one participant (P1) indicate the issues that were not addressed in MIOD service, which were:

- detailed analysis of sales value for the company's products (based on public statistics),
- the issue of the impact of production volume on efficiency.

Based on the evaluation of the test services, we can conclude that the service was rated as highly useful and its substantive scope was well suited to the needs of enterprises.



**Figure 3.** Assessment of the MIOD service by enterprises after the service has been provided [ $n_2 = 4$ ].

Source: own elaboration.

The MIOD method and its practical verification are the key findings of the presented research. The practical nature of the results obtained should be emphasized: the MIOD was designed for production companies in the materials processing industry.

## 4. Conclusions

Designed service MIOD could be useful for enterprises only if the regional business environment institutions could adapt it to their real offer. In the process of service creation no additional resources were devoted to training the staff of business environment institutions about MIOD service realization. To obtain high quality of the service the knowledge of the personnel is crucial. The leading consulting companies offers different types of services for mastering innovation management practices<sup>2</sup>. The test of the MIOD service shows that the basic improvement of the innovation management process could be limited to nine areas (Fig. 2), as the starting point to in-depth analysis.

A full, scientifically based critical assessment should also include a peer review by a business consulting institution and a scientific opinion. Such reviews have not been conducted - so this is the basic limitation of the presented results. The service is devoted to enterprises of materials processing industry only and it was tested in four small companies in Poland – it is the second practical limitation of the presented method. However lessons learned from the testing of MIOD service could be also very valuable for management science. The importance

<sup>2</sup> For example AT Kearny offers at least eight types of consulting services in innovation management for business, see: Consulting Imp<sup>3</sup>rove, <https://www.imp3rove.de/services/consulting/>.

of strategic level of innovation management is the first key findings of the service testing. The second one is the role of innovation management measures/indicators for implementing innovation management strategy.

Moreover the following observations were made during the process of designing the service:

1. Tests of the new service confirmed its usefulness and value for enterprises in the materials processing industry. A positive assessment during the tests is a condition for further commercialization of the MIOD service.
2. Full commercialisation of the service can be carried out once the service has been formally handed over to the business environment institutions. By the time the article was published (the end of 2023), this had not happened.
3. Further development of the MIOD service could include the creation of a web-based version. In its current version, MIOD is based on a manual and relies heavily on the knowledge of the experts implementing the service. Creating an online version would certainly reduce the individual value for the entrepreneur but would increase the reach to other businesses in Poland.
4. An important part of the process of developing and testing the MIOD service was the practical knowledge about the companies in the sector of materials processing industry. While quantitative research can provide general overview of innovation management in enterprises, services realized in four enterprises shows the details of innovation management practices and indicate the causes of problems in this area.
5. Future works in this area will be extended not only in the area of organization innovation capability but also maturity of innovation system in organizations. Meeting this challenge will require a combination of theoretical and practical elements. The conducted studies have shown that both the practical offer of consulting companies and the theoretical knowledge related to innovation management in enterprises are developing. The author's further research will be devoted to these problems.

## **Acknowledgements**

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## **GDP GROWTH OF POLAND 2004-2023: DID THE ECONOMIC POLICY CHANGE A LOT?**

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**Purpose:** This study aims to analyze the effects of the economic policy change in 2016 on the characteristics of Poland's economic growth enjoyed during the EU membership period and the prospects of future development.

**Design/methodology/approach:** The research presented in this article takes, as a starting point, the analysis of the main factors driving the economic growth of Poland during the whole EU membership period. Then, the analysis period is divided into. After having considered the most critical changes in the economic strategy that took place in 2016, we use the data analysis, including the methodology of growth accounting, to determine essential differences in the outcome of the policies. The results obtained create a basis for conclusions about the impact of the policy change on Poland's future development prospects.

**Findings:** The study supports the point that the main driving force of Poland's development during the EU membership period was the dynamic integration effects, particularly the shift of production from Western Europe to new EU member states, leading to the enormous increase of FDI and exports. The economic policy of Poland until 2015 was based on institutional development, care for the economic equilibrium and investment, and support for further EU integration. The stress of the policy applied since 2016 shifted to the support for consumption and wages, with the clear recourse in institutional development, a fall in the investment rate, and growing tensions with EU institutions. The results of such a policy may limit Poland's future GDP growth.

**Originality/value:** The article uses a new approach to analyze the driving forces of Poland's economic growth to formulate, in a pioneering way, conclusions on the effects of the economic policy change in 2016-2023.

**Keywords:** economic growth, growth accounting, European integration, growth prospects.

**Category of the paper:** research paper.

## 1. Introduction

The first decades of this century, particularly the years of Poland's membership in the European Union (EU), were characterized by rapid development of the Polish economy and a significant reduction in the development gap separating it from the more developed Western European countries.

During 19 years of EU membership, Poland recorded an average annual GDP growth rate of 4.0% (which meant more than doubling the GDP level). It is worth noting that this development took place in highly unfavorable external conditions: membership was accompanied by the global financial crisis of 2008-2009 and the global recession it caused in 2009, the debt crisis of the southern countries of the eurozone and the European recession it generated in 2012-2013, the pandemic crisis and the resulting global recession in 2020, and finally the war in Ukraine in 2022-2023. As a result of these phenomena, the average annual growth rate of the economies of developed countries decreased from 3.2% in the twenty years 1984-2003 to 1.6% in the years 2004-2022. Despite such unfavorable conditions, the Polish economy recorded the highest economic growth of all the new member states during the membership period.

It should be noted, however, that since 2016, there has been a significant change in Poland's economic policy during the years of its membership. Despite changes in government, until 2015, this policy was based on three foundations: (1) the development and improvement of institutions, (2) attachment to the principles of economic stability and balance, (3) close integration within the EU, and cooperation with EU institutions. After the change of government as a result of the elections in October 2015, the emphasis on economic policy changed significantly: the promotion of wage and consumption growth came to the fore, with less attention paid to the existing foundations (and in the case of relations with the EU, even to an open reversal of the principles of deepening integration).

While the issue of Poland's economic growth throughout EU membership has received much attention in scientific discussion (including Rapacki, Próchniak, 2009; Nölke, Vliegenthart, 2009; In t'Velt, 2019; Orłowski, 2020; Kawecka-Wyrzykowska, 2021; Hagemeyer, Michałek, Svatko, 2021; Polish Economic Institute, 2022; Orłowski, 2022), the consequences of changes in economic policy after 2015 have so far received surprisingly little attention. In the absence of attempts at a synthetic assessment based on data and scientific analyses, this role is to some extent played by journalistic texts published by respectable economists (e.g., Gomułka, 2017; Hausner, Gronicki, 2023; Wojtyna, 2023; Orłowski, 2023).

In the article, we will try to fill this gap by analyzing the impact of the economic policy change on the trends and prospects for Poland's further development. After recalling the main growth mechanisms throughout EU membership, we will show the effects of its changes after 2015 and discuss their probable consequences in the future, in particular taking into account the development megatrends occurring in the world today.

## 2. Sources of Poland's economic growth in the years of EU membership

According to economic theory, the integration processes that occurred as a result of Poland's accession to the EU led to the emergence of three groups of effects accelerating GDP growth (Orłowski, 2021): (1) static integration effects, (2) the impact of development support under the EU cohesion policy, (3) dynamic integration effects resulting from the shift of production factors, which in the case of Poland meant the inflow of capital (straightforward investments, FDI) primarily and the shift of production, and to a lesser extent the flow of labor to Western Europe (economic emigration).

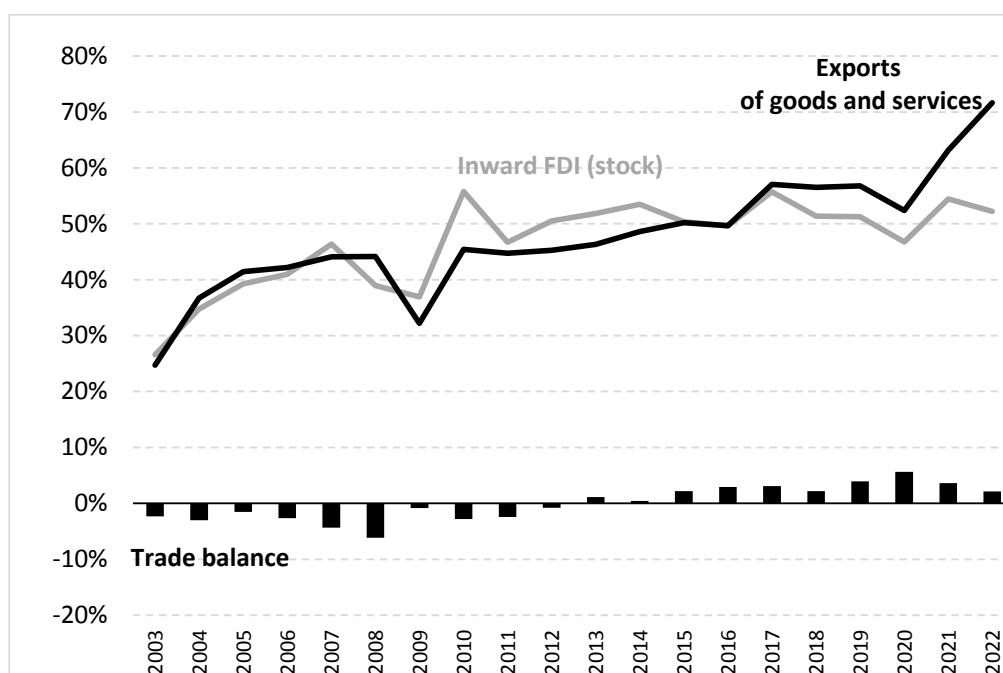
The static effects resulting from the elimination of customs duties and non-tariff barriers in exchange with EU countries were largely realized even before accession as a result of the creation, under the Association Agreement, of a free trade area with the EU (excluding agri-food products and maintaining customs controls). And some hidden non-tariff barriers; Kawecka-Wyrzykowska, 2021). That does not mean, of course, that these effects were not felt at all after accession, especially in those sectors of the economy where restrictions still existed in 2003 (especially in the agri-food and services sectors).

EU development aid played a more critical role in dynamizing the development of the Polish economy. With accession, Poland was covered by the EU's cohesion policy, quickly becoming the largest recipient of EU development funds and receiving total aid of EUR 188 billion by November 2023. The inflow of these funds to Poland during the membership period corresponded on average to 2.2% of GDP per year (relatively lower than that obtained by Greece and Portugal during their membership, 3.8% and 3.4%, respectively). The inflow of funds undoubtedly resulted in a positive growth effect, both on the demand side (revival in the economy caused by additional spending) and on the supply side (elimination of infrastructure bottlenecks facilitating investment growth, improvement of the institutional environment of the Polish economy and the quality of human capital). The impact of EU funds is usually estimated at 0.4-0.5% of the average annual additional GDP growth (Ministry of Funds and Regional Policy, 2020).

However, as numerous studies show, membership's most critical economic benefits were related to the dynamic effects of integration. Never in the history of previous enlargements has there been such a significant difference in the level of economic development between the existing and new member countries. The average level of wages in the countries that joined the EU in 2004-2007, converted according to current exchange rates, at the time of accession was on average only 20% of the level in Germany (19% in Poland). For comparison, at the time of Greece's accession to the EU in 1981, the similarly calculated local wage level was the equivalent of 58%. At the time of the accession of the Iberian countries in 1986, their average wage level was the equivalent of 48% of West German wages (Orłowski, 2020). That meant a substantial competitive advantage for the new member states, and especially Poland, as a

place for locating production, which should lead to dynamic solid effects of integration (shifting investments and output), i.e., a significant increase in foreign investments and then an increase in exports directed to the entire single European market and resulting in a substantial trade surplus. The most important economic benefits for Poland would result from the combination of three factors: unrestricted access to the entire EU market (both due to the abolition of formal obstacles and the elimination of bottlenecks in the transport infrastructure, Kawecka-Wyrzykowska, 2021), cost advantages resulting from lower labor costs (Orłowski, 2020), and finally, increasing investment credibility and decreasing the risk premium (Baldwin, Francois, Portes, 1997).

Statistical data confirm the occurrence of all these effects (see Fig. 1).

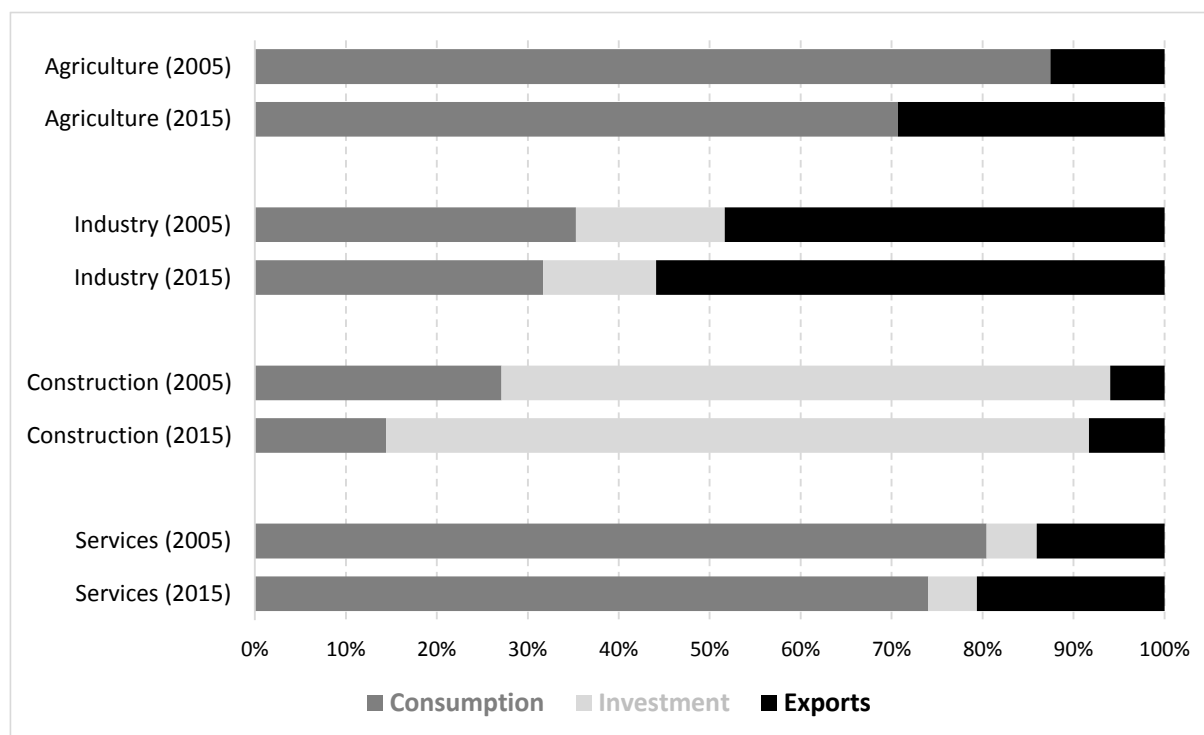


**Figure 1.** Stock of inward FDI, exports, and trade balance of Poland, as a percent of GDP, 2003-2022.

Source: Author's calculations based on GUS and NBP data.

Firstly, EU membership resulted in a large scale of FDI inflows to Poland, and the ratio of the cumulative FDI resource to GDP increased from 27% in 2003 to 52% in 2022 (the value of the FDI resource, expressed in euro, supplemented by an average annual rate of 9.3%). Secondly, this was followed by a sharp increase in the export of goods and services. Its ratio to GDP increased from 25% in 2003 to 72% in 2022 (the value of exports, expressed in euro, increased annually by 11.5%; in 2022, over 80% of the total was directed to the markets of EU countries and Great Britain). Thirdly, Poland's trade balance, negative during the first nine years of membership and amounting to -2.7% of GDP on average, turned positive in the next decade and amounted to 2.8% of GDP on average (a positive trade balance in exchange with EU countries appeared already in 2005, and in 2022 it was the equivalent of 14% of GDP).

The growing openness of the Polish economy during the EU membership can also be traced by analyzing data from input-output tables. Between 2005 and 2015, the share of exports in final demand increased in all main sectors of the Polish economy. In the case of industry this share reached 56% (which means that the EU market, not the domestic market, is crucial for the Polish industry), in agriculture 29%, services 21%, and construction 8% (see Fig. 2).



**Figure 2.** Share of demand categories in the final demand for products of main branches of the Polish economy, 2005 and 2015.

Source: Author's calculations based on GUS data (input-output tables).

Poland's membership in the EU increased the openness of the economy, i.e., an increase in the trade exchange ratio (the sum of exports and imports) to GDP from 52% before accession to 141% in 2022. According to numerous comparative studies, such a substantial increase in the ratio of trade to GDP, especially when achieving a positive trade balance, leads to a significant acceleration of the GDP growth rate (Frankel, Romer, 1999). This acceleration is mainly due to the acceleration in the growth of total factor productivity (TFP). The most frequently mentioned factors leading to this effect are increased competitive pressure forcing companies to increase efficiency and eliminating the weakest companies from the market, economies of scale, specialization (Noguer, Siscart, 2005), as well as faster accumulation of knowledge and diffusion of technology and innovations, essential point of view of the theory of endogenous growth (Barro, Sala-i-Martin, 1995). According to estimates, the dynamic effects of integration were responsible for most of the GDP growth recorded by Poland in the period of the EU membership (Hagemejer, Michałek, Svatko, 2021; Orłowski, 2021).

### 3. Changes in Polish economic policy in 2004-2015 and 2016-2023

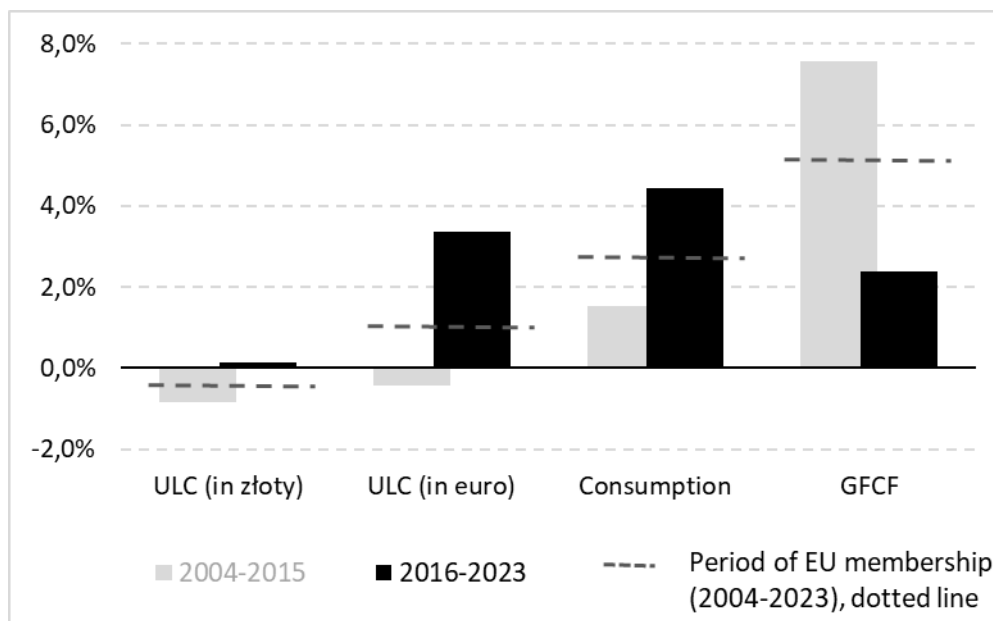
However, Poland's economic policy during the EU membership years can be divided into two clearly different subperiods.

In the first subperiod, 2004-2015, despite changes in government and the resulting sharp verbal criticism of predecessors, economic policy was dominated by attachment to three fundamental pillars: (1) strengthening market institutions, (2) caring for the economic equilibrium (which means, in the long run, care for savings and investments) and increasingly closer integration with the EU, a policy aimed to strive for maximum use of development opportunities created by membership.

In turn, 2016-2022 is a period of politics whose starting slogan is the famous "Poland in ruins" - a fundamental criticism of the current course of economic transformation. Despite parallel plans announced to maintain a balance between stimulating the demand and supply sides of the economy (Ministry of Development, 2017), in reality, this policy turned out to be aimed at increasing consumption (which had to be done at the expense of savings and investments), weakening institutions in the name of short-term political interests and growing conflicts with EU institutions (Gomułka, 2017; Orłowski, 2023).

Despite evident changes in policy, in both analyzed periods, the average annual GDP growth rate was 4.0%. At the same time, however, there were apparent differences in the essential characteristics of this growth, which undoubtedly influenced the prospects for further development.

While the unit labor cost (UCL) expressed in PLN changed only slightly throughout the entire membership period, they were falling in the first sub-period (the increase in labor productivity was ahead of the rise in real wages) and increasing marginally in the second sub-period. However, this picture changes when the UCL changes are calculated in euros; thus, the indicator that is most important for the competitiveness of Polish exports. With a similar average annual increase in wages expressed in euro in both subperiods (5.4% and 6.5%, respectively), a marked slowdown in labor productivity growth in the second subperiod (3.2% compared to 5.8% in the first) changed the trend of a slight decline in UCL into quite strong growth (annual average 3.4%, see Fig. 3).



**Figure 3.** Effects of changes in the economic policy in the years 2004-2015 and 2016-2023: yearly average change of Unit Labor Cost (UCL), consumption, and Gross Fixed Capital Formation (GFCF).

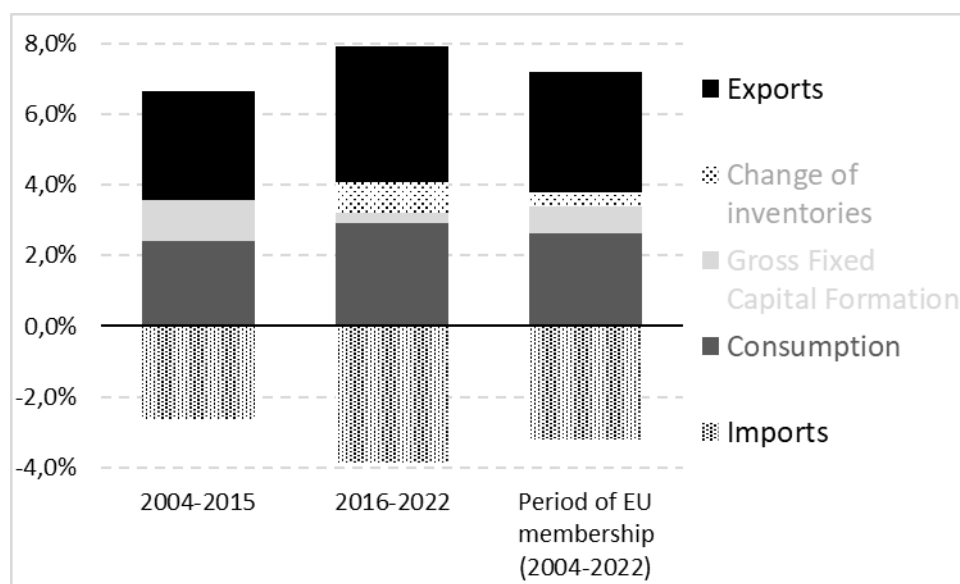
Source: The author's calculations are based on Central Statistical Office data for 2023—author's forecast.

Another effect of the policy (although having an undoubted impact on changes in the labor productivity growth rate) was the acceleration of the consumption growth rate (from 1.5% on average in the first subperiod to 4.5% in the second) at the expense of a three-fold slowdown in investment growth (from 7.6% to 2.4%). As a result, the investment rate (the ratio of gross fixed capital formation to GDP) increased in the first subperiod and decreased in the second.

#### 4. Anatomy of Poland's economic growth in 2004-2015 and 2016-2023

The critical importance of EU membership, including primarily the increase in investments and exports related to Poland's participation in the single European market, is reflected in the structure of GDP growth both during the entire period of membership and in the subperiods 2004-2015 and 2016-2022 (due to the lack of complete data from the analysis of growth anatomy we exclude the year 2023).

Let's start the analysis from the demand side of the economy. Regardless of the economic policy pursued, the most dynamically growing component of final demand from the point of view of GDP growth, both in 2004-2015 and 2016-2022 and also in total for the entire period of Poland's membership in the EU, was export (see Figure 4).



**Figure 4.** Impact of final demand categories on the yearly average GDP growth, percent points, 2004-2022.

Source: The author's calculations are based on Central Statistical Office data.

While the entire domestic and foreign final demand increased annually during the membership period by 7.2 percentage points of GDP, nearly half of this growth came from increased exports. Of course, both strong production ties, especially within global value chains (supplies of raw materials and semi-finished products for export production), and the usual macroeconomic mechanism (increased exports influencing income growth and strengthening the exchange rate) led to the emergence of increased imports. However, the negative impact of import growth on GDP growth was smaller than the positive impact of exports. Interestingly, the share of exports in the final demand growth remained similar both in 2004-2015 and 2016-2022. Although the economic policy pursued influenced the structure of final demand, this impact was limited to increasing the role of consumption at the expense of investment. That allows us to conclude that the effect of EU membership, expressed in the dynamic growth of exports, was more substantial than the effects of national policy in the observed period.

The analysis of the structure of final demand allows us to conclude that the effect of Poland's membership in the EU was an increase in GDP in both sub-periods, based mainly on a similar rate of export growth (the average annual growth in exports of goods and services was 6.4% and 6.7%, respectively, in both sub-periods and imports 6.8% and 6.9%.) As a result of the dynamic effects of integration, exports, carried out with a trade surplus, contrary to sometimes proclaimed theses, were the main driving force of the development of the Polish economy in the years 2004-2022.

The confirmation of the impact of EU membership on Poland's economic growth can also be found in analyzing the supply side of the economy using growth accounting tools (Barro, Sala-i-Martin, 1995; Rapacki, Próchniak, 2009), which allows for isolating the effect of the increase in total factor productivity in GDP growth (Total Factor Productivity (TFP)). TFP growth means that part of GDP growth that an increase in labor and capital inputs cannot



explain. This quantity, the "Solow residual", is identified with technical and organizational progress broadly understood. Let us recall that, according to the postulates of economic theory, both the increase in the openness of the economy (resulting from the dynamic effects of integration) and the improvement of the economic environment, infrastructure, and the quality of human capital (resulting mainly from development support from European funds) should first lead to a significant increase in TFP (Noguer, Siscart, 2005).

The starting point for growth accounting may be the neoclassical, two-factor Cobb -Douglas production function of the form:

$$Y_t = A_t K_t^\alpha L_t^{(1-\alpha)} \quad (1)$$

where:

$Y_t$  is production (GDP) in period  $t$ ,

$A_t$  is the level of technology equivalent to total factor productivity (TFP),

$K_t$  and  $L_t$  are capital and labor inputs, respectively,

the parameter  $\alpha$  is the elasticity of production with respect to capital.

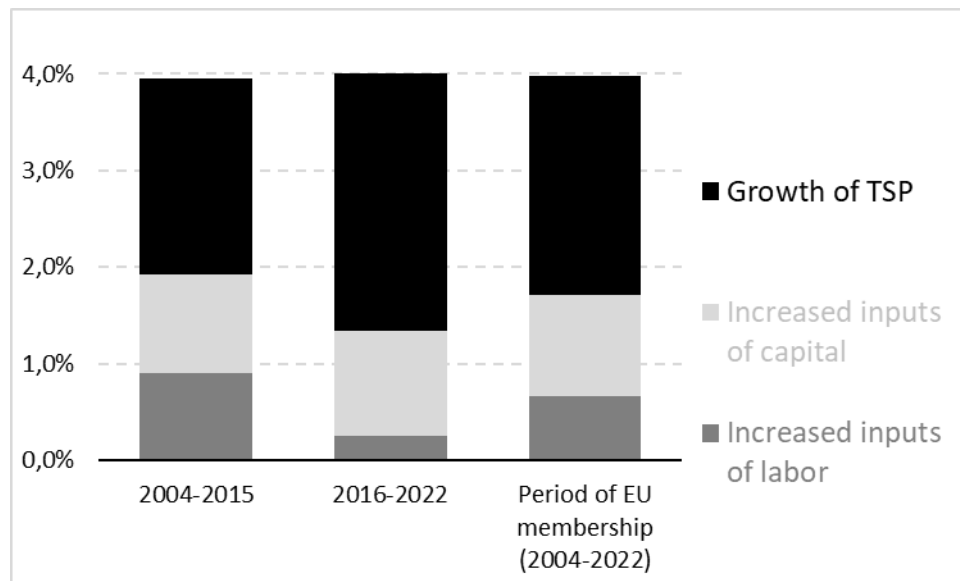
The assumption of no economies of scale means that the elasticity of output with respect to labor is  $(1 - \alpha)$ .

Performing a series of transformations of the above production function allows us to determine the formula used to calculate the growth rate of total factor productivity (TFP), i.e., the Solow residual, in the form of equation (2), which is a standard growth accounting tool (the dot above the symbol indicates the increase in the variable):

$$\frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - \left[ \alpha \frac{\dot{K}}{K} + (1 - \alpha) \frac{\dot{L}}{L} \right] \quad (2)$$

This formula means that the GDP growth rate is the sum of the growth rates of labor and capital inputs, weighted by the shares of income of these factors in total income (equal to the parameters  $\alpha$  and  $(1 - \alpha)$  from the production function), increased by the growth rate of TFP (Barro, Sala-i -Martin, 1995; Rapacki, Próchniak, 2009).

The analysis of growth accounting confirms the hypothesis about the critical importance of TFP growth, most likely linked to the increased openness, for Poland's economic development throughout membership. TFP growth accounted for half the growth rate achieved in 2004-2015 and two-thirds in 2016-2022. The factor that clearly distinguished both periods was the impact of the increase in labor input, which was significant in the first period and insignificant in the second (see Fig. 5).



**Figure 5.** Impact of labor, capital inputs, and the Total Factor Productivity (TFP) increase on the yearly average GDP growth, percent points, 2004-2022.

Source: The author's calculations are based on Central Statistical Office data.

In general, it can be concluded that the obtained results confirm the hypothesis of the critical importance of the effects of EU membership for Poland's growth in the entire period 2004-2022, in particular, the effects of increased openness leading to pressure on TFP growth, regardless of changes in the country's economic policy. It is worth adding that a similar phenomenon was also observed in the other new member states (Młynarzewska -Borowiec, 2018).

## 5. The impact of changes in Poland's economic policy on the prospects for further development

However, the analysis of Poland's undoubted economic success during the period of EU membership also requires referring to the problem of maintaining a relatively high growth rate in the long term, particularly the issue of the so-called traps of middle development. This risk was highlighted both in theoretical studies (Nölke, Vliegthart, 2009) and government documents (Ministry of Development, 2017). Further growth will take place in the conditions of the Fourth Industrial Revolution. That may mean that in the conditions of rising labor costs, Poland's current competitive advantage leading to the shifting of production in the EU may be threatened by a decline in labor costs in high-wage countries resulting from robotization (especially in industry) and the use of artificial intelligence in services (International Federation of Robotics, 2023).

The analysis of Poland's economic growth over the past 19 years suggests that the main driving force of development was the increase in exports and the openness of the economy resulting from the dynamic effects of integration. This mechanism, however, is primarily associated with the inflow of capital from that part of the integration area where there is relatively much of it and its marginal productivity is low to that where there is little capital and a lot of labor resources (so wages are low and marginal productivity of capital high). However, the condition for the continuation of economic growth is, as differences in wages decrease, a change in the development model to one in which internal investment mechanisms play a more significant role, leading to an increase in the share of capital in GDP growth and to more intensive use of knowledge, accelerating the growth of TFP (Gomułka, 2009). The inability to change the development model this way may mean getting stuck in the middle-income trap.

Although the possibility of forming a middle-income trap does not result directly from theoretical growth models that assume a smooth process of necessary institutional adjustments (Barro, Sala-I-Martin, 1995), it is supported by empirical experience. This risk was observed when analyzing economic growth in Southeast Asian countries: after a period of rapid development based on cheaper labor, many countries managed to achieve an average level of GDP per capita, but only a few managed to maintain rapid economic growth and reach a high level of GDP per capita in conditions of increasing labor costs (Kharas, Kohli, 2011). Further development required not only further intensive investments in improving human and physical capital but, above all, fundamental changes and improvement in the functioning of institutions, which most of the surveyed countries were incapable of.

Considering the above statements, we can assess the extent to which changes in Poland's economic policy during the membership period contributed to avoiding the trap of average development, thus maintaining a relatively high growth rate in the future.

Firstly, demographic forecasts indicate growing problems with job availability. During the period of membership, Poland managed surplus labor resulting from its underutilization (measured based on BAEL surveys, the unemployment rate decreased from 20.7% at the beginning of 2004 to 2.6% in mid-2023, which in practice means zero unemployment, and the number employed increased by 20%). However, a further increase in the number of working people is unlikely for demographic reasons (according to Central Statistical Office forecasts, the working-age population is expected to decrease by 15.7% in the twenty years 2025-2045, and its share in the total population of the country will drop from 58% to 54%). Although the phenomena of solid immigration may change the situation, increased economic activity and a gradual shift up of the actual retirement age, one should take into account the prospect of a minimal, or probably even negative, impact of labor input on GDP growth, which can only be mitigated by improving the quality of education (growth of human capital). Although there was an apparent increase in economic activity during the membership period (the share of working people in the working-age population increased from 53% to 69%), this process has wholly slowed since 2016. It should be noted that the social and economic policy pursued after

2015 (including lowering the retirement age and increasing non-work-related social transfers) may contribute to deepening difficulties in maintaining a relatively high pace of development in the future (Melich-Iwanek, 2021).

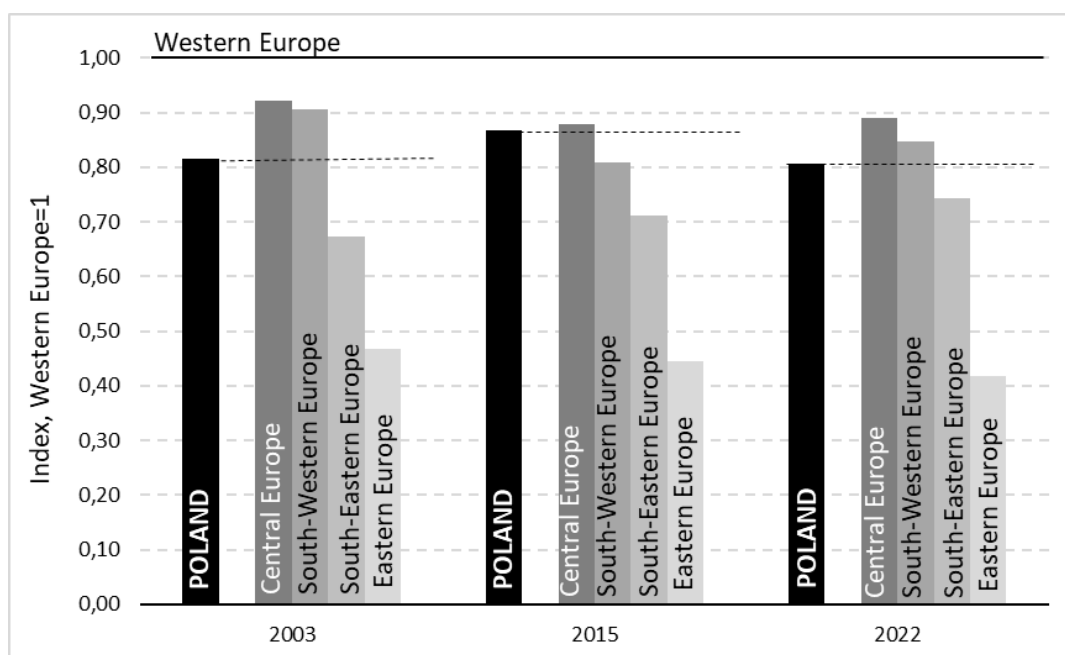
Secondly, changes in economic policy during the membership period resulted in a reduction in investment intensity and, therefore, in the accumulation rate of physical capital. The share of investment (Gross Fixed Capital Formation) in GDP increased in 2004-2015 from 18.3% to 21.2%, but in the 2016-2022 subperiod, it decreased to 17.5% (in the first three quarters of 2023 to 15.3%). There is no doubt that the collapse of investment activity should be considered the greatest failure of Poland's economic policy in 2016-2022, especially in the context of the declaration that one of its main goals was to increase this share to 25% to avoid the middle-income trap (Ministry of Development, 2017). Low investment activity for a long time will limit both the impact of the increase in capital expenditure on GDP growth and the improvement of the technological level of the economy necessary to increase TFP (Gomułka, 2009).

Third, the rate of TFP growth is crucial for further growth. Because, along with the increase in wages observed in Poland during the membership period, the cost attractiveness underlying the process of transferring production decreases (the average salary expressed in current euros increased during the membership period from EUR 475 to EUR 1,585, i.e. 3.3 times and increased from approx. 19% of the German level in 2003 to approximately 39% in 2023), it is necessary to change the development model towards the one based on knowledge and innovations (Gomułka, 2009; Grzybowska, 2013). Such a change requires, first of all, institutional changes aimed at improving the efficiency of management and the effectiveness of the implementation of pro-efficiency economic policy (Wojtyna, 2009; Orłowski, 2020). It should be noted that, currently, Poland is one of the EU countries with the lowest advancement of knowledge-based growth processes (the synthetic innovation index compiled by the European Commission places Poland in the group of 6 EU countries most lagging behind in this respect, the European Commission, 2023).

However, the economic policy pursued in both analyzed subperiods differed significantly in terms of the emphasis on improving the institutional environment of the Polish economy. While until 2015, improving the quality of institutions' operation was the focus of development policy, in the years 2016-2022, there was an apparent regression in this respect, and the efficiency of their functioning decreased.

The efficiency of an institution can be measured by a synthetic indicator of management quality (Worldwide Governance Indicators) compiled by the World Bank as an average of 6 partial indicators: (1) government accountability and civil liberties, (2) stability and security, (3) government efficiency, (4) quality of regulations, (5) rule of law, (6) control corruption (World Bank, 2023).

The development of the synthetic indicator of management quality in Poland during the period of EU membership, against the background of various European regions, is presented in Figure 6.



Note: Western Europe - Germany, France, UK; Central Europe - Austria, Czechia, Hungary, Slovakia; South-Western Europe – Italy, Spain, Portugal, Greece; South-Eastern Europe - Romania, Bulgaria, former Yugoslav countries; Eastern Europe – Russia, Ukraine, Belarus.

**Figure 6.** The level of effectiveness of institutions influencing the economic development of Poland compared to 5 regions of Europe<sup>1</sup>.

Source: The author's calculations are based on World Bank data (World Bank, 2023).

In 2003, the level of efficiency of Polish institutions could be estimated at 82% of the level observed in Western Europe; this level was lower than in Central and Southern Europe. The progress achieved in 2004-2015, both as a result of the policies pursued and the pressure created by EU membership, resulted in an increase in efficiency to 87% of the level of Western Europe, bringing it on par with the rest of Central Europe and overtaking other regions of the continent. Unfortunately, the improvement process was reversed in 2016-2022, resulting in the efficiency level of Polish institutions dropping again in 2022 to 81% of the level of Western Europe and below that of Central and Southern Europe. However, it was still higher than in South-Eastern Europe (although the difference decreased significantly compared to 2015) and higher compared to Eastern Europe.

<sup>1</sup> Western Europe - Germany, France, UK; Central Europe - Austria, Czechia, Hungary, Slovakia; South-Western Europe – Italy, Spain, Portugal, Greece; South-Eastern Europe - Romania, Bulgaria, former Yugoslav countries; Eastern Europe – Russia, Ukraine, Belarus.

## 6. Summary and Conclusions

The analysis of Poland's economic development during the period of EU membership and the effects of economic policy changes in the subperiods 2004-2015 and 2016-2023 leads to several important conclusions.

Firstly, Poland has achieved great success throughout its membership in reducing the difference in the level of development compared to Western European countries. That was possible thanks to achieving the highest economic growth among all new EU member states despite unfavorable external development conditions. Considering both the scale and the pace of improvement measured by changes in GDP per capita, this success should be regarded as historic.

Secondly, the primary source of economic growth that allowed for such a spectacular success was Poland's membership in the EU, especially the dynamic effects of integration related to the inflow of capital and shifting production. Poland's continuing competitive advantage resulting from lower labor costs led to increased investments aimed at production for the entire European market. Subsequently, it led to a massive increase in exports and a trade surplus.

Thirdly, throughout the period 2004-2022, there was a substantial increase in the openness of the economy, leading to accelerated TFP growth. Rapidly growing exports became the central demand engine of development, regardless of changes in the country's economic policy.

Fourthly, the changes in economic policy observed after 2015, in particular the decline in the efficiency of institutions, weakening investment intensity, and the lack of effective measures to mitigate the decline in labor supply resulting from demographic reasons, mean that the chances of maintaining a relatively high growth rate in the future leading to a further decline in the development gap compared to Western European countries have decreased.

Fifthly, the changes mentioned above led to a substantial increase in unit labor costs expressed in euro and, at the same time, to a reduction in the intensity of investment and the rate of technological progress (increase in total factor productivity). In the conditions of the Fourth Industrial Revolution, this may lead to weakening of export-based growth processes and to reducing the possibility of taking full advantage of the development opportunities created by EU membership.

Further economic convergence is possible but requires changes in economic policy and effective actions towards strengthening the institutions, creating more favorable conditions for investment, increasing the technological level and innovativeness of the economy, and developing human capital.

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## ASSESSMENT OF THE READINESS OF MANUFACTURING COMPANIES IN IMPLEMENTING A CIRCULAR ECONOMY

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**Purpose:** The article is devoted to the analysis of the genesis, ideas, assumptions, and implementation of the circular economy (CE) in the context of organizational and business management, with particular emphasis on the readiness of enterprises to introduce CE. The aim of the study is a comparative analysis of the readiness of manufacturing enterprises, taking into account their size, in terms of implementing the principles of the circular economy. Considering the developed readiness model for the introduction of the circular economy, the following research questions were created:

1. How do manufacturing enterprises assess the economic viability of the circular economy?
2. How does the external environment affect the pace of introducing the circular economy in enterprises?
3. What is the technological, infrastructural, financial, and competence readiness of the staff in terms of introducing the circular economy?
4. What practices related to the circular economy are already introduced, which are planned for introduction, and which are not considered in enterprises?

**Design/methodology/approach:** The method of analysis of subject literature and the quantitative method were applied, using the survey technique. The survey was conducted using the CAWI technique.

**Findings:** The key findings pertain to the role of external and internal factors in determining the readiness to implement circular economy practices in business operations. Research indicates that although many companies have a positive attitude towards the circular economy, discrepancies exist between their declarative scope and the level of implementation of good business practices in manufacturing enterprises. Standards such as BS 8001 can play a pivotal role in promoting the circular economy. Hence, state institutions should increase the availability of information on ISO standards and simplify certification procedures. The government, regulatory bodies, and the private sector must collaborate to enable the full implementation of the circular economy model. Large corporations have more financial resources, which can facilitate the implementation of CE practices, while small businesses are more constrained in terms of funding. Due to their visibility, large companies feel greater social pressure to adapt to CE principles. Despite environmental pressures, many companies do not feel strong competition or market pressure to accelerate their adaptation to the CE model. However,

both small and medium-sized, as well as large enterprises, recognize the economic viability of the circular economy.

**Research limitations/implications:** The following directions for further research have been proposed, including the development of measurement tools for Sustainable Development Goals (SDGs) alignment, analysis of the impact of SDGs on innovation, and the study of the role of leaders and organizational culture. There is a need for further exploration of the influence of regulations and public policies on SDGs alignment.

**Practical implications:** The circular economy has practical implications for changes in business models, resource management, strategy, and corporate marketing activities. It also recommends the development of tools for assessing the level of implementation of CE principles in enterprises and promoting pro-environmental attitudes among consumers.

**Social implications:** The circular economy has the potential to influence social attitudes and behaviors by promoting more sustainable consumption and production practices, which in turn may affect the quality of life and the balance of ecosystems. Actions in the field of the circular economy can also impact public and industry policy.

**Originality/value:** The article proposes a research model that takes into account various factors influencing the readiness of enterprises to implement circular economy practices, allowing for the identification of key barriers in the decision-making process by owners and managers of manufacturing companies in the aspect of changes bringing the company closer to the introduction of CE principles. This model can be valuable for researchers and practitioners interested in sustainable development, as well as governmental institutions wishing to support transformations towards CE.

**Keywords:** The readiness to implement a circular economy, a manufacturing enterprise, sustainable development, circular economy, level of readiness.

**Category of the paper:** Research paper.

## 1. Introduction

The concept of a circular economy (CE) has its origins in the late 1960s (Kulczycka, 2019), emerging as a response to the growing need for waste reduction and care for the natural environment. Today, the principles of CE are increasingly widespread due to the actions of political decision-makers and social movements. Changes in the business environment, aimed at a zero-emission economy, are forcing many companies to adjust their activities to meet environmental protection requirements. The research problem relates to globalization and the increasing consumption of resources, posing the question of how organizations can change their business models to have a lesser impact on the environment while maintaining appropriate product quality. The key issues involve understanding the main barriers to adopting the CE model in manufacturing enterprises and identifying the factors that influence companies' readiness to adopt this approach. The goal of this scientific paper is to conduct a comparative analysis of the readiness of manufacturing companies of different sizes to implement the principles of the circular economy. The readiness issue is crucial for the effective implementation of the CE concept, as it determines the extent to which organizations and

societies are prepared for changes associated with transforming processes and systems towards sustainable resource use.

## 2. Circular economy - the idea, objectives, and principles

The idea of a circular economy emerged in the late 1960s (Kulczycka, 2019), although it can also be traced back to earlier works in the field of economics. Initially, it was a concept associated with environmental protection and waste reduction. Currently, this concept assumes that the economy should be designed in a way that allows for the maximum utilization of resources by minimizing the production of waste and greenhouse gas emissions, as well as through the recovery and reuse of raw materials. For the purposes of further considerations in this paper, the applicable definition of a circular economy is adopted as created by X. Pin and Y. Hutao in 2007, which states that “a circular economy requires organizing economic activities in order to produce a “resources-products-secondary resources” feedback flow with characteristics of low exploitation, high utilization, and low emission. The entire substance and energy can be used in a reasonable and sustainable manner in a continual economic cycle, in order to reduce as much as possible the impact on the natural environment caused by economic activity” (Pin, Hutao, 2007).

This model is based on principles such as: sharing, lending, utilizing, repairing, renewing, and manufacturing materials and products for as long as possible (Sitko-Lutek, Lutek, 2022). The introduction of the circular economy aims to limit the negative impact of businesses on the environment and ensure that nature is not excessively exploited for economic growth (European Environment Agency, 2016). In this context, the CE is the opposite of the linear economic model, which relies on the "take → make → consume → dispose" scheme (Lacy, Rutqvist, 2015). Implementing the CE requires the engagement of new business models and collaboration of all stakeholders in creating new relationships and value chains both within and outside the company (Lacy, Rutqvist, 2015). The main goals of the CE are: to maximize the added value of raw materials, materials, and products, to minimize the amount of waste generated, and to manage resources effectively (Stahel, 2016).

The circular economy encompasses a wide range of activities and areas, such as: eco-design, technological innovation, education, and environmental impact assessment (Stahel, 2016). The application of the circular economy can lead to economic, ecological, and social benefits, such as the reduction of greenhouse gas emissions, increased competitiveness and employment, and savings for consumers (European Environment Agency, 2016).

The concept of the circular economy gained popularity in the 1990s in connection with the growing interest in issues of sustainable development and environmental protection. A pioneer in research on ecological economics (a field of economics that focuses on sustainable

development and the protection of the natural environment, it is an economic approach that tries to take into account the impact of economic activities on the environment and consider ecological and social costs in making economic decisions) and sustainable development was the ecologist and economist Robert Costanza, who, together with co-authors in the work “The value of the world's ecosystem services and natural capital” (Costanza et al., 1997), emphasized that ecosystem services, such as food production, water purification, climate regulation, and providing habitats for wildlife, are essential for human life. Meanwhile, natural capital, understood as natural resources such as forests, waters, minerals, and oil, is indispensable for the economy's functioning. The authors in the aforementioned work presented an estimated value of ecosystem services and natural capital worldwide (most of which remains outside the market), amounting to \$16-54 trillion annually, averaging \$33 trillion per year. It was noted that natural capital is often undervalued and ignored by political decision-makers, leading to the degradation of the natural environment and irreversible loss of resources (Costanza et al., 1997).

The destruction or degradation of ecosystems can lead to a reduction or complete disappearance of certain ecosystem services, which has serious implications for humanity and the natural environment. Therefore, in the 1990s, various regulations and economic instruments were introduced to encourage entrepreneurs to implement practices consistent with the principles of sustainable resource management in their organizations. Asian countries, such as China and Japan, were pioneers in this field. Currently, following the recommendations of the European Commission, actions have been initiated in many member countries of the European Union to broaden the implementation of sustainable resource management (Kulczycka, 2019).

### **3. Circular economy in the light of management sciences and quality**

Management in the context of the circular economy encompasses theories and models that consider economic, ecological, and social aspects. One of the key aspects of management according to the principles of the circular economy is the transformation of business models from linear to circular. Introducing the idea of the circular economy into management and quality sciences implies changes in various areas, such as (Wijkman, Skånberg, 2015):

1. Business models - management and quality sciences analyze how companies can transform their traditional business models to achieve the objectives of the circular economy, considering product durability and resource optimization.
2. Innovations - are crucial for designing products and services consistent with circular economy principles, such as ease of repair, reusability, or recycling. Management and quality sciences study how companies can develop and stimulate innovation.

3. Strategies and change management - management and quality sciences analyze how organizations can develop strategies that incorporate the goals of the circular economy, helping them in identifying and exploiting new market opportunities.
4. Collaboration strategies and networks of mutual relationships - the circular economy relies on cooperation between different entities, such as businesses, governments, and non-governmental organizations, to achieve common goals. Management and quality sciences examine how these entities can collaborate, create networks, and share knowledge and resources to support the development of the circular economy.
5. Marketing activities - based on consciously and consistently developing pro-environmental attitudes among consumers contributes to increasing demand for products that are less burdensome for the natural environment.
6. Metrics and impact assessment - in the context of the circular economy, management and quality sciences focus on developing metrics and assessment tools that can help companies measure and monitor progress in achieving circular economy-related goals. These metrics can include indicators for resource efficiency, waste reduction, greenhouse gas emissions, and social impact.

CE is not merely a theoretical concept, but an achievable and practical approach to modeling business activities that can bring benefits to the environment, societies, and enterprises. Therefore, management and quality sciences play an extremely important role in translating the theory and principles of CE into practical solutions in business (Kirchherr et al., 2017). Adapting business models to the framework of CE can open up new market opportunities and introduce innovative solutions that support sustainability and social responsibility (Korhonen et al., 2018). Collaboration between enterprises, the public sector, and other stakeholders can support broader-scale changes, enabling the creation of networks and communities based on common goals and values.

## **4. The readiness of manufacturing enterprises in terms of implementing a circular economy**

### **4.1. Research model**

The research model was developed based on a literature review. The creation of the model was based on the works of S.K. van Lengen, C. Vassillo, P. Ghisellini, D. Restaino, R. Passaro, S. Ulgiati (Van Lengen et al., 2021), M.P. Singh, A. Chakraborty, M. Roy (Singh et al., 2017) and M.G. Gnoni, F. Tornese, B.K. Thorn, A.L. Carrano, J.A. Pazour (Gnoni et al., 2018). The created model is based on the assumption that favorable external factors focused around stakeholders expectations, availability of support, and resources from recycling determine the perceptions and attitudes of entrepreneurs, which affects their level of readiness to implement

the principles of the circular economy in their organizations (Figure 1). This model assumes that understanding and engagement of different stakeholder groups in the transformation process to a circular economy are essential for its effective implementation and wide adoption. Factors determining the readiness to implement CE include: social pressure and expectations of external stakeholders; availability of raw materials and external support; attitudes and perceptions towards sustainable development; perceived behavioral control; and the internal potential of the organization to implement CE.

The implementation of circular economy in enterprises is a complex and multi-stage process that can be driven or inhibited by various external factors, which the organization has limited influence over. These factors include social pressure and the expectations of external stakeholders, as well as the availability of raw materials and external support. Social pressure and the expectations of external stakeholders refer to the perceived pressures and requirements that society and external stakeholders (competitors, customers, suppliers, regulators, and strategic partners) place on the organization to conform to certain standards, values, and expectations. In analyzing this factor, it should be considered:

1. Social norms - general beliefs and expectations about how organizations should operate within a specific social context.
2. External stakeholders - individuals or groups that can influence an organization but are not part of its internal structure.
3. Expectations - specific requirements or desires expressed by stakeholders regarding the organization's activities.
4. Relationships and sanctions - potential consequences (positive or negative) that an organization may experience in response to its actions or inaction in the context of stakeholder expectations.

Social pressure and the expectations of external stakeholders can play a crucial role in shaping the attitudes and behaviors of organizations within the context of a circular economy. If an organization feels strong social pressure and faces increasing expectations from stakeholders (to implement practices associated with CE), this can influence its perceived behavioral control. Organizational leaders may believe that they have greater potential to implement these practices, seeing that these changes are necessary for their survival and success. Pressures and expectations can motivate the organization to invest in the resources, technologies, and skills necessary to implement CE. Organizations may be more inclined to seek partnerships, innovations, or training that will help them meet the expectations of the external environment, and the constant social pressures and stakeholder expectations can influence organizational culture, promoting values associated with sustainable development and CE.

The availability of raw materials and external support as a factor refers to the extent of the ubiquity of necessary raw materials and support from external units, institutions, or organizations that can support an organization's activities in the context of implementing CE. When analyzing this factor, the following should be considered:

1. Resource availability – the ease of obtaining material, financial, human, or other types of resources that are necessary for the introduction and maintenance of CE practices.
2. External support – the availability and extent of support from external parties, such as suppliers, business partners, financial institutions, non-governmental organizations, or governmental units, which can support the organization by providing key resources, knowledge, financing, or other forms of support.
3. Networks and partnerships – the ability to establish and maintain relationships with external units that can provide valuable resources or support to the organization.
4. Market conditions – the state and dynamics of the raw materials market and the availability of alternative sources of raw materials.

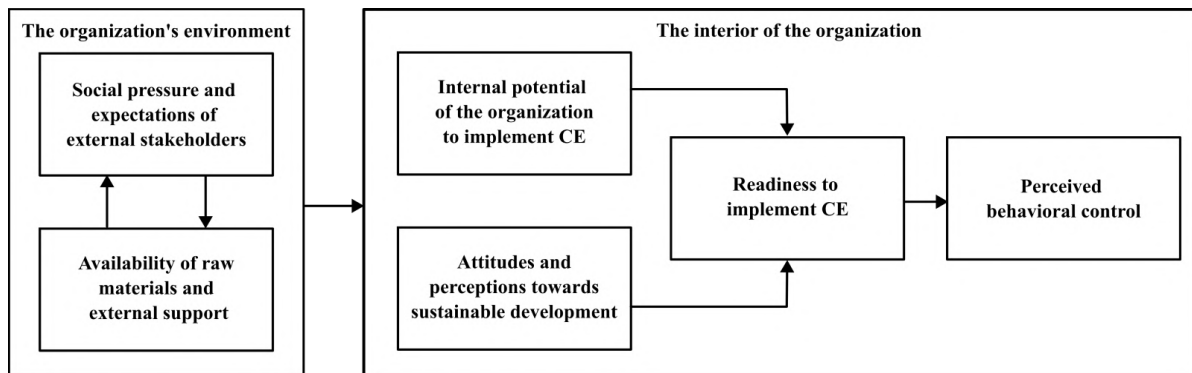
The availability of raw materials and external support is essential for the broader implementation of the circular economy in enterprises. A key aspect of CE is the reintroduction of resources and materials into the production cycle. Without access to recycled raw materials, organizations may encounter obstacles in effectively implementing CE practices. External support, by providing new technologies, knowledge, and innovations, can significantly enhance an organization's capabilities, as well as reduce the risk and uncertainty associated with implementing CE (by diversifying raw material sources and guaranteeing the necessary operational and financial support). Effective support in this area can lead to greater social pressure and stakeholder interest, which further strengthens the perceived behavioral control of the enterprise.

The internal factors that play a crucial role in shaping the behavior and readiness of organizations to implement CE include: the internal potential of the organization to introduce CE, attitudes and perceptions towards sustainable development, and perceived behavioral control. These concepts are related to the adaptation and implementation of sustainable development practices in organizations, but they differ in terms of their significance, scope, and implications.

The internal potential of an organization to implement CE is defined as the totality of an organization's actual resources, capabilities, skills, and values that enable adaptation and the implementation of CE practices, focused on waste minimization and the reuse of resources. Key to this potential are elements such as technological capability, financial ability, employee qualifications, infrastructure, environmental awareness, and pro-environmental attitudes, which indicate the company's readiness to implement CE. This objective approach, which can be measured through the availability of technology, financial resources, employee qualifications, etc., suggests that a strong internal potential of an organization can significantly increase perceived behavioral control, translating into greater certainty in taking action.

Attitudes and perception towards sustainable development focus on how an organization perceives the importance, benefits, and the need to implement sustainable development within the context of its operations. It centers on the subjective perception and beliefs of the organization regarding sustainable development. Key elements such as: economic profit, competitiveness, or the need for change play a significant role here. These attitudes have a direct impact on how the organization views its capabilities to implement changes and what actions it undertakes towards CE.

Perceived behavioral control refers to the perceptions regarding the level of difficulty or ease of performing a specific behavior or action, focusing around the perception of one's ability to effect change. In an organizational context, this is the belief about whether a company possesses the necessary resources, skills, and capabilities to implement changes, such as the adoption of circular economy practices. Organizations that perceive themselves as having significant resources and competencies (including in areas such as technology, recycling, environmental management, or IT strategies) and have the appropriate attitudes and perceptions, demonstrate a higher ability to introduce CE principles and may prove to be more ready to undertake actions in the field of sustainable development, compared to organizations that do not have the appropriate attitudes and perceptions or internal potential.



**Figure 1.** The Conceptual Model of Readiness for the Implementation of a circular economy.

## 4.2. Research methodology

The aim of the study is to conduct a comparative analysis of the readiness of manufacturing enterprises, taking into account their size, in terms of implementing the principles of the circular economy. Considering the developed readiness model for the introduction of the circular economy, the following research questions were created:

1. How do manufacturing enterprises assess the economic viability of the circular economy?
2. How does the external environment influence the pace of circular economy implementation in enterprises?
3. What is the technological readiness, infrastructure, financial capability, and staff competence in terms of introducing the circular economy?



4. Which practices related to the circular economy are already implemented, which are planned for implementation, and which are not considered in enterprises?

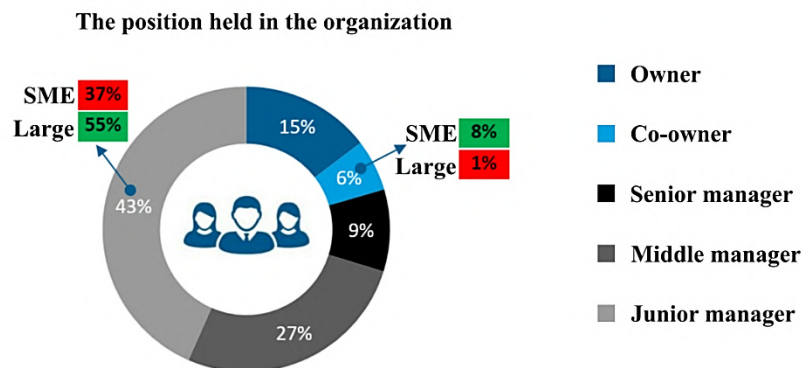
The research method used is a survey conducted using the Computer-Assisted Web Interviewing (CAWI) technique, which involves respondents independently filling out the questionnaire via the internet.

The research tool was a questionnaire consisting of 38 questions, which utilized a five-point Likert scale, and 11 questions related to good practices associated with various aspects of business operations, where respondents indicated the level of implementation of a given practice in the daily functioning of the organization. The Likert scale questions measured the level of agreement or disagreement with a statement within one of the 5 groups of factors described in the research model, of which: social pressures and expectations of external stakeholders were assigned – 7 items; availability of raw materials and external support – 4 items; attitudes and perceptions towards sustainable development – 12 items; the internal potential of the organization to implement CE – 12 items; perceived behavioral control – 3 items. These questions concerned: the economic viability of the circular economy, the influence and pressure of the external environment (micro and macro environment) on the pace of CE implementation, the company's potential for implementing CE (potential: technological, infrastructural, financial, intellectual, and staff competencies), availability of recycled raw materials, and the organization's pro-environmental actions. In questions about the level of implementation of good practices, respondents had to mark one answer out of 4 proposed options: implemented; to be implemented within the next year; considered for future implementation at an unspecified date; there are no indications for its implementation in my company. These questions related to: ISO standards; monitoring and assessing the impact of production on the environment; cyclic analyses of: material flows, use of recycled materials, waste production levels, environmental costs; work on: designing sustainable product solutions and packaging, solutions that reduce the carbon footprint of products.

The subject of the study were manufacturing companies located in Poland, specifically their owners and managerial staff (Figure 2). The thematic scope included the assessment of companies' readiness in terms of implementing the principles of the circular economy, the analysis of their involvement in practices related to this economy, and the identification of potential obstacles and challenges. The study covered enterprises of various sizes and scopes of activity. The research sample was  $N = 205$ , consisting of  $N = 134$  small and medium-sized enterprises (employing fewer than 250 people) and  $N = 71$  large enterprises (employing 250 or more people). The owners and managers participating in the study work across multiple sectors, with the dominance of the food industry at 13%, followed by: automotive 9%, metal industry 7%, furniture production 7%, manufacturing (general) 6%, electronics 6%, wood processing/treatment 4%, machinery production 4%, paper production 4%, window production 3%, energy 3%, cable production 2%, chemical 2%, packaging production 2%, cosmetics 2%,

decoration/ornaments/candles 2%, with others comprising 22%. The companies under study have a regional (30% of respondents), national (74%), and international (49%) reach.

The study was conducted in the period from november 25 to december 11, 2022. After conducting the data analysis, the results were interpreted and presented in the form of research conclusions regarding the readiness of manufacturing enterprises to conduct a circular economy. The study is concluded with recommendations for enterprises, public policymakers, and other interested parties, aimed at improving forms of actions and supporting the transformation towards a circular economy in the manufacturing sector.



**Figure 2.** The position held by respondents in the manufacturing enterprise.

#### 4.3. Assessment of the readiness of manufacturing enterprises to Implement the circular economy

In the results obtained, it was observed that social pressures and the expectations of external stakeholders play a significant role in only a few aspects of exerting pressure on manufacturing companies regarding the introduction of circular economy principles in the organization. The average number of ratings for statements assigned to the group of these factors fluctuates between 3.26 and 4.01. Ratings characterized by high variability and significant discriminator power concern two following areas: the role of regulatory institutions and the need for CE principles adaptation. The role of regulatory institutions, which insist on compliance with stringent waste management rules, was emphasized. The overall average was 3.84, with small and medium-sized companies rating this question at 3.92, and large companies at 3.69. Considering the urgent need for companies to adapt to CE principles due to pressures from outside the organization, the average response was 3.27, with small and medium-sized companies scoring significantly lower at 3.18, compared to large companies at 3.44. The distribution of responses on this subject is highly varied among both groups of respondents, which precludes drawing definitive conclusions regarding the importance of this factor's pressure on the company. Analyzing results that are characterized by low variability and low discriminator power, of significant importance for companies, revealed that the market exerts pressure on manufacturers to produce cheaply while minimizing environmental impact. The overall average rating for the question measuring this aspect was 4.01. When separating small and medium-sized and large companies, scores of 4.03 and 3.97, respectively, were

obtained. It was also found that customers and consumers are interested in the environment and willing to make positive changes in their behaviors or business practices. The overall average for this question was 3.62, with both small and medium-sized, as well as large companies, rating it at 3.62 and 3.63, respectively. It was recognized that financial institutions are increasingly demanding that companies consider environmental parameters, with an overall average of 3.78. Small and medium-sized companies gave a response of 3.76, while large companies rated it slightly higher at 3.82. Evenly distributed responses across the scale concerned buyers' readiness to pay higher prices for ecological products and society's demand for the implementation of CE. The overall average response for the question regarding buyers' willingness to pay higher prices for ecological products was 3.24, with small and medium-sized firms at 3.20, and large firms at 3.32. Respondents indicated that society demands the introduction of CE with an overall average of 3.49. Small and medium-sized companies gave this aspect slightly more importance with a score of 3.54 compared to large companies, which responded with 3.41.

The analysis of the study results in the context of raw material availability and external support shows that the responses to the presented questions are mixed and oscillate around the answer "no opinion," indicating variable perceptions in the context of the following aspects. The average number of ratings for statements assigned to the group of these factors ranges between 3.01 and 3.58. It should be emphasized that the results in this area are characterized by relatively higher variability and discriminative power. Regarding the availability of grants and tax benefits for the implementation of CE practices, the overall average response was 3.01. The distinction in responses between small and medium-sized enterprises and large companies is noticeable, where SMEs scored 2.89 and large companies 3.24, suggesting weaker support and/or lack of awareness of government support among smaller enterprises. The availability of recycled materials compared to primary raw materials received an overall average response of 3.29. Although the results for small and medium-sized enterprises (3.23) and large firms (3.41) are not significantly different, they indicate a moderate perception of the financial benefits resulting from the availability of secondary raw materials. In terms of financial incentives in promoting CE, entrepreneurs and managers rated it on average at 3.23, with subtly lower ratings from small and medium-sized enterprises at 3.17 compared to larger companies at 3.35, which again may suggest differences in access to or awareness of available financial incentives. Meanwhile, regarding the financial attractiveness of CE and related activities, the highest average response was 3.58. Here, it is clear that both SMEs (3.53) and large enterprises (3.68) recognize certain financial factors that make CE-related activities attractive.

The analysis of results in the context of attitudes and perceptions towards sustainable development allows for an understanding of how manufacturing enterprises perceive the significance and benefits of implementing CE principles within their operations. The average number of ratings for statements attributed to this group of factors ranges between 3.34 and 4.07. The profitability of CE as determined by respondents is deemed significant,

with an overall average response of 3.72. The difference between small and medium-sized enterprises (3.73) and large companies (3.69) is marginal, suggesting a similar perception of CE profitability in both groups. The responses in this aspect are characterized by low variability. Ecological awareness in terms of the organization's evaluation of product and production process obtained an average response of 3.97. It is interesting to note that both small and medium-sized as well as large companies expressed very similar opinions in this aspect. Considering the focus on reducing the consumption of primary raw materials and the emphasis on recycling, the overall average response was 4.07, indicating that the majority of respondents 'strongly agree' with the statement relating to the reduction of primary raw materials and orientation towards recycling. Small and medium-sized enterprises showed a greater tendency towards this approach (4.13) compared to large companies (3.94), which indicates a significant discrimination between small and large firms. In the axiological aspect, owners and managers of companies declare that their organization is environmentally oriented. This means that they value the natural environment and take into account environmental responsibility in their actions. In this aspect, an overall average response of 3.98 was obtained. The differences between small and medium-sized (3.99) and large firms were minimal (3.96). In the aspect of promoting product design in such a way that they are suitable for reuse and recycling, the overall average response was 3.76. Most respondents 'agree' with this statement, and both small and medium-sized as well as large companies have similar opinions on this subject, each obtaining an average response of around 3.76. Encouragement to implement a recycling system for used and defective products received an average response of 3.88. The results suggest that the majority of respondents "agree" with this statement, with larger companies showing slightly more inclination towards this approach (3.97) compared to small and medium-sized enterprises (3.84). In the aspect of recognizing the gap between what an organization is currently doing and what it could and should do in the field of circular economy, the average response was 3.34. Larger firms, with a response of 3.48, indicate slightly greater concerns regarding the mismatch of organizational actions to environmental capabilities and needs, while SMEs with a score of 3.26 seem more confident that they do not have such a gap. Considering the distribution of responses, only 7% of large companies and 3% of SMEs are certain of the absence of a gap, while 12% of large companies and 9% of SMEs are definitely convinced of the existence of discrepancies in this aspect. Taking into account external pressures for sustainable development in today's world, changes to embrace a circular economy are the right response for organizations, which received an average response of 3.73. Here, large firms (3.99) show a clearly positive attitude towards this statement, in contrast to smaller firms (3.59). In terms of awareness and the level of preparedness for CE activities, respondents' answers hover around an average of 3.71, with minimal differences between small (3.70) and large firms (3.72). Generally, organizations will acquire funds and also invest significantly to build operations around CE principles. The average response regarding this statement was 3.56. The distinction in responses between SMEs (3.50) and large firms (3.68) indicates a slightly greater willingness

of large firms to invest in this issue. Considering the distribution of responses, a comparable number of large enterprises (58%) and SMEs (56%) will be acquiring funds to build operations around the circular economy. Significant differences between these groups emerge in terms of the definite lack of participation in this aspect, with 5% of owners and managers of large firms declaring that they are unlikely or definitely will not undertake such actions, while in the group of SMEs this number rises to 20%. Considering the need to improve actions in terms of sustainable development, an average response of 3.70 was obtained. With a slight difference between SMEs (3.64) and large firms (3.80), this indicates that overall organizations are aware of the need for changes in sustainable development through the implementation of organizational changes in favor of the circular economy. Analyzing the distribution of responses, a significant portion of entrepreneurs declare that they must take action in this aspect, with 70% of large and 66% of SMEs of this opinion. The belief that changing actions towards a circular economy will improve organizational outcomes received an average response of 3.62, with minimal differences between small (3.60) and large firms (3.66). In summary, responses to questions about attitudes and perceptions towards sustainable development fall into the category "the majority of respondents agree," with the exception of recognizing the gap between current and expected actions, which falls into the category "no opinion." Large companies seem to be slightly more certain and positive in their approach to CE than SMEs, although these differences are not distinctly marked, excluding the focus on reducing the consumption of primary resources and emphasis on recycling, here there is a significant difference between large and small and medium-sized companies.

Based on responses regarding the assessment of the internal potential of organizations to implement the circular economy, we can assert that answers in this area range between 3.29 and 3.96. In terms of technological capacity, the overall average score indicates that respondents agree with the statement that their company has the technological capability to implement circular economy practices (3.61). The analysis highlights slight differences in responses, with small and medium enterprises hovering around a value of 3.63, and large firms scoring 3.58. With such close results, the variability of responses is low, and the power of discrimination is limited. The financial ability to implement sustainable waste management practices has been estimated at an average of 3.75. Here, the differences shown between small and medium enterprises (3.67) and large firms (3.90) suggest greater variability and a significant power of discrimination among responses. Considering the distribution of responses, a similar number of respondents declare the capability, with 72% among large firms and 68% among SMEs; a significant difference between these groups exists in the area of lack of financial capacity, where 8% of large firms declare it, compared to 15% of SMEs. Employee preparedness for recycling activities is rated relatively high, with an overall average of 3.96, with SMEs rated slightly higher (4.01) than large firms (3.86). In the context of infrastructure supporting CE practices, the average response is at 3.57. Responses are relatively uniform across different types of firms (SMEs: 3.54, large: 3.61). Conversely, the issue of increasing the share of reused

or recycled/renewable materials obtains an overall average of 3.79, with SMEs (3.77) and large firms (3.83) yielding quite close results, with little variability. In the aspect of the organization's impact on increasing demand for products by lowering production costs and minimizing their environmental impact throughout the lifecycle, it shows an average of 3.66. In this case, the difference between SMEs (3.75) and large firms (3.49) indicates greater variability of responses and potentially a higher power of discrimination. Considering the distribution of responses, 58% of large companies and 66% of small and medium-sized enterprises declare an influence, while 18% of respondents from large companies claim that as an organization they have no impact on the increase in demand, and similarly, 10% of SMEs share this opinion. Analyzing the respondents' answers, it has been shown that the average rating for the statement "We have an adequate number of qualified people in the field of environmental management" is 3.65. Comparative analysis between SMEs and large enterprises reveals slight differences, at 3.69 and 3.58 respectively. In the case of the capacity of information technology and information systems to support the transition to a circular economy, the overall average is 3.54, suggesting that respondents generally agree with this statement. Here too, the value for SMEs is slightly higher (3.60) compared to large enterprises (3.44). As for the availability of capital for investments in business models and activities related to CE, the average response (3.53) suggests agreement with this statement, whereas SMEs show less readiness (3.44) compared to large companies (3.69). Considering the distribution of responses, among SMEs 57% declare that they have the funds, and 23% indicate a lack of capital, while 65% of large companies declare capital availability, and 12% lack thereof. Moreover, regarding the organization's possession of technical knowledge and ideas for developing new skills necessary for adapting CE practices, responses indicate general agreement, with an average of 3.62 and similar results among SMEs (3.63) and large enterprises (3.61). Responses to the statement concerning a clearly defined strategy for adapting the organization to operate in a CE also hover around agreement, with an average of 3.44. SMEs (3.45) and large enterprises (3.42) present similar perspectives in this area. In the context of having a detailed implementation plan for CE, the average response of 3.29 leans closer to the "no opinion" category, with small differences between SMEs (3.30) and large companies (3.27).

Based on responses concerning perceived behavioral control, we are able to assert that the average responses in this domain range between 3.48 and 3.76. In terms of belief in the availability of resources and the ability to manage them, with the aim of implementing circular economy principles in the organization, the overall average rating of this factor was 3.57. This indicates that the responses are mostly positive. Differences are noticeable between small and medium-sized companies (3.52) and large enterprises (3.65), where the latter demonstrate a slightly greater conviction regarding the availability of resources and capabilities to manage them. In the aspect of availability and possibilities of implementing CE from a technical perspective and utilizing available know-how, the average rating was 3.48. Both small and medium-sized firms (3.49), as well as large enterprises (3.46), exhibit similar beliefs,

which suggests that the perception of availability and capabilities of implementing CE technically and know-how is comparable and independent of the size of the company. Considering the flexibility of a company's organizational culture and its ability to adapt CE practices, the highest average rating among the presented results in this group of factors was obtained, amounting to 3.76. Such a result signals that the majority of respondents agree with the statement that the company's organizational culture is flexible and can easily implement changes adapted to circular economy practices. It is noteworthy that the distribution of responses is extremely close between small and medium-sized enterprises (3.76) and large companies (3.75), which suggests that the organizational culture and readiness to adapt in terms of CE is perceptually similar in organizations of different sizes.

In the matter of implementing best practices, manufacturing enterprises most frequently introduce cyclic analyses of waste production (48%), systems for utilizing recycled materials (47%), complete cost analyses (including environmental costs) (39%), monitoring the impact of production on the environment (36%), and the application of the ISO 14001 standard (35%). Large companies more often make use of the ISO 14001 standard as well as planning and evaluation of actions to minimize the negative impact on the environment. The differences in these two cases are substantial, with 49% of large firms conforming to the ISO 14001 Standard, whereas only 27% of small and medium-sized enterprises do. Planning and evaluation of actions to minimize the negative impact of production on the environment is declared by 39% of large firms, and among medium and small ones, 31%. However, there is also an area of practices that are rarely implemented and not planned for future implementation. Among these is the BS 8001 standard concerning the implementation of circular economy within an organization.

#### **4.4. The conclusions regarding the readiness of manufacturing enterprises to implement a circular economy**

In response to the first research question, we can assert that company owners and managers positively appraise the economic profitability of the circular economy. Regarding the size of enterprises, it has emerged that managers of larger companies are more inclined to view the circular economy as economically viable. There are several key elements contributing to these results. From an axiological perspective, the study demonstrated that owners and managers of companies, regardless of size, are environmentally oriented. This suggests that values and beliefs related to environmental protection are deeply rooted in the organizational culture of businesses. Both large and small organizations seem to recognize the financial appeal of the circular economy. This is due to the fact that practices such as recycling, reuse of raw materials, or efficient resource management can lead to cost savings. Moreover, the ability to create products with a lower environmental impact can attract more ecologically aware customers. A significant conclusion from the research is that the profitability of the CE is perceived by managers and business owners as key, both in financial terms and in terms of business sustainability.

In response to the second research question, based on the results, we can assert that managers of large enterprises (with 250 or more employees) are more likely to recognize the need for shifts towards sustainable development in response to environmental pressures. Primarily, the large scale of their operations and their market visibility mean that they more readily become prime targets of public criticism and are subject to stricter regulations. Consequently, there is a stronger motivation within these organizations to adapt to new business models based on the principles of the circular economy.

Considering the social pressure and expectations of external stakeholders, regulatory institutions play a significant role in forcing organizations to adapt and align with the principles of circular economy, particularly in terms of waste management (a factor that determines the operations of small and medium-sized enterprises more than large ones). Financial institutions, as well as society, also impact organizations, demanding the inclusion of environmental parameters by companies in the production process. Nevertheless, less than 50% of respondents agree with the statement that there is an urgent need for their organizations to adopt CE principles due to falling behind other competitive firms. This may suggest that many enterprises do not feel direct competition or market pressure to accelerate adaptation to the circular economy model. Additionally, the assertion regarding the existence of a gap between the current actions of companies and what they could and should do in terms of implementing CE principles also found agreement among less than half of the respondents. This indicates a possible underestimation by firms of the potential or benefits of full adaptation to the circular economy. As a result, the external environment, in the form of market competition or societal expectations, does not seem to be the main motivator for many enterprises to implement CE-related practices more swiftly.

In response to the third research question, which refers to the readiness to implement circular economy principles in the technological, infrastructural, financial, and staff competency contexts, we can ascertain that in enterprises of various sizes, this readiness can take different forms. In terms of employee competencies, we observe that both small and medium-sized as well as large companies report positive evaluations. According to owners and managers, employees are prepared to carry out activities in the area of recycling and waste management, which is a key element of the circular economy. In small and medium-sized enterprises, there appears to be an even stronger declaration of employee readiness to act in this area, which may be due to the smaller scale of operations and the potential for a more individualized approach. Technological and infrastructural readiness is a matter that can be assessed differently in the context of the organization's size. Large enterprises may have access to more advanced technologies and infrastructure, which facilitates the implementation of circular practices on a larger scale. On the other hand, smaller organizations may be more flexible and capable of quickly adapting to technological novelties, although they may be more limited in terms of access to certain infrastructural solutions. The financial capacity to implement changes is a point of clear divergence between large and smaller companies.



Large enterprises often have access to greater financial resources, which eases investments in new technologies, processes, and training necessary for the implementation of the circular economy. Small and medium-sized enterprises, despite potentially being more flexible and innovative, may struggle with budgetary constraints that hinder their ability to carry out more costly sustainable economic practice initiatives.

In the research, a general readiness of enterprises to adopt circular economy practices is evident, albeit with a slightly higher degree of certainty regarding the availability of capital, technological capabilities, and staff competencies. It is also noteworthy that small and medium-sized enterprises often exhibit a similar, and sometimes even higher, level of readiness compared to large companies. The clear differences in perception between small and medium-sized firms and large enterprises may serve as a starting point for further, in-depth analyses and support strategies in the process of implementing CE in the manufacturing sector.

In response to the fourth research question, we can determine that manufacturing enterprises are increasingly engaging in eco-friendly activities. The study indicates that over 80% of surveyed companies confirm the reduction in the use of primary raw materials, focusing on the reuse and recycling of resources. Equally important for them is the environmental awareness of the product and the production process. These enterprises also increasingly identify themselves as environmentally responsible, which underscores their commitment to sustainable development issues. However, there are areas that still require attention and are planned for implementation by the companies. Approximately 40% of the surveyed firms intend to conduct an internal audit in the field of the circular economy and introduce innovative technological solutions in this area. This suggests that although there is an awareness of the need for change, these processes are still in the planning phase and have not yet been fully implemented. Nevertheless, it is noteworthy that only a small number of entrepreneurs have actually introduced practices that allow for the precise determination of the use of recycled resources or monitoring the level of waste emissions. For this reason, it is necessary to increase the role of standards and certifications. The BS 8001 standard could play a key role in promoting good practices in the field of the circular economy. To accelerate this process, state institutions could simplify certification procedures and increase the availability of information about such standards, which would encourage more enterprises to implement them.

In examining the readiness of enterprises to implement a circular economy, we can identify aspects where this readiness was greatest: reducing the consumption of primary raw materials, emphasizing the reuse and recycling of resources (4.07); the market pressures to produce inexpensively while simultaneously minimizing environmental impact (4.01); the organization values the natural environment and identifies itself as environmentally responsible (3.98); the organization considers the potential environmental awareness of the product and production process in its activities (3.97). The aspects where this readiness was lowest are: the conviction of an urgent need for the organization to adopt CE principles because it is behind other similar organizations (3.27); the belief that institutional and retail buyers are willing to pay a higher

price for ecological products (3.24); the belief in the existence of financial incentives to promote the transition to a circular economy (3.23); confidence that the government provides grants and tax benefits for the implementation of circular economy practices (3.01).

To summarize, the study results indicate the existence of differences between the declarative level and the level of implementing good practices as part of a company's operations. Therefore, the government and public institutions should take advantage of the willingness to introduce a circular economy and support it by creating favorable conditions, such as increased government support, promoting the benefits of the circular economy, and encouraging cooperation between the private and public sectors which can bring about positive changes. The enactment of the aforementioned measures may contribute to accelerating the transformation towards sustainable development and a circular economy.

## 5. Summary

The study results indicated that owners and managers of manufacturing enterprises positively assess the economic viability of the circular economy, with managers of larger companies being more convinced of the benefits arising from CE. Over 80% of companies focus on reducing the consumption of primary raw materials in favor of those sourced from recycling. Managers of large firms more often recognize the need for a shift towards sustainable development, mainly due to greater market visibility. However, there is an unnoticed gap by a large number of organizations, existing between the actual actions of enterprises and what they could be doing in terms of the circular economy. A significant number of respondents declare that they have no opinion on the presence of a gap between what is done and what could be done, yet comparing this with the degree of readiness to implement CE and the level of environmentally friendly practices in the enterprise, it is evident that organizations are not utilizing their full potential with respect to the principles of CE. Interpreting the study results, it was noted that values and beliefs associated with environmental protection are deeply rooted in corporate culture. Yet the external environment, in the form of market competition or societal expectations, is not the main motivator for many companies to introduce practices related to the circular economy. Financial readiness and staff competencies vary depending on the size of the company, with larger firms often having greater resources but may be less flexible in introducing environmentally friendly practices. In small and medium-sized enterprises, owners and managers report a slightly higher readiness of their employees to act in the realm of CE, which may be due to a smaller scale of operations and the possibility of a more individualized approach than in large companies.

In practical terms, the study reveals that companies of various sizes require different types of support in the process of implementing a circular economy. Small and medium-sized enterprises more often than large ones report a lack of financial capacity to introduce pro-environmental changes in production (8% of large companies; 15% of SMEs), and their owners and managers are not aware of the existence of financial support directed to them from state institutions.

The research results can be useful for management staff in manufacturing enterprises, decision-makers, and regulators. They can serve to shape appropriate strategies and support programs to accelerate the transformation of manufacturing companies towards more sustainable business models.

The study's results present a positive view of the economic viability of the circular economy, particularly among larger companies. Owners and managers, regardless of company size, exhibit environmentally friendly beliefs, which may promote the broader implementation of circular economy practices. The financial attractiveness of such practices is evident, arising from cost savings and the appeal to more environmentally conscious customers. Larger firms, those employing from 250 people upwards, feel environmental pressures to a greater extent and recognize the need for actions towards sustainable development. Many of these organizations feel the pressure from various institutions and societal expectations, yet less than 50% of respondents see an urgent need to implement CE practices due to market competition.

The limitation of the study was primarily the use of a questionnaire as the sole research tool, which may affect the depth of analysis. In the future, it would be worthwhile to apply qualitative research, particularly interviews conducted with management staff or analysis of companies' internal documentation to, for example, estimate the extent of the use of renewable sources and recycled materials. The study is also dominated by companies in the food industry, therefore, further research on readiness should focus on individual industries or groups of industries that use similar technologies, patents, or raw materials. In light of the findings, it is worth continuing research on the readiness of companies to implement circular economy principles, taking into account the differences resulting from the size of the enterprises.

From a theoretical standpoint, the study confirms and extends existing theories regarding the implementation of sustainable practices in business, highlighting key factors influencing corporate decisions. Insight into the understanding of the dynamics and perceptions of the circular economy in various types of enterprises can support the development of models and theories related to the adaptive processes of CE principles.

There is a need for intensified educational and informational actions and support, aimed at facilitating the transition of enterprises to more sustainable business models, also taking into account the diversity of needs and perceptions of companies of various sizes and industries. The results of the study are significant not only for the academic world but also for politicians, policymakers, business owners, and managers. In a world where ecological issues are becoming increasingly important, understanding the motivations and readiness of firms to act towards sustainable development is key to the advancement of future economic and social strategies.

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## TOWARDS SUSTAINABLE URBAN MOBILITY – ACTIONS OF THE ŚLĄSKO-ZAGŁĘBIOWSKA METROPOLIS

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**Purpose:** identification of actions implemented by Śląsko-Zagłębiowska Metropolis (Metropolis GZM) aimed at sustainable mobility that ensures that the inhabitants of the cities of the agglomeration meet their needs and improve the quality of life.

**Design/methodology/approach:** The work uses a case study, observations and a method of analysis of the source materials regarding urban mobility.

**Findings:** The article presents the most important EU legal documents regulating the issues of urban mobility and Polish statutory initiatives related to it. Initiatives undertaken by the cities that are part of the Metropolis GZM are the response to the legal regulations.

**Practical implications:** The article presents examples of undertaken and planned GZM activities aimed at encouraging residents to use eco-friendly means of transport (sustainable mobility - micromobility and public transport).

**Social implications:** The actions of the cities in the Metropolis are well perceived by the inhabitants and encourage them to protect the environment. High position of the Metropolis cities in various rankings should be an incentive for further activities in the field of promoting sustainable mobility.

**Originality/value:** The article is addressed to people interested in urban mobility, especially in the context of sustainable development. It shows the complex character of the topic and the possibilities of solving related problems. It highlights the benefits that can be achieved from sustainable mobility and at the same time outlines the scope of activities for the future.

**Keywords:** urban mobility, sustainable mobility, city management, inclusiveness of transport systems.

**Category of the paper:** Research paper, Case study.

### 1. Introduction

Currently observed trends determine the directions of civilization development. Omnipresent globalization broadly understood digitalization and activities related to sustainable development and corporate social responsibility have the greatest impact on socio-economic development. These trends affect various aspects of the socio-economic life of cities

and villages and the communities inhabiting these areas, while becoming the main determinants of their development.

Cities are seeking opportunities to develop and meet their residents' expectations related to improving the quality of life. Most of the activities implemented by city authorities are aimed at ensuring that residents can meet their social needs in terms of movement (mobility). It is observed that the issue of mobility is especially important for large and medium-sized cities and their functional areas. It should be noted that cities are places of high concentration of mobility of people and goods, which contributes to growing transport problems resulting from the diverse needs and expectations of residents and entrepreneurs. Actions implemented at many levels aim to improve mobility through the development of public transport or the integration of various transport subsystems, among others. These activities are considered in the context of determinants resulting from land development, spatial distribution of various types of economic and social activity and limitations resulting from the promoted concept of sustainable development.

The paper presents the activities undertaken by the management of Śląsko-Zagłębiowska Metropolis in the field of sustainable urban mobility and the effects of these activities that translate into the positions in the Ranking of Sustainable Mobility Cities.

## **2. Urban mobility vs sustainable urban mobility**

For most cities, mobility issues cause many problems. These problems result from a two-fold understanding of mobility. Firstly, urban mobility means the freedom of movement between specific places in urban areas using the available transport network and transport services. It is possible to move using public transport and micromobility means, i.e., bicycles, scooters, walking or transport by individual cars. Each of these forms is complementary and influences the others, but the first three constitute the basis of a system that aims to encourage city residents and visitors to abandon traveling by private car. (Janczewski, Janczewska, 2021). Secondly, mobility is also a way of meeting and securing the needs and social services, work style and ways of spending free time by residents.

For city authorities, managing urban mobility is a big challenge, which is often reduced to making decisions that are difficult to accept by all interested parties. The difficulty of the decision-making lies in the occurrence of conflicting goals. On the one hand, the expectations of residents related to guaranteeing a high quality of life are formulated, while on the other - the expectations of entrepreneurs, i.e., creating attractive conditions conducive to running a business; reducing traffic in sensitive areas without restricting the necessary movement of goods and people<sup>1</sup> are established (European Commission, 2013).



Therefore, the essence of actions implemented in the field of urban mobility is to change the transport behavior of residents, consisting in reducing the demand for travels by individual transport in favor of increasing the share of journeys by public and non-motorized transport (bicycles, scooters, on foot) in accordance with the concept of sustainable development. When talking about urban mobility in relation to sustainable development, the need to integrate various means of transport and invest in more ecological (sustainable) solutions for the sake of the quality of life and the climate is highlighted. Therefore, all activities should aim at sustainable mobility.

Sustainable urban mobility refers to all forms of collective mobility - traditional public transport along with new services based on sharing, including new business models, active mobility (walking, cycling), intermodality and door-to-door mobility, road safety, urban logistics (delivery of goods, last mile), mobility management and smart transport systems (Janczewski, Janczewska, 2021). Urban policy implementing sustainable development goals, e.g., electromobility, zero-emission transport and urban logistics, and appropriately developed and adapted transport infrastructure is a prerequisite for sustainable mobility. Sustainable urban mobility should have features that enable meeting the needs of all stakeholders, considering the efficiency of the ecosystem. The most important features are shown in table 1.

**Table 1.**  
*Features of sustainable urban mobility*

<b>Features of sustainable urban mobility</b>	<b>Description</b>
Safe	Safe for all users regardless of the means of transport and method of travel/movement
Accessible	Meaning accessibility to various means of transport; aimed at eliminating white spots on the communication map of districts, cities and communes
Reliable	Reliable and ensuring that various types of services complement each other
Efficient and effective	Guaranteeing achievement of the goal regardless of the selected method and means of transport, providing alternative and satisfying solutions
Compact	Giving a sense of completeness and consistency by combining accessibility and ease of use
Ecofriendly	Mobility that supports protection of natural resources and the environment. Now, it is one of the most important values in modern societies.
Fair	Egalitarian mobility in the access to many inclusive means of transport at the user level and in the context of the division of space between the users of various forms of transport
Close	Achievable (available) and adequate to demographic factors and living conditions, i.e., keeping pace with the suburbanization process
Healthy	Promoting healthy behaviors and intermodal mobility
Seamless	Internally consistent, compact in terms of quick identification and transparent application of a uniform system of use

Source: [https://metropoliagzm.pl/wp-content/uploads/2021/07/SUMP\\_raport\\_web2.pdf](https://metropoliagzm.pl/wp-content/uploads/2021/07/SUMP_raport_web2.pdf)

Overall, the implementation of sustainable urban mobility solutions supports the scale of benefits, including:

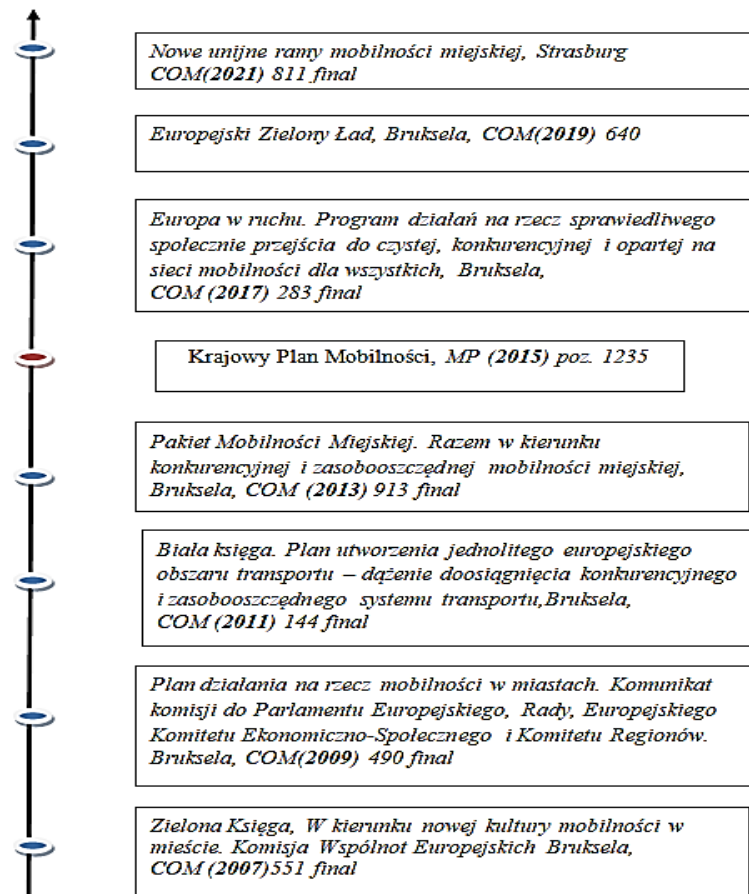
- Reducing CO<sub>2</sub> emissions and noise.
- Improving air quality.
- Encouraging the use of active means of transport benefits public health and road safety.
- Complementarity - meets the individual needs of residents in terms of mobility.
- Reducing competition for public space between different forms of transport.
- Impeding the decline in the use of public transport.
- Increasing the efficiency of public transport.
- Reducing the number of residents using private cars.
- Building improved infrastructure - bicycle paths, wider sidewalks for pedestrians and bicycles or scooters, enforcing speed limits.
- Increasing residents' awareness and their participation in the development of sustainable mobility.

The list of benefits is not exhaustive. It only shows a wide range of ecological, social and economic benefits that can be achieved.

### **3. Legal conditions of sustainable mobility**

Actions in the field of urban mobility refer to the assumptions of EU transport policy aimed at promoting sustainable transport, including sustainable mobility. This involves developing strategies that stimulate a shift to greener and more sustainable means of transport, such as walking, cycling and public transport, and adoption of new patterns of vehicle use and ownership (Communication from the Commission to the European Parliament, 2013).

Actions aimed at sustainable urban mobility have been undertaken by the EU Commission for two decades and are implemented in stages. Fig. 1 presents in chronological order the most important EU documents regulating the issues of sustainable urban mobility.



**Figure 1.** The most important EU documents regulating the issues of sustainable urban mobility.

Source: own study.

Legal regulations regarding urban mobility were initiated in 2007 by the Green Paper "Towards a new culture of urban mobility". Transport problems identified in the Green Paper (Commission Communication, 2007) include transport congestion, negative impact on the environment - air pollution, high CO<sub>2</sub> emissions, noise, energy consumption, limited accessibility, especially for the elderly, disabled people, parents with small children and road traffic safety, safety in public transport vehicles and at stops (Wołek, 2014). The "Action Plan on Urban Mobility" published in 2009 (Commission Communication, 2009) is the first document in which a comprehensive set of actions aimed at sustainable mobility in cities was presented. White Paper. The 2011 plan to create a single European transport area - striving to achieve a competitive and resource-efficient *transport system* is the next document. Attention was drawn to the main problems, including: congestion in cities as well as external costs, and at the same time recommendations to reduce the number of conventionally fueled cars to the benefit of greener ones, integrate various means of transport in cities and develop sustainable urban mobility plans for cities were formulated (Commission Communication, 2011). In 2013, the Commission adopted the Urban Mobility Package Together towards competitive and resource-efficient urban mobility. It includes recommendations on urban mobility in order to strengthen support for European cities in the face of mobility-related challenges in the sphere

of urban logistics, urban access regulations, the use of Intelligent Transport Systems solutions (ITS) and road safety (Communication from the Commission, 2013). In 2017, the communication “Europe on the move. An agenda for a socially just transition towards clean, competitive and connected mobility for all”. It includes a set of initiatives to modernize the EU's mobility and transport system Europe on the Move (Commission Communication, 2017). Two years later, in 2019, a communication proposing the introduction of the "European Green Deal" strategy aimed at achieving climate neutrality on the continent was issued (Commission Communication, 2019). The communication also mentions the pursuit of more sustainable mobility in cities. Further work enabled publication of A new EU urban mobility framework in 2021. They include recommendations for implementing actions to move towards a safe, accessible, inclusive, smart, resilient and zero-emission urban mobility which requires a clear focus on active, collective and shared mobility based on low-emission and zero-emission solutions (Commission Communication, 2021).

The initiatives on urban mobility implemented in Poland are consistent with the recommendations of the European Union. Thus, in 2015, a key document in this regard, entitled National Urban Policy 2023 was published (KPK 2023, 2015). The document presented the main objectives, including:

- Polish cities in 2023 should be efficient, compact and balanced, coherent, competitive and strong.
- support for the sustainable development of urban centers, including counteracting the negative phenomena of uncontrolled suburbanization (compact and sustainable city).
- achievement of sustainable mobility in the functional area of the city, perceived as making trips in such a number and of such length as is required to meet the living needs of travelers with the rational use of individual urban transport subsystems.

The original document of the National Urban Policy 2023 was updated, and the time horizon was extended to 2030 - *KPM 2030*. The outline of the National Urban Policy 2030 included five essential goals, such as: building cities accessible and friendly to all residents, increasing the competitiveness and economic attractiveness of cities, adaptation of cities to climate change and increasing the use of nature-based solutions, digital technologies and counteracting the negative effects of suburbanization as well as reusing space in cities (National Urban Policy - We invite cities to the debate, 2021).

Despite emerging difficulties in implementing the KPM 2023 goals, all cities are confronting the related challenges.

#### **4. Identification of the Metropolis' activities in the field of sustainable mobility (<https://www.metropoliaztm.pl/>)**

Since its establishment in 2018, the Górnośląsko-Zagłębiowska Metropolis (GZM) has implemented activities in the field of sustainable mobility, promoting all "green" solutions that have a positive impact on the environment and do not pollute the air. In this context, it is particularly important for the Metropolis to have ecological and integrated transport. As a result, the Metropolis has undertaken a number of actions aimed at integrating transport in all 41 communes that constitute the GZM and guaranteeing sustainable mobility for its residents.

The establishment of the ZTM [Metropolitan Transport Plant], covering the bus, tram and trolleybus transport subsystems was the first step towards the integration of transport systems. Now, the fleet of 1,352 buses, 303 trams and 25 trolleybuses operate under the ZTM [*Metropolitan Transport Plant*] banner, which is gradually being replaced with more modern and environmentally friendly one. This means that in 2022, ZTM had 87 ecological and low-emission vehicles. In June 2023, 32 modern electric buses were delivered to four metropolitan PKMs [*Municipal Transport Companies*], i.e., Katowice, Sosnowiec, Gliwice and Świerklaniec. In the near future (2024), the Metropolis also plans to purchase up to 30 hydrogen-powered buses (20 as part of the principal contract and another maximum of 10 as part of the option right). The vehicles are to be delivered to PKM [Municipal Transport Companies] in Tychy, Katowice and Świerklaniec. In addition, 16 mobile chargers which can be used by two buses at a time will be activated, as well as 11 fast stationary pantograph chargers will be installed in six cities of the Metropolis, including Będzin, Gliwice, Katowice, Mikołów, Sosnowiec and Tarnowskie Góry. Thanks to the investments in public transport vehicles, the fleet of ecological, low-emission buses in GZM [Górnośląsko-Zagłębiowska Metropolis] will increase.

Using ecological public transport fleet to improve travel between the communes of the Metropolis, ZTM [Metropolitan Transport Plant] has introduced additional bus connections as an alternative to motorized private transport. They are called metropolitan lines (or metrolines) and run between all GZM [Górnośląsko-Zagłębiowska Metropolis] communes. Metrolines are marked with the letter "M" and are characterized by increased frequency and extended operating hours, also at night. So far, 27 metrolines have been created, and ultimately 32 metrolines are to be started. Figure 2 shows the current list of metrolines.

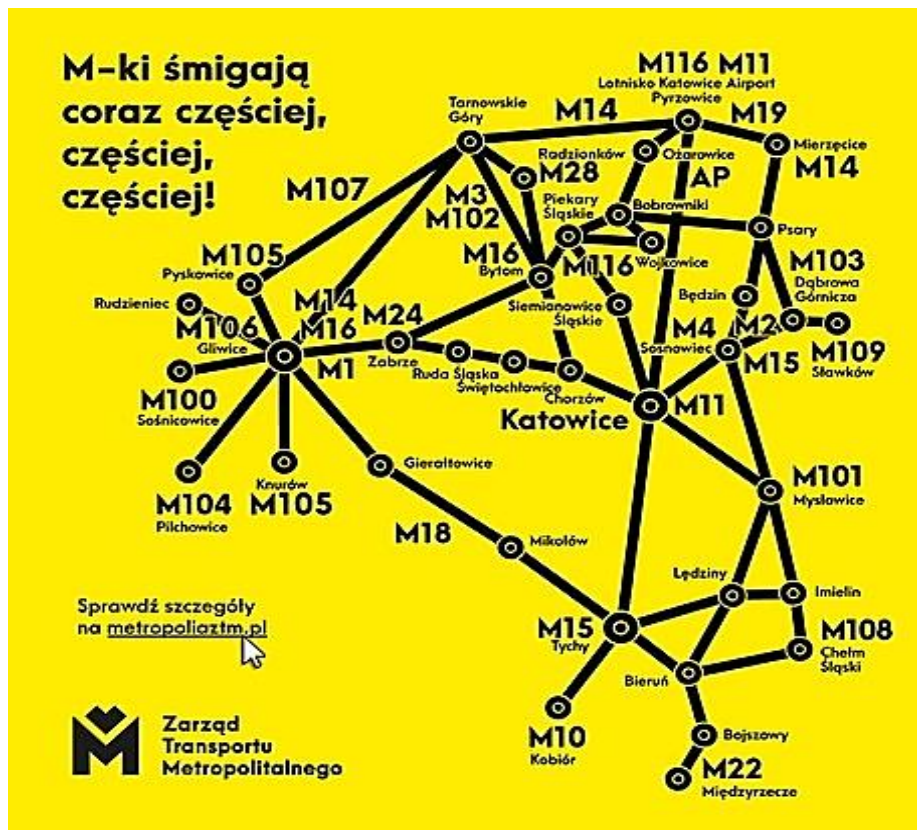


Figure 2. List of metropolitan line routes.

Source: <https://www.metropoliatm.pl/pl/s/linie-metropolitalne>, July 29, 2023.

Sustainable urban mobility is not only public transport, but it is also individual transport. These are technologies perceived as "green solutions in transport". Following the global trend towards ecological transport, the Metropolis takes actions encouraging business entities and individuals to use electric cars. More and more electric vehicles are seen on the roads. This is the result of investments made by GZM [Górnośląsko-Zagłębiowska Metropolis] in creating infrastructure for charging this type of vehicles, i.e., building a dense network of electric charging stations. In accordance with the law on electromobility and alternative fuels, the Metropolis is obliged to have electric vehicles for business purposes. Therefore, GZM [Górnośląsko-Zagłębiowska Metropolis] owns 71 electric vehicles, which were provided, among others, to city offices, city guards, greenery maintenance plants, waterworks services, sports and recreation centers, cultural institutions and social welfare institutions. The 71 vehicles include both city compact vehicles and heavy delivery vehicles. The majority, i.e., 54, are passenger cars of various segments (5 were purchased, 4 are leased and 45 are rented). The remaining 17 vehicles are delivery trucks (12 purchased, 3 rented and 2 leased). Last year, in addition to the existing network of charging points, a further 59 wallbox electric vehicle charging points i.e., those that allow you to charge an electric car at home or at work (e.g., in an underground garage) with a much higher power than from a mains socket – even up to 22 kW were purchased.

The development of rail transport in the Metropolis is one of the main demands of GZM [Górnośląsko-Zagłębiowska Metropolis] in the field of sustainable mobility. It is assumed that in the future, rail transport will be the backbone of public transport in the Metropolis area. For this to happen, the creation of the Metropolitan Railway is necessary. The activities of the Metropolis are currently at the concept stage that assumes that the construction of the Metropolitan Railway will take place in four stages:

- stage 0 assumes co-financing of the existing infrastructure, increasing railway connections, purchasing new rolling stock and establishing two main transport corridors: west-east (Gliwice-Katowice-Dąbrowa Górnicza) and south-north (Tychy-Katowice-Tarnowskie Góry).
- stage 1 is based on the construction of approximately 220 km of new dedicated tracks from Gliwice to Dąbrowa Górnicza and from Nowy Bieruń to Tarnowskie Góry, which would not interfere with trains of other carriers. Additionally, the plan includes the purchase of 33 trains and the construction of 26 additional railway stops, the number of which in a given area depends on the population density.
- stage 2, in addition to traditional railways, includes the creation of light urban railway and monorail. The north-south route from stage 1 will be extended to Pyskowice. Residents could travel by city rail on the Gliwice - Ruda Śląska - Mikołów - Tychy route. The monorail will be created for faster transport between the International Airport in Pyrzowice, Katowice and Sosnowiec.
- stage 3 includes the maximum expansion of rail transport in the Metropolis and light urban railway from Gliwice through Knurów, Gierałtowice to Ornontowice and Orzesze.

The implementation of a bicycle policy including the so-called urban bicycle system, the so-called Metropolitan bike and bicycle infrastructure is another activity of GZM [Górnośląsko-Zagłębiowska Metropolis] in the field of promoting sustainable urban mobility aimed at micromobility. The aim of the Metropolitan bike is to improve the quality of life of residents who gain wide access to a healthy and ecological means of transport. At the beginning, the urban bike system in Katowice operated as a classic bike rental that allowed the use of a bike only within a given commune/city, which made the use of this form of transport much more difficult. In the following years, city bike systems were created in Sosnowiec, Siemianowice Śląskie, Tychy, Gliwice, Chorzów and Czeladź communes, with the possibility of returning the bike in the rentals in another city.

In August 2023, the procedure for launching the Metropolitan Bike system was completed. 7000 bicycles and 924 bicycle rental stations are available to users. They are in 31 communes that are part of GZM [Górnośląsko-Zagłębiowska Metropolis]. They are 4th generation bikes. Renting them and leaving them at the station does not involve plugging them in and unplugging them from the rack. Each bike is equipped with a GPS transmitter. Due to the scale of the operation resulting from a large area and a large number of bicycles, the system will be

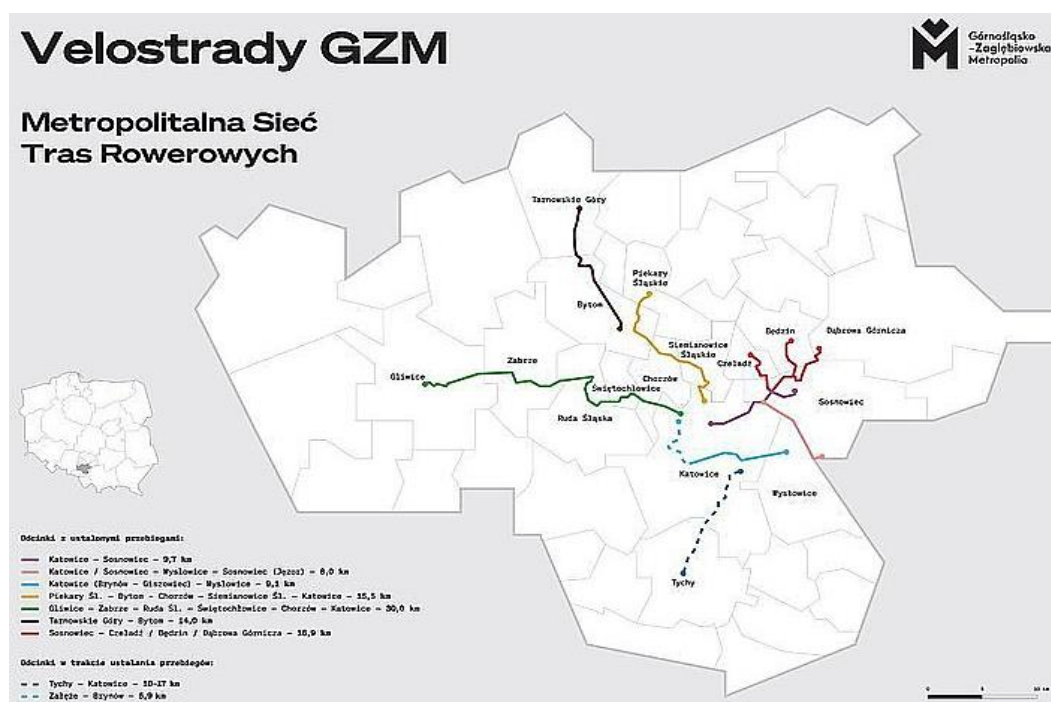
implemented in stages. In the first phase, 1,260 bicycles will be made available in 7 cities where similar systems are currently operating, i.e., Katowice, Sosnowiec, Gliwice, Zabrze, Tychy, Czeladź and Siemianowice Śląskie. In the second phase, started within 12 months from signing the contract, the number of bicycles will increase to almost 4,800. Bicycles will then appear in other cities: Bytom, Ruda Śląska, Dąbrowa Górnicza, Chorzów, Mysłowice, Piekary Śląskie and Świętochłowice. In the last, third phase of the system implementation, the number of bicycles will reach the target of 7,000. Within 22 months from signing the contract, bicycles will appear in the remaining cities and communes that joined the project: Będzin, Bieruń, Chełm Śląski, Gierałtowice, Knurów, Łaziska Górne, Mikołów, Pyskowice, Radzionków, Rudziniec, Siewierz, Sławków, Świerklaniec, Tarnowskie Mountains, Wojkowice, Wry and Zbrostawice.

The final stage of integration will be the creation of the Metropolitan Public Bicycle Rental System (MSWRP) in GZM [Górnośląsko-Zagłębiowska Metropolis]. The new system will enable the use of bicycles in each commune using one application and for the same rate. Additionally, long-term rent of bicycles with electric support, the so-called e-bikes will be possible.

In terms of bicycle infrastructure, two documents have been developed. The first of them, "Study of the bicycle route system", is the development of a "skeleton" of bicycle routes in the Metropolis. Based on it, a network of paths that will enable comfortable and safe travel by bicycle in the GZM [Górnośląsko-Zagłębiowska Metropolis] is to be created. "Standards and guidelines for shaping bicycle infrastructure" is the other document. It contains guidelines that will allow for the unification of bicycle routes in the communes and cities of the Metropolis. Based on the above-mentioned documents, the Metropolis has plans to create 940 stations located on average every 350-400 meters with over 8000 bicycles available all year round, and an additional eight velostrades (Fig. 3), i.e., fast bicycle paths separated from car traffic, 120 km long running through 11 cities and communes.

The possibility of using electric scooters is an alternative in the field of micromobility. They appeared in GZM in 2019 along with dynamic development of urban electric scooters in Poland and Europe. Currently, there are 5 operators in the Metropolis, including 3 foreign operators, i.e., Lime, Bolt, Tier, and 2 Polish operators, i.e., Roler and Blinker.city., but their operation is now limited only to the cities of the Metropolis. It is observed that this means of transport is very popular, especially among the young generation - it is easy to equip and return (stationless system), however, many city residents notice problems related to it, which result from the lack of regulations on the use of this method of transport. The main problem was solved in 2021 by amending the Road Traffic Law, introducing the status of an electric scooter (definition of a scooter, technical requirements, user, speed limit and parking method).





**Figure 3.** Velostrades GZM. Metropolitan Network of Bicycle Routes.

Source: <https://:metropoliagzm.pl>> tag> velostrada

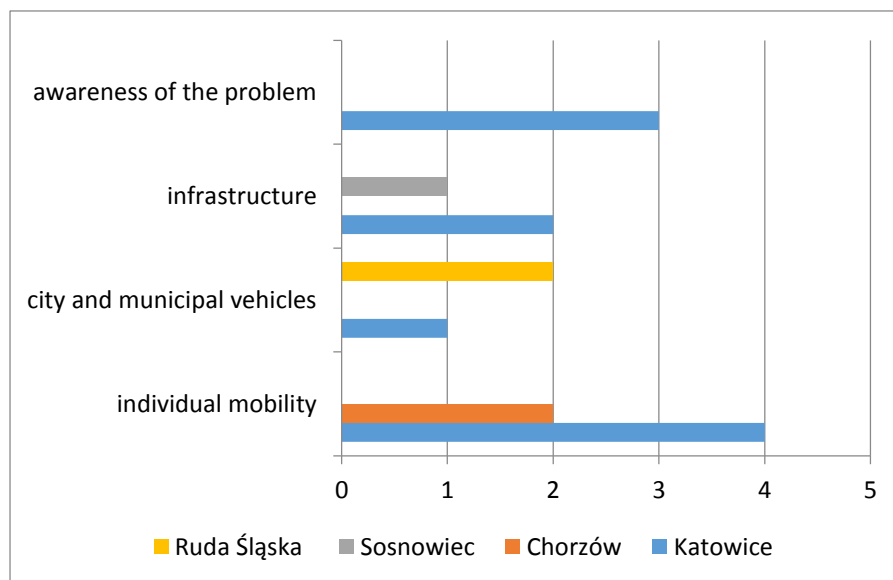
## 5. Results of activities - Ranking of cities

In accordance with the adopted mobility plan, the GZM [Górnśląsko-Zagłębiowska Metropolis] implements the basic goals of sustainable development. It is difficult to assess clearly and objectively the achievements of the Metropolis in the field of sustainable development, because due to the structure of the GZM [Górnśląsko-Zagłębiowska Metropolis], the final assessment covers the activities of all the cities that are part of the metropolis. In addition, the overall assessment is affected by other factors that characterize each commune and city separately, e.g., the level of economic development, the number of residents and preferences of the population, transport infrastructure, the amount of financing and the implemented commune/city mobility policy.

So, what is the assessment of the activities of the Metropolis in the field of sustainable urban mobility? The cities of GZM [Górnśląsko-Zagłębiowska Metropolis] make numerous efforts to promote ecological means of transport and encourage residents to use them. These actions require many changes in the mentality of residents and large financial investments in digitalization and in building transport infrastructure. Despite numerous difficulties related to sustainable urban mobility, the results of the actions implemented so far should be assessed positively. This is also confirmed by the results of research published in the Sustainable Mobility Cities Report 2023 (Piznal, 2023). All cities participating in the study

were assessed in 5 categories, including individual mobility, city and municipal vehicles, infrastructure, awareness of the problem - clean air, public transport as well as regulations and policies.

Among the 8 cities of the Metropolis participating in the study, some of them can boast of being leaders of sustainable mobility cities 2023 (Fig. 4). They include Katowice, Sosnowiec, Chorzów and Ruda Śląska. Warsaw, Wrocław, Gdańsk, Opole and Kraków are other cities high in the ranking.



**Figure 4.** Ranking of the cities of the Metropolis – leaders.

Source: own study based on Piznal, 2023.

The third place of Katowice in the "problem awareness" category was influenced by social campaigns promoting the use of available forms of micromobility, encouraging residents to use public transport, informing and making residents aware of the negative impact of pollution from transport. Katowice are also distinguished by a well-developed system for monitoring air quality and reporting pollution concentrations, installed on the initiative of the local government. In the case of other cities in the agglomeration, the occupied places are the result of the lack of GIOŚ [Chief Inspectorate for Environmental Protection] measurement stations.

The high result of the two cities of the agglomeration, Chorzów and Katowice, was influenced by the well-developed bicycle paths. In the case of Chorzów, taking second place was possible thanks to the availability of a large number of bicycles - 4.6 bicycles per 1 thousand residents. Katowice owes its fourth place to the fastest expansion of bicycle paths in 2020-2021 (their length increased by over 55 km during this period). The total length of DDR [*bicycle roads*] in the city was 111 km per 100 km<sup>2</sup>, which was above the average in this subcategory. In addition, the services of e-scooter operators with whom the city hall has concluded agreements regulating their operation can be used in the city. However, Katowice offers few public bicycles per 1000 people and does not have developed covered bike-parks (Piznal, 2023).

In the "city and municipal vehicles" category, Katowice had the highest percentage of zero-emission vehicles in municipal vehicle fleets - in 2022 it was 43% – and the largest increase in this percentage compared to 2021 – by 19 percentage points. The capital of the metropolis was also distinguished by the high share of electric cars in the fleet of the city hall (25%). The second place was occupied by Ruda Śląska, which also had a high percentage of zero-emission vehicles in the official fleet (22%) and in the fleet of municipal services (almost 29%), e.g., the city guard (Piznal, 2023). Activities in this area may contribute to the interest and persuasion of residents to purchase zero-emission vehicles, especially because the infrastructure enabling charging of electric cars is being built.

Sosnowiec realized that, because it has the second (after Olsztyn) densest network of public charging points for electric vehicles (103 points per 100 square kilometers of the city's area). Katowice has had a well-developed network of charging points for several years (Piznal, 2023).

Referring to the previously presented discussion on the general activities of the Metropolis, it can be concluded that the efforts of cities in implementing sustainable mobility initiatives translate into the achieved results (Table 2). Although the cities of the Metropolis occupy distant places in the "public transport" category (second and third ten), on a daily basis the inhabitants notice the efforts of their cities, e.g., bus connections, the so-called *Metrolinie* or *metrobilet* [metrotickets] that integrates all means of public transport in the Metropolis, including buses, trams, trolleybuses and Silesian Railways trains.

**Table 2.**

*Results of the cities of the GZM Metropolis*

City	Individual mobility	Public transport	City vehicle	Infrastructure	Regulations and policies	Problem awareness	Result
Katowice	38.73 (4)	21.47 (14)	42.38 (1)	65.26 (2)	49.55 (16)	83.14 (3)	50.08
Sosnowiec	25.77 (13)	22.48 (13)	7.57 (23)	81.19 (1)	27.94 (32)	40.00 (30)	34.16
Gliwice	17.38 (27)	10.24 (30)	6.12 (25)	3.57 (34)	31.08 (30)	50.00 (20)	19.73
Zabrze	12.49 (34)	18.75 (19)	3.55 (29)	4.99 (31)	37.51 (26)	31.18 (32)	18.08
Bytom	20.27 (23)	15.61 (24)	0.0 (34)	3.67 (33)	28.11 (31)	30.00 (33)	16.27
Ruda Śl	16.67 (28)	12.85 (28)	33.18 (2)	0.65 (36)	31.19 (29)	30.00 (33)	20.76
Tychy	19.42 (26)	17.91 (20)	17.24 (10)	40.20 (14)	50.70 (13)	10.00 (36)	26.91
Dąbrowa Górnicza	8.74 (35)	9.53 (32)	0.00 (34)	0.00 (37)	8.33 (37)	40.59 (29)	11.20
Chorzów	46.19 (2)	13.08 (27)	0.89 (33)	9.52 (28)	12.02 (36)	10.00 (36)	15.28

The places that cities obtained in the ranking in each category are placed in brackets.

Source: own study based on Piznal, 2023.

We can therefore congratulate the Metropolis and individual GZM cities on their positions in the ranking showing the effects of activities for sustainable mobility and encourage them to continue fruitful activities.

## 6. Conclusions

Urban mobility involves many problems, which is why activities in the field of sustainable urban development, including mobility, are nowadays implemented in many directions. The European Union is undertaking a number of legislative works aimed at determining current directions of action to adapt sustainable urban mobility activities to society's expectations. Through specific sustainable mobility policies, cities make numerous efforts in this sphere.

In the case of the Śląsko-Zagłębiowskie Metropolis, this is an extremely difficult task, because the metropolis is unique due to its composition (it includes 41 communes). The cities and communes that form the Metropolis simultaneously implement the GZM policy and their own sustainable mobility policy. The possibilities of its implementation vary depending on the economic level, the condition of transport infrastructure and the possibilities of financing activities improving urban mobility towards sustainable mobility, while simultaneously improving the quality of life and encouraging society to act in pro-ecological way.

According to the authors, the Metropolis will continue to undertake numerous activities aimed at encouraging residents to be more active in the field of sustainable mobility. Observing the activities in this area, it can be seen that not all actions implemented by the Metropolis are enthusiastically received by its residents, e.g. introduction of clean transport zones (SCT), or paid parking zones in cities. The challenge for the Metropolis is the need for further promotional activities e.g. encouraging the use of transfers centers or public transport, that will change the attitudes of residents and increase the attractiveness of sustainable urban mobility.

Analyzing GZM's activities in the field of sustainable urban mobility, it appears that the implemented actions bring positive results. Certainly, this is related to further investments in this area, but the high positions of metropolitan cities in the ranking of sustainable mobility cities may be a factor motivating further activity.

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## ERP IMPLEMENTATION AND PROJECT SUCCESS

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**Purpose:** The purpose of this paper is to evaluate the impact of the implementation of an ERP system on the success of projects in a selected company operating in the mechanical engineering industry. Here, project success is referred to both the fulfilment of the constraint triangle criteria and the satisfaction of stakeholders - customers and project team members.

**Design/methodology/approach:** The research was carried out using desk research and 2 survey questionnaires addressed to different groups of respondents: project team members and clients. The desk research study analysed 96 projects carried out by the company, while 34 clients and 32 project team members took part in the survey.

**Findings:** According to the research, the implementation of the ERP system significantly influenced the triangle of constraints and the fulfilment of the two success criteria considered most important in the analysed entity, i.e. compliance with the budget and the project schedule. Moreover, it was found that customer satisfaction with the products and services offered by the selected company increased under the implementation of the system, and project team members themselves considered that the system allowed them to improve their work in projects.

**Originality/value:** The paper presents an assessment of project success from the perspective of the implementation of an ERP system into company operations, including project activities.

**Keywords:** project success, project triangle, ERP system, project teams.

**Category of the paper:** research paper, case study.

### 1. Introduction

Today's business environment, which is characterised by dynamic change and competitiveness, especially for companies in the industrial sector, means that they must constantly strive to improve their processes and increase the efficiency of their operations. This enables them to offer attractive prices to customers and shorter lead times for projects. One of the key actions in this respect is also the implementation of an ERP system. In fact, it can be said that ERP systems are currently the bare minimum for companies wishing

to computerise and automate their business processes (Fajfer, 2011). And what's more, the development of software implemented in a company has a pretty good impact on the company (Supriyono and Sutiah 2020). For this reason, a strong trend can be observed nowadays, whereby more and more companies decide to implement this type of system.

An enterprise resource planning (ERP) systems is an information systems (IS) that simultaneously integrates and supports multiple areas of business operations, including planning, sales, production (Jessup, Valacich, 2006) or project execution. These systems integrate business functions into unified platforms for automation and analysis (Kunduru, 2023), making it possible to collect and store data from different departments and locations through a standardized user interface (Al-Okaily et al., 2023; Ouiddad et al., 2020; Al-Jabri, 2015).

The implementation of an ERP system is a very complex process, as many factors, both internal and external, influence the implementation (Ahmad, Pinedo-Cuenca, 2013). An enterprise system like an ERP usually requires several years of implementation and post-implementation before becoming part of the company (Al-Mashari et al., 2003). An ERP system supports tactical movements and strategic direction in enterprises, but its implementation requires management and implementers to have a broad understanding of ERP architecture and the specific components that may be required for each business need (Amini, Abukari, 2020). An effectively incorporated ERP system can improve operational efficiency by backing up a firm's business processes and gain competitive advantages by allowing innovative practices (Al-Mashari et al., 2003).

Indeed, the adoption of ERP systems has become a global phenomenon. The ERP systems market grew at a rate of 14% in 2004, reaching a global value of \$23.6 billion (Chen et al., 2009). What's more, according to the Panorama Consulting Group's 2022 report, more than 80% of companies surveyed met their return on investment expectations for an ERP system (Panorama Consulting Group 2022). It is therefore worth considering what impact the implementation of an ERP system will have on the success of projects implemented in enterprises. Therefore, the aim of the paper was to assess the impact of the implementation of an ERP system on the success of projects carried out in the surveyed enterprises. The research was conducted using the desk research method comparing the results of projects before and after the implementation of the ERP class system in the period 2020-2023 and using 2 survey questionnaires. The survey was addressed to different groups of respondents: project team members and customers. In the case of project team members, the impact of the ERP implementation on their work in the project team was analysed, while with regard to customers, their satisfaction with the cooperation with the surveyed company in the implementation of individual projects was investigated.



The paper is organised as follows. The first part describes ERP class systems and its implementation process. The second part describes the project success and its criteria. Chapter 3 describes the methodology of empirical research. The results are presented in Chapter 4, and the Discussion in Chapter 5. The summary includes theoretical and practical implications.

## **2. Theoretical background**

### **Definition and implementation of ERP systems**

In order to understand the essence of ERP systems, it is worth quoting the various definitions of the concept proposed by theorists and practitioners. Davenport (2002) defines an ERP system as "a commercial software package that enables the integration of all information flowing through an enterprise related to finance, accounting, human resources, supply chain and customers". Deloitte, in its report 'ERP's Second Wave', defines this tool as "a business software package that enables an enterprise to: automate and integrate most of its business processes, share data and operating procedures across the enterprise, produce information and access it in real time" (Deloitte Consulting, 1998). This definition is strongly linked to the concept of information and also to the set of information characteristics necessary to manage it effectively. In contrast, Klaus et al. (2000) describe ERP as "a software package for integrating all business functions and processes of an enterprise and providing a homogeneous information and computer architecture for managing the entire company". What emerges here is an acknowledgement of the importance of ERP systems as those capable of supporting the management of the entire enterprise. Kale (2001), when defining this term, uses the term "a ready- to-implement integrated set of modules (applications) supporting all business functions of the enterprise and having the possibility of dynamic configuration. It enables enterprises to process real-time data in an integrated, process-oriented and information-driven environment". In turn, Ahmadzadehet al. (2021) and Tavana et al. (2020) pointed out that ERP facilitates the production of various tangible and intangible benefits via the integration of best business practices, leading to improvements in productivity and production of profit.

Due to the continuous evolution of IT management systems, the increasing number of options available both in terms of the application provider and companies implementing ERP systems, and taking into account the unique needs of enterprises, it is not possible to develop step-by-step instructions for the implementation of this type of software (Nagpal et al., 2015). However, a number of frameworks and models have emerged that define how an ERP implementation should proceed. These have been defined both by authors of scientific and industry publications, software manufacturers and companies involved in the implementation of management support systems in enterprises. The models developed in the literature are presented in Table 1.

**Table 1.**  
*Models of ERP implementation stages and their authors.*

Author(s)	Steps in the implementation of ERP systems
N. Bancroft, H. Seip, A. Sprengel	<ol style="list-style-type: none"> <li>1. Focus,</li> <li>2. Creating the current image,</li> <li>3. Creating a target vision,</li> <li>4. Construction and testing,</li> <li>5. Implementation.</li> </ol>
M. Makipaa	<ol style="list-style-type: none"> <li>1. Initiative,</li> <li>2. Evaluation,</li> <li>3. Choice (solution),</li> <li>4. Modification, process re-engineering and data conversion,</li> <li>5. User training,</li> <li>6. Go-Live,</li> <li>7. Completion,</li> <li>8. Maintenance and development.</li> </ol>
A. Parr, G. Shanks	<ol style="list-style-type: none"> <li>1. Planning,</li> <li>2. Project configuration,</li> <li>3. Reengineering,</li> <li>4. Development of the project concept,</li> <li>5. Construction and testing,</li> <li>6. Implementation,</li> <li>7. Upgrading.</li> </ol>
J.W. Ross, M.R. Vitale	<ol style="list-style-type: none"> <li>1. Concept development,</li> <li>2. Implementation,</li> <li>3. Stabilisation,</li> <li>4. Continuous improvement,</li> <li>5. Transformation.</li> </ol>

Source: Nagpal et al., 2015; Seip, Sprengel, 1998; Makipaa, 2003; Parr, Shanks, 2000; Ross, Vitale 2000.

From the table above, it can be seen that the approaches proposed by the different authors differ profoundly from each other. These differences manifest themselves not only in the number and naming of the stages, but also in the order or level of detail to which the stages are reduced.

As the leading producers of IT management systems became established in the market, they began to develop their own implementation frameworks to make it easier for companies to implement their software. There are three leading methodologies for implementing ERP systems, developed successively by SAP, Oracle and Microsoft (Nagpal et al., 2015). A comparison of ERP implementation stages according to these methodologies is presented in Table 2.

**Table 2.**  
*Methodologies of ERP implementation*

Methodologies		
Accelerated SPA	Oracle Unified Method (OUM)	Microsoft Dynamics Sure Step
<b>Project preparation</b> - includes defining the project, identifying and specifying the scope of implementation, outlining the implementation strategy, laying out the implementation schedule, defining the implementation objectives, defining the steering committee and allocating resources	<b>Commencement</b> - key stage, implies a clear definition of implementation objectives by all stakeholders, setting the scope of implementation with requirements and main risk factors	<b>Diagnosis</b> - this stage includes a review of the organisation's requirements for an ERP system, an overview of the computer infrastructure, a preliminary concept for the solution is proposed, and a budget and implementation schedule are determined
<b>Creation of a business plan</b> - involves the creation of an input database for system configuration, includes requirements specification, documentation of business processes and documentation of organisational structures	<b>Development</b> - the scope developed in the previous phase is broken down into individual requirements to which solutions are selected. A system, concept is created as the basis for the construction phase	<b>Analysis</b> - the organisation and its processes are modelled and documented, specific activities are determined, work is planned, data on the organisation's business needs is collected. A gap-fit document is created, which lists the individual requirements, depending on whether they are included in the base version of the system or whether it needs to be adapted
<b>System configuration</b> - involves configuring the system to suit the needs of the organisation, according to the data that was obtained as a result of the previous phase. This phase requires complex testing	<b>Construction</b> - in this phase, the base version of the system, together with the concept, is adapted to the specified requirements and also tested. A beta version of the system is prepared for customer approval	<b>Design</b> - at this stage, it is determined how each requirement will be implemented in the target solution, the required modifications to the base system are designed and data migration templates are established
<b>Final preparation</b> - involves final testing of the system and training of end users. In this phase, a version of the software is created that will be used at the time of implementation	<b>Transition</b> - this phase, through systematic beta testing, prepares the system for final customer approval and subsequent implementation in the organisation	<b>Construction</b> - the aim of this stage is to create and test the individual functionalities defined in the previous stage, followed by the installation of the system on the organisation's infrastructure
<b>Implementation and post-implementation support</b> - in this phase, there is a full implementation of the new system and a cutover of the previously used software. The amount of support needed by users begins to gradually decrease	<b>Operation</b> - in this phase, post-implementation support is implemented and the operation of the system is gradually transferred to the resources of the organisation	<b>Commissioning</b> - at this stage, the ERP system, becomes operational in the organisation, end-user training and final testing is carried out
		<b>Operation</b> - in this phase, post-implementation support is implemented and the operation of the system is gradually transferred to the resources of the organisation

Source: own work based on (Nagpal et al., 2015; Microsoft Corporation).

As can be seen from the table above, just as in the case of the models proposed by various authors (Table 1), the number of stages and their scope differ. It should also be mentioned that, in addition to the methodologies presented above, one can also encounter methodologies developed by companies involved in the implementation of ERP systems and dedicated methodologies, where stages, processes and tools are defined individually for a given implementation.

### Project success and evaluation criteria

Definitions of project success developed in the literature and in project management standards contain many points in common. Karbownik describes project success as "the realisation within the agreed deadline and within the planned budget, with the achievement of the project objectives and with the satisfaction of the recipient regarding the quality of the project results and the degree of satisfaction of its business objectives" (Karbownik, 2017). Trocki defines project success as "the successful outcome of a project" and emphasises that, in addition to the project's compliance with the constraints triangle, the focus should also be on the needs of the customer when determining its success (Trocki, 2012). In the PMBoK standard, success is defined as a measure of the achievement of the project's benefits in relation to its objectives. It is emphasised that the end result of a project is often not known at the end of the project, but only after some time (PMBoK, 2019).

Based on the above-mentioned definitions and an analysis of other (Spalek, 2004) project management publications, the following elements of project success can be distinguished (Chauhan et al., 2011):

- **compliance with the triangle of constraints** - the project completed within the intended timeframe, within budget and met the agreed scope,
- **compliance with customer requirements** - the final product of the project meets the customer's requirements,
- **satisfaction of other stakeholders** - project stakeholders, both internal and external to the project company, are satisfied with the project and the changes brought about by its implementation.

The definition and perception of project success has evolved with the development of the project management discipline (Table 3).

**Table 3.**  
*Criteria and success factors over the decades*

	1960s-70s	1980-2000	The 21st century
<b>Criteria for success</b>	The iron triangle (time, cost, scope)	Iron triangle Customer satisfaction Benefits for the organisation End-user satisfaction Benefits for stakeholders Benefits for project staff	Iron triangle Strategic goals of the client organisation and operational success Satisfaction of end users Benefits for stakeholders Benefits for project staff Symbolic and rhetorical evaluation of success and failure criteria
<b>Success factors</b>	A cursory list	Lists and structures of critical success factors (CSF)	A more global CSF structure and symbolic and rhetorical success factors
<b>Focus area</b>	Successful project management	Success of the project and its outcome/product	Project, product, programme and portfolio success; narrative of success and failure

Source: Urbanelis, 2014; Ika, 2009.

Karbownik points out that for each project, the manager, together with the project team, should work out together a definition of project success by answering the questions (Karbownik, 2017):

- a) "what are the attributes of a successful project from the point of view of the team and what are the attributes of a successful project from the point of view of the project recipient?"
- b) are we aware of the obstacles to success, i.e. can we identify the so-called critical success factors of the project?"
- c) do all members of the project team have a full understanding of the critical success factors of the project?"

The concept of project success is complex and variable, as its definition evolves with the development of the project management field. Project stakeholders have different perceptions of success, depending on their individual project goals and expectations. It is important to define project success at the beginning of a project in order to have clear and unambiguous criteria to guide the evaluation of the outcome.

Taking into account the above considerations, the following research questions were formulated in the paper:

- RD1: How has the implementation of the ERP system affected the compliance of the implemented projects with the assumed budget and schedule?
- RD2: How did the implementation of the ERP system improve project management in the company under review?
- RD3: How has the implementation of the ERP system affected the satisfaction of project team members and the company's customers?

### **3. Methods**

In order to investigate the satisfaction of project stakeholders and to analyse the impact of the ERP system on their satisfaction, a diagnostic survey method was used and a survey questionnaire tool was applied. Two types of questionnaires were used - the first, aimed at project team members, and the second, aimed at customers of the analysed entity. A satisfaction survey of project team members was conducted among the employees of the selected company, who regularly use the ERP system implemented in the company during project implementation. As of 6 May 2023, the number of people meeting this criterion was 40. These people received an invitation to participate in the survey by email. The survey itself was prepared electronically, using the Google Forms tool. The survey used a 5-point Likert scale (from '1' to '5', where '1' meant strongly disagree and '5' meant strongly agree).

The second survey, examining customer satisfaction, was handed over by the company, either electronically or on paper, after each completed project. Depending on the language of communication with the client, the survey was transmitted in Polish or English. In the survey, customers were asked to rate eight factors influencing their level of satisfaction, i.e.: quality of products and services, proposed prices for products and services, timeliness of deliveries, terms of payment, flexibility in relation to possible changes in the project, adherence to agreements, manner of communication - ease of contact and staff competence. Customers were also given the opportunity to include additional comments regarding their cooperation with the company. The survey adopted a 3-grade rating scale (where '1' meant bad and '3' meant good).

The desk research, on the other hand, was aimed at comparing the results of projects before and after the implementation of an ERP system. Here, a quantitative document analysis technique was used, analysing project documentation and reports (financial results and project schedules) for all projects implemented by the selected company between 2020 and 2023. The research used a nomenclature specific to the automotive industry, where project durations and milestone dates are given using consecutive weeks and week numbers, according to the European week numbering system (ISO 8601).

In the course of the study, the impact of the implementation of an ERP system was assessed in terms of two aspects: (1) the financial result (margin) obtained through the implemented projects, (2) the delay of the implemented projects. The following formula was used to calculate the margin:

$$\text{Margin} = \frac{\text{Project sales price} - \text{Project implementation costs}}{\text{Project sales price}}$$

The following formula was used to calculate the percentage project delay:

$$\text{Delay} = \frac{RZ - PZ}{PZ - P}$$

where:

P – project start date,

PZ – date of planned completion of the project,

RZ – date of actual completion of the project.

The project start date was considered to be the week in which the project initiation meeting was held. The end date of the project was considered to be the week in which the signature on the final project acceptance report was obtained.

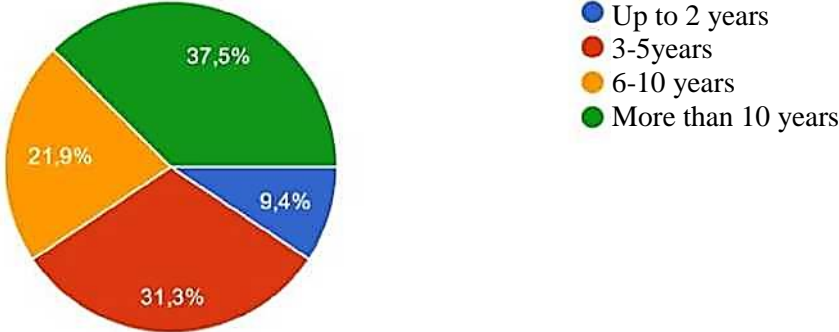
The first part of the study analysed the overall financial and schedule performance of projects. In the second part, the results were evaluated by dividing the projects according to the method adopted and applicable in the selected company, i.e., by project value:

- small (usually modifications to existing machinery) - up to PLN 100,000 of project value,

- medium (individual machines) - from PLN 100,000 to PLN 500,000 of the project value,
- large (large machines or production lines) - more than PLN 500,000 of the project value.

**Sample**

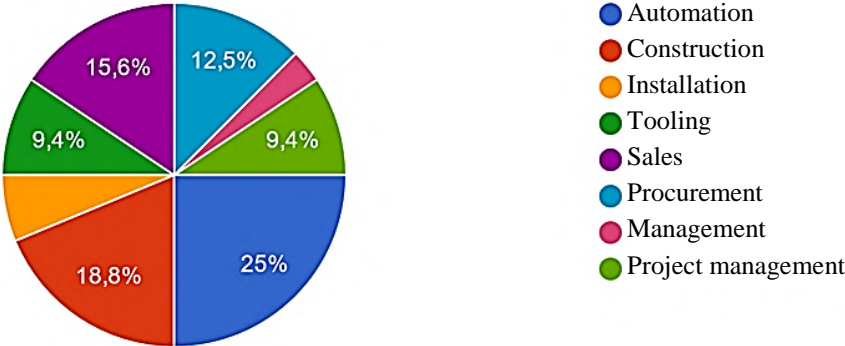
Of the 40 people asked to participate in the satisfaction survey of project team members, a completed questionnaire was received from 32 people, representing 80%. The respondents included 27 men, four women and one person did not wish to disclose their gender. The largest age group was between 26 and 30 years old, with 37.5% of respondents. The respondents were highly experienced in their profession, with as many as 59.4% working in their profession for 6 years or more, as shown in Figure 1.



**Figure 1.** Structure of experience in the profession among respondents.

Source: own work.

The majority of the respondents were people with relatively long seniority in the company - as many as 71.9% of the respondents had seniority of 3 or more years. The largest group among the respondents were representatives of the automation department, with 25%. In second place were representatives from the design department, who accounted for 18.8% of the respondents, followed by respondents from the sales department (15.6%). The distribution of respondents by department is shown in Figure 2.

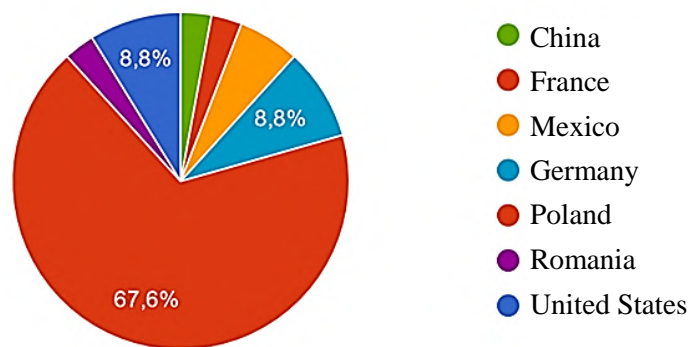


**Figure 2.** Structure of the departments in which respondents work.

Source: Own work.

Among the employees surveyed, 43.8% of respondents had worked with an ERP system before it was implemented in the company.

For the second survey, 34 completed questionnaires were received. The respondents were clients (customers) of the analysed projects implemented between 2020 and 2023. 12 of the responses received were for projects implemented using an ERP system, and 22 were for projects implemented prior to the implementation of the system. Among the respondents, 23 respondents represented Polish companies and the remaining respondents were customers from foreign companies, most of which came from the United States, Germany and Mexico. The distribution of respondents from each country is shown in Figure 3.



**Figure 3.** Structure of countries from which completed questionnaires were received.

Source: own work.

The desk research study, on the other hand, analysed 96 projects, with an average value of PLN 458k, a median of PLN 101k and an average actual duration of 22 weeks. 33 of the analysed projects were implemented using an ERP system. The analysed projects were classified as follows:

- 48 projects are small projects with an average value of PLN 33k, a median of PLN 25k and an average actual duration of 16 weeks,
- 25 projects are medium projects with an average value of PLN 278k, a median of £253k, and an average actual duration of 24 weeks.
- 23 are large projects, with an average value of PLN 1.55m, a median of PLN 1.3m, and an average actual duration of 33 weeks.

## Results

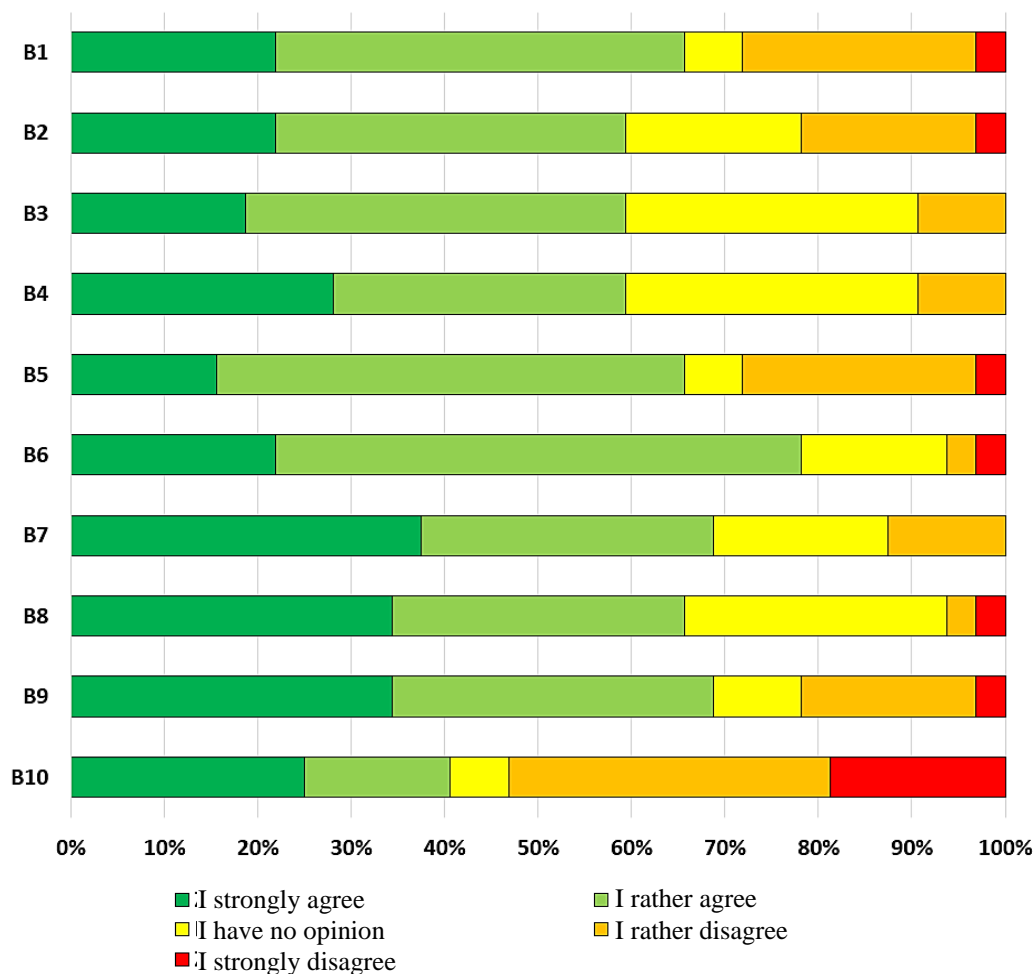
The first part of the research, carried out using a 2 questionnaire survey, concerned the evaluation of the impact of the implementation of an ERP system on the work of project team members and customer satisfaction. With regard to the project team, the following results were obtained:

- B1: increased comfort with the system after implementation (mean score: 3.56),
- B2: improving the processes implemented by respondents during the projects (mean score: 3.56),



- B3: speed and intuitiveness of project data provision, resulting in decision support (mean score: 3.69),
- B4: facilitating participation in several projects simultaneously (mean score: 3.78),
- B5: improved information flow between project team members from the same departments (mean score: 3.5),
- B6: improved information flow between team members from different departments (mean score: 3.91),
- B7: facilitating access to archived data and support in drawing conclusions (mean score: 3.94),
- B8: reducing the risk of confusion and exposing the company to losses (mean score: 3.91),
- B9: greater optimality relative to the previous solution (mean score: 3.78).

One statement - B10: increasing the speed of task completion - received an average score of less than 3 (mean score: 2.94). This statement also received the highest dispersion among the responses, with a standard deviation of as much as 1.5. The distribution of responses to the above statements is shown in Figure 4.



**Figure 4.** Impact of ERP implementation on the work of project teams.

Source: Own work.

Analysing, in turn, the impact of the implementation of an ERP system on the satisfaction of the selected company's customers, one can see a significant increase in the ratings for six of the eight factors, i.e.:

- customers rated the quality of the products and services offered by the selected company as having increased significantly after the implementation of the ERP system (mean score increased from 2.68 to 2.92),
- the prices offered by the selected company have become more affordable for customers (average score increased from 2.41 to 2.75),
- the timeliness of deliveries improved (average score increased from 2.50 to 2.67),
- the payment terms offered by the company have become more attractive (average score increased from 2.68 to 2.83),
- the company's flexibility in relation to possible changes to the project increased (mean score rose from 2.64 to 2.83),
- the ease of contact and communication with company representatives has improved (mean score increased from 2.64 to 2.92).

For two factors, ratings remained similar or declined:

- keeping to agreements (mean score changed from 2.91 to 2.92),
- staff competence (average score dropped from 3.0 to 2.92).

The assessment of timeliness of delivery was the one where respondents' evaluations varied the most. The standard deviation was 0.66 when assessing projects before ERP implementation and 0.47 for projects after implementation. The scores obtained are shown in Table 4.

**Table 4.**

*Assessments of eight customer satisfaction factors for projects before and after ERP implementation*

	Before implementation of the ERP system	After implementation of the ERP system
Quality of products/services	2.68	2.92
Proposed prices for products/services	2.41	2.75
Timeliness of deliveries	2.50	2.67
Payment terms	2.68	2.83
Flexibility in relation to possible changes in the project	2.64	2.83
Keeping to agreements	2.91	2.92
Mode of communication - ease of contact	2.64	2.92
Staff competence	3.00	2.92

Source: own work.

To summarise the first part of the research, it can be concluded that project team members positively assessed the impact of the ERP system implementation on their project job satisfaction. It is also noticeable that the satisfaction of the selected company's customers with the products and services offered increased after the implementation of the system.

The second part of the research, carried out using the desk research method, compares project performance (in terms of time and budget) before and after the implementation of ERP systems. The projects - small, medium and large - followed the criteria outlined in the earlier subsections.

Of the 48 projects that were categorised as small, 37 were implemented using an ERP system and 11 without. Guided by the parameters outlined above, the following results were obtained (Table 5):

- The total gain of projects completed without an ERP system was 37.86% and the average gain was 44.73%. The average duration of these projects was 17.4 weeks and the average delay was 44%.
- The total profit of projects completed using the ERP system was 51.95% and the average profit was 49.38%. The average duration of these projects was 10 weeks and the average delay was 11%.

**Table 5.**

*Financial performance and schedule compliance of projects classified as small*

	Number of projects	Small projects			
		Financial result		Duration	
		Total profit	Average profit	Average duration (weeks)	Average delay
Implemented without using an ERP system	37	37.98%	44.73%	17.4	44%
Implemented using an ERP system	11	51.95%	49.38%	10	11%

Source: own work.

Of the 25 projects that were categorised as medium, 17 were implemented using an ERP system and eight without. The following results were obtained here (Table 6):

- the total gain of projects completed without the use of an ERP system was 13.97% and the average gain was 12.34%. The average duration of these projects was 22 weeks and the average delay was 17%.
- the total profit of the projects implemented using the ERP system was 24.93% and the average profit was 30.16%. The average duration of these projects was 21 weeks and the average delay was 13%.

**Table 6.**

*Financial performance and schedule compliance of projects classified as medium*

	Number of projects	Medium-sized projects			
		Financial result		Duration	
		Total profit	Average profit	Average duration (weeks)	Average delay
Implemented without using an ERP system	17	13.97%	12.34%	22	17%
Implemented using an ERP system	8	24.93%	30.16%	21	13%

Source: own work.

Of the 23 projects that were categorised as medium, nine were implemented using an ERP system and 14 without. In this case, the following results were obtained (Table 7):

- the total gain of projects completed without the use of an ERP system was 6.46% and the average gain was 4.29%. The average duration of these projects was 30.4 weeks and the average delay was 25%.
- the total profit of the projects implemented using the ERP system was 28.36% and the average profit was 26.25%. The average duration of these projects was 35 weeks and the average delay was 19%.

**Table 7.**

*Financial performance and schedule compliance of projects classified as large*

	Number of projects	Large projects			
		Financial result		Duration	
		Total profit	Average profit	Average duration (weeks)	Average delay
Implemented without using an ERP system	9	6.46%	4.29%	30.4	25%
Implemented using an ERP system	14	28.36%	26.25%	35	19%

Source: Own work.

In summary, it can be seen that projects that were completed after the implementation of an ERP system achieved better financial results, while maintaining greater compliance with the schedule. The positive impact of implementation was noted regardless of the size and sophistication of the projects.

## 4. Discussion

The paper answers 3 research questions relating to the evaluation of the impact of ERP implementation on project success in a selected company from the industrial sector.

Referring to the first research question concerning the *way in which the implementation of the ERP system affected the compliance of implemented projects with the assumed budget and schedule*, it should be indicated that the implementation of the ERP system significantly affected the triangle of constraints and, in particular, the achievement of the two success criteria considered most important in the analysed entity, i.e. compliance with the budget and project schedule. It should be noted that, following the implementation of the ERP system, the duration of small projects (where administrative work accounts for the bulk of project work) was significantly reduced, and the company undertook more large, more advanced and complex projects. The projects were implemented successfully and the results were satisfactory.

With regard to the second research question on how the implementation of the ERP system improved project management in the analysed company, it can be concluded that the integration of various functionalities within one software enabled better monitoring of project progress, resource management and tracking of resource utilisation. After the implementation of the software, the comfort of the users increased and the tasks performed by them were carried out much more efficiently. The research also found that the ERP system was rated as a great support in decision-making and facilitating work on several projects simultaneously. Moreover, by having a more advanced liquidity management tool, the company is able to offer more favourable payment terms. The ERP system has also meant that the ease of contact and communication with company representatives has improved, while also influencing the company's greater flexibility. This is a result of the facilitation in the context of stakeholder management and change management that the ERP system brings. The role of ERP in improving organizational performance is also confirmed by other researchers, e.g. Barna et al. (2021); Ram et al. (2014).

In the context of the third research question - *How has the implementation of the ERP system affected the satisfaction of project team members and the company's customers* - it can be indicated that both project team members and customers perceive the benefits associated with the implementation of the ERP system and its impact on the implemented projects. The ERP system was evaluated by project team members as a more optimal solution than the previously used solution, as it facilitated the exchange of information between project team members, as well as reduced the risk of mistakes and exposure of the company to losses. In relation to customers, according to the survey, it was noted that their satisfaction with the products and services offered by the selected company increased. The quality of the products and services offered has also improved, while at the same time the price level has become more attractive. At the same time, the timeliness of product deliveries has increased, which, as stated, is crucial for the specific industry in which the selected company operates.

## 5. Conclusions

This paper contributes to the project management literature in the area of project success and project evaluation criteria and from the perspective of organisations in the industrial sector improving their internal processes through information systems. Thus, the paper extends existing knowledge in the field of project management and highlights the importance of implementing ERP systems in the context of achieving project success.

In practice, the paper addresses the needs of organisations facing the decision to implement an ERP system and points to certain considerations when implementing such systems. Firstly, information about the implementation of the system should be clearly communicated

within the organisation so that employees understand its purpose and have no concerns about their position and comfort at work. Future users of the system should also be communicated the benefits of implementing the system, including in the area of projects. Secondly, the needs of the organisation and the future users of the system should be carefully examined before implementation, so that the software fulfils its function and provides due support in their work. Analysis of these needs will allow the system to be tailored to the specific requirements of the organisation and increase the chances of implementation success. It should also be mentioned that over-formalisation and complexity of the activities performed within the system can also have a negative impact on the satisfaction of the system users and can slow down project activities. Thirdly, for proper system implementation, it is crucial that end users are properly trained in the use of the system. It is worth investing time and resources in comprehensive training that will enable employees to use all system functions effectively and avoid potential errors. For this, it is necessary to secure adequate financial resources to cover the costs associated with implementation, including the purchase of software, staff training and technical support. And fourthly, for the implementation of an ERP system to be successful, the management should be actively involved in the implementation process and monitor its results and impact on the organisation's operations, including project work. In addition, proper communication and availability of the implementation company and the implementation manager on the enterprise side should also be emphasised.

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## **ANALYSIS PENITENTIARY PROCESSES: A NEW PROCESSES CLASSIFICATION APPROACH IN MANAGEMENT SCIENCES**

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**Purpose:** Carry out a detailed analysis of existing processes classifications and propose a new one, the main focus of which will be on the unique requirements of the functioning of the penitentiary system, which is the totality of the institutions of penitentiary law and the applicable legislation. In addition, the article also aims to point out the differences between the classical view of identifying and defining processes carried out in typical organisations and those carried out in prisons.

**Design/methodology/approach:** The objectives of the article were achieved through an in-depth analysis of the literature on the identification and classification of processes carried out in typical organisations and those carried out in prisons and a modification of Porter's classic value chain model. Furthermore, throughout his career, the author has been investigating the functioning of the penitentiary system in terms of executing logistical processes over the past few years.

**Findings:** The author of the article compared the existing classifications of processes and suggested a new one more fitting to the functioning of the penitentiary system that defines the rules of the prisons that carry out the execution of imprisonment.

**Originality/value:** The originality of the article lies in the modification of the classic Porter's value chain model, illustrating the organization's activities as a systematic sequence of actions aimed at delivering the final product to the end user in the form of the proper implementation of imprisonment in prisons. In the face of dynamically changing challenges posed by the contemporary penitentiary system, understanding and properly classifying the implemented processes become crucial for effective management and improvement of the quality of the implemented actions.

**Keywords:** process classification, process identification, penitentiary system, process decomposition, penitentiary.

**Category of the paper:** Research paper.

## 1. Introduction

In recent years, there has been a noticeable increase in the complexity and significance of process management within organizations. However, this does not automatically translate into increased efficiency despite the emergence of factors that have led to a focus on process implementation (Bugdol, Szczepańska, 2016). Factors such as the implementation of logistics systems and the need to adapt to legal regulations necessitate a focus on managing logistical activities and comprehensive planning within organizations (Kuc, 2002). These factors urge the construction of flexible organizational structures in process management. Paying attention to the implemented processes creates the necessity for implementing innovative organizational solutions (Odlanicka-Poczobutt, 2016; Coyle et al., 2010).

Every organization operating in a specific environment must undertake measures to secure the implementation of processes, which are factors enabling the achievement of desired outcomes and are integral components of the system (Stabryła, 2012; Blaik, 2010). Process identification is crucial for the proper functioning of an organization and is a highly complex task due to the multidimensional nature of processes, determined by the overall goals of the organization and the system of planning, organizing, directing, and controlling (Brandt et al., 1999; Cokins, 1996). Process identification requires creative and innovative teamwork involving a specially appointed interdisciplinary team (Miller, 2000). The outcome of the team's work should be a set of processes containing information about the identified processes and their metrics (Leahy, 1999).

The main goal of this publication is to conduct a detailed analysis of existing process classifications and propose a new one, focusing primarily on the unique requirements of the penitentiary system, which constitutes the entirety of penitentiary law institutions and applicable regulations. This system defines the principles of operation for correctional facilities that carry out the execution of sentences of imprisonment (Ziemiński, 1973; Śliwowski, 1978).

Given the dynamically changing challenges posed by the contemporary penitentiary system, understanding and appropriately classifying the implemented processes become crucial for effective management and improving the quality of these processes. In this article, an overview of existing process classifications is presented, along with the decomposition of processes occurring within the penitentiary system. Subsequently, a classification of processes implemented in the penitentiary system is proposed, taking into account the specific aspects of its operation. The publication aims to provide a comprehensive view of the structure and organization of processes in the penitentiary system, thereby contributing to the development of the field of science.

## 2. Identification of existing process classifications

In the subject literature, there are many different classifications and criteria for dividing processes. The classification proposed by J.G. Miller and T.E. Vollman categorizes processes based on their task criteria as follows (Miller, Vollman, 1985):

- Informational processes – they serve the purpose of updating data collected in the organizational unit's information system.
- Regulatory processes – they ensure the adjustment of the workforce and production resources to the demand for products.
- Logistic processes – they are responsible for coordinating material flows from the moment of purchase to the transportation of sold products.
- Control processes – they are oriented towards the course of the production process, order fulfillment, and product quality.

On the other hand, P. Grajewski has distinguished the following processes (Grajewski, 2012):

- Non-intelligent processes – processes that achieve output effects without their own organizational contribution.
- Intelligent processes – processes that incorporate a system of utilizing their own experience to optimize the flow of individual operations from the perspective of estimated results.

The two most popular and frequently used classifications of processes have been proposed by M. Porter and R.S. Kaplan and R. Cooper. According to M. Porter, processes can be divided into support processes and core processes. Support processes include activities related to procurement, managing the entire unit, development aimed at improving products and processes, and human resources management. Core processes include product manufacturing, after-sales services, marketing, and logistics, which involve activities related to production preparation and tasks associated with product sales (Porter, 1985).

R.S. Kaplan and R. Cooper distinguished operational, innovative, and after-sales service processes. Operational processes are focused on delivering and manufacturing products suitable for customers. Innovative processes are related to creating product and service offerings and determining the target market. After-sales service processes encompass customer service activities after delivering the appropriate product (Kaplan, Cooper, 2000). They also classified processes into essential, non-essential, and necessary categories. Essential processes provide value, although there is potential to improve or simplify them. Non-essential processes should be eliminated as quickly as possible, while necessary processes cannot currently be simplified, improved, eliminated, or reduced and are essential for delivering value (Kaplan, Cooper, 2001).

The most comprehensive classification of processes was presented by the American Productivity Quality Center (APQC), which developed a model for process classification (Winiowski, 2017). APQC proposed a division into 12 categories of processes, which are divided into two groups (Ossowski, 2012):

- Operational Processes – key processes for a given business entity.
- Supporting Processes – processes that complement operational processes.

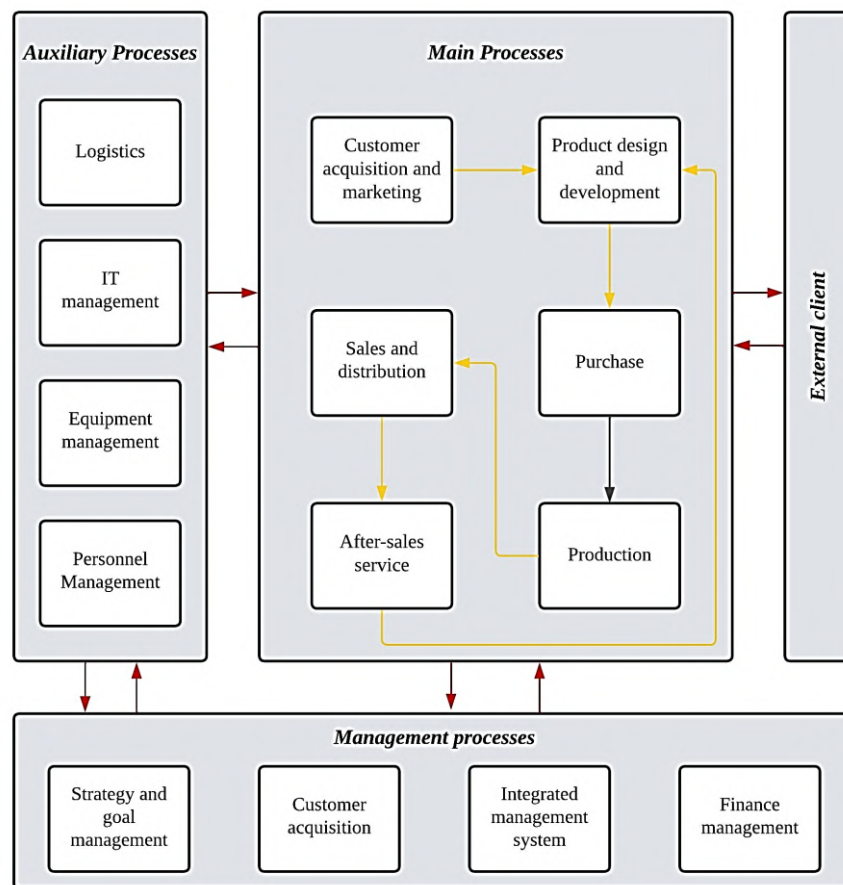
Table number 1 presents the 12 categories of processes proposed by the APQC organization.

**Table 1.**  
*Process Classification according to the APQC Model*

Process	Characteristics	
<b>Operational</b>	1.0	Development of vision and strategy.
	2.0	Development and management of products and services.
	3.0	Marketing and sales of products and services.
	4.0	Procurement, fulfilment and delivery of products and services.
	5.0	Customer service management.
<b>Supporting</b>	6.0	Organisation and management of human capital.
	7.0	Information technology management.
	8.0	Management of financial resources.
	9.0	Acquisition, construction and management of property.
	10.0	Environmental and health and safety management.
	11.0	External relations management.
	12.0	Knowledge, improvement and change management.

Source: own elaboration based on Ossowski, 2012.

The presented process classifications allowed the creation of a map with a division into core processes, management processes, and support processes. The map is presented in Figure 1.



**Figure 1.** The map illustrating the process classification.

Source: own elaboration based on Krawczyk, 2012.

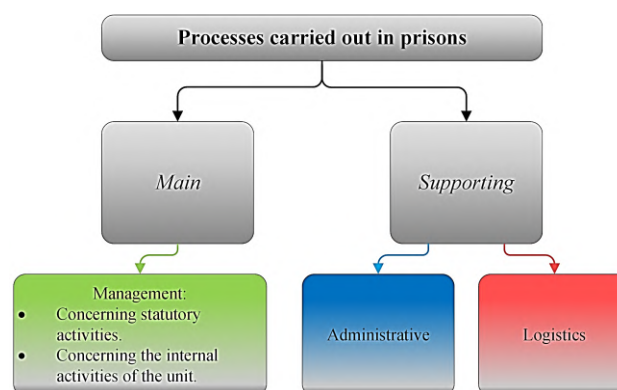
In the presented map, core processes are oriented towards external customers, while support processes and management processes are also outlined. Additionally, within the support processes, a broad sense of logistics has been considered, which is primarily directed towards core processes and management processes, influencing the external customer through them.

### 3. Decomposition of processes in the penitentiary system

The execution of logistical processes goes beyond staff and linear structures (Gołembiewska, 2005). It focuses on creating logistical value and customer satisfaction. In a company, efficient logistics organization must have precisely defined positions related to logistics, scopes of responsibilities, reporting relationships, and methods for measuring job performance. Properly defining qualifications for individual positions and flexibility in defining roles are also crucial. These possibilities are often limited in the case of predetermined legal conditions in penitentiary institutions. The most significant factor is typically the extensive professional experience and general knowledge of officers and civilian staff employed in penitentiary institutions. A broader perspective on organization, facilitating the proper coordination of information flows and logistical activities between departments and positions after prior, proper identification, is highly important (Bowersox et al., 1989; Copacino, 1993).

The processes carried out in penitentiary institutions have been divided into main and supporting processes. Within the main processes, management processes stand out as the foundation of penitentiary operations. Management processes are further categorized into processes related to statutory activities and processes related to the internal functioning of the institution. Supporting processes include logistical and administrative processes, especially those that have a significant impact on the execution of main processes. The identified processes differ from the classical business approach used in enterprises due to the specific nature of organizational functioning.

Figure 2 presents the proposed classification of processes implemented in penitentiary institutions.



**Figure 2** The classification of processes implemented in penitentiary institutions.

Source: own elaboration.

B. Słowiński defines management processes as processes aimed at creating the company's strategy along with its goals. They relate to the implementation of (Słowiński, 2008):

- Internal audits,
- System reviews,
- Preventive and corrective actions,
- Supervision over documentation and records.

Management processes in penitentiary institutions are of a decision-making nature, and their outcome is an intangible service, such as preparation, communication, and decision-making, or supervision over the implementation of all statutory activities.

The management processes in penitentiary institutions are a manifestation of fulfilling statutory functions, where logistical activities are not always directly identified, although they constitute a fundamental part of these processes. Within the management processes, activities related to the internal functioning of units have also been distinguished, where the identification and coordination of influencing logistical activities can impact the course of all implemented processes. Achieving goals can be ensured by streamlining activities and frequent repeatability, which generates the most significant value. The application of such an approach in penitentiary institutions stems from the identification of operational objectives within the framework of the mission, which is legally formalized. This approach promotes the adoption of a process-oriented perspective.

Table 2 presents a compilation of selected definitions of logistical processes.

**Table 2.**  
*Selected definitions of the logistics process*

ID	Authors of the definition, year	Definition
1.	Kauf S., Płaczek E., Sadowski A., Szoltysek J., Twaróg S. (2016)	Logistics processes are a regulated and structured chain of operations, closely linked to the handling of individual materials. They focus on the achievement of objectives by physically moving materials through all phases of an organisation's activities (Kauf et al., 2016).
2.	Szymonik A. (2011)	Logistical processes are defined as the following consecutive, at a given time and place, facts (future and past phenomena) in the field of the physical flow of products and services and information, as well as the risks that accompany each action. (Szymonik, 2011).
3.	Ficoń F. (2001)	Logistical processes, consist of the physical movement of goods and the associated information, in the course of these processes further transformations (revalorisation) of the product take place (Ficoń, 2001).
4.	Słowiński B. (2008)	Logistics processes - supporting the functioning of the management system and ensuring its effectiveness and efficiency. They include activities and actions related to the preparation of the infrastructure of basic and management processes, the establishment of information systems, transport, storage, accounting and finance, reporting and controlling (Słowiński, 2008).

Source: own elaboration.

In correctional facilities, logistics processes revolve around the movement of people, materials, and documents, supporting the execution of other managerial and administrative processes.

In organizations, administrative processes affect its smooth operation and determine the crucial flow of documents and information. Ensuring efficient flow and complete automation of repetitive tasks are key objectives of administrative processes.

Administrative processes in correctional facilities involve the preparation of various types of documentation and are responsible for inputting specific data into internal and external systems. They also encompass all conducted checks and verification of documentation. These processes impact managerial processes and are regulated by them.

The nature of activities performed by correctional officers, involving the execution of many specific and repetitive tasks, lends itself to structuring them into processes. This applies to actions conducted in a manner defined by regulations and procedures. To ensure the quality of executed processes, all internal procedural activities should be organized according to a logical content pattern based on rules and procedural guidelines.

Figure 3 illustrates the decomposition of processes carried out in correctional facilities.

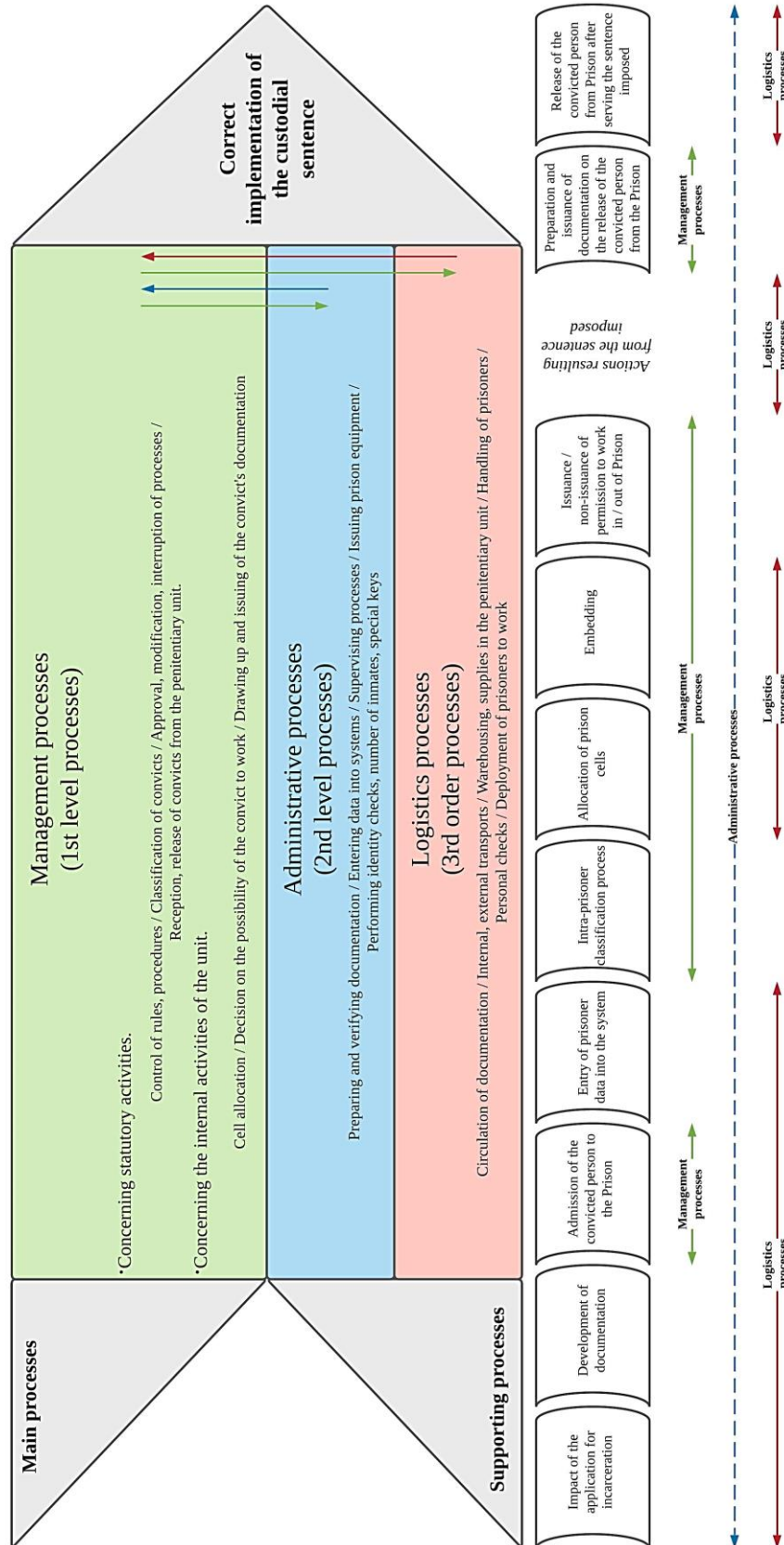
The decomposition of the entire process of implementing custodial sentences in correctional facilities demonstrates a detailed breakdown of main and supporting processes. Furthermore, the decomposition and comprehensive information about the course of these processes highlight the impact of logistical activities on managerial and administrative functions. They are carried out during specific tasks and play a supportive role in all ongoing processes.

The decomposition of processes shows that the main processes - first level processes, are specifically managerial processes, which are divided into processes related to statutory activities and processes related to the internal operations of the unit. Processes related to statutory activities can thus include:

- conducting checks on regulations and procedures,
- classifying convicts,
- approving, modifying, and discontinuing processes,
- admitting and releasing convicts from the facility.

The managerial processes related to the internal operations of the unit include activities associated with:

- assigning prison cells and living units,
- deciding on the possibility of convicts engaging in work,
- preparing and issuing convict documentation.



**Figure 3.** Decomposition of processes carried out in prisons.  
 Source: own elaboration based on Odlanicka-Poczobutt, 2016.



Supporting processes are divided into administrative processes - second-order processes, and logistical processes - third-order processes. Administrative processes include activities related to:

- preparing and verifying documentation,
- entering data into systems,
- supervising ongoing processes,
- issuing prison equipment,
- conducting identity, inmate count, and special key controls.

Third level processes, or logistical processes, in correctional facilities pertain to:

- document circulation,
- transportation activities,
- warehousing and supply management,
- inmate handling, including delegation to work assignments.

The key principle is the pursuit of flawless execution and the elimination of the risk of delays in the implementation of custodial sentences. It is assumed that this is achievable through continuous supervision of correctional facilities, carried out by appropriate department managers and the director of the respective unit.

All activities carried out in correctional facilities must comply with regulations and procedural instructions. Failure to adhere to these guidelines can result in the annulment or interruption of the entire process. Some of these processes also have a purely administrative nature and are executed by civilian employees.

#### **4. Conclusion**

In summary, it can be stated that the identification of processes is a complex task due to the multidimensional nature of processes, determined by the goals of the entire organization and the system of planning, organizing, controlling, and monitoring. The implementation of processes goes beyond the organizational structure and focuses on creating value and customer satisfaction. Proper qualification for specific positions and flexibility in defining roles also play a crucial role. However, these possibilities are often limited due to predetermined legal constraints in correctional facilities.

The decomposition of processes in the penitentiary system highlights the differences between the classical approach to identifying and defining processes in typical organizations and the processes carried out in correctional facilities. A modification of Porter's classical value chain model has been made, illustrating the organization's activities as a systematic sequence of actions aimed at delivering the final product to the end user in the form of proper

implementation of imprisonment in prisons. This modified model distinguishes between the main and supporting processes within correctional facilities and emphasizes the integrated and correct execution of custodial sentences.

The decomposition and comprehensive information about the course of the executed processes have highlighted the impact of logistical activities on managerial and administrative functions. These activities are carried out during individual tasks and play a supporting role in all ongoing processes.

The nature of activities performed by correctional officers, involving the execution of many specific and repetitive tasks, favors structuring them into processes. This applies to actions conducted in a manner defined by regulations and procedures. To ensure the quality of executed processes, all internal procedural activities should be organized according to a logical content pattern based on rules and procedural guidelines. In the context of logistics within correctional facilities, the primary goal is to adhere to prison procedures, which should be supported by efficient logistics management in the execution of custodial sentences. Units should strive for optimal process execution within the right timeframe, in the right manner, and with the appropriate implementation of process tasks. It is crucial to adopt a broader perspective on the organization, facilitating proper coordination of information flows and activities between departments and positions after prior, accurate identification.

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## APPLICATION OF TOWS/SWOT ANALYSIS AS AN ELEMENT OF STRATEGIC MANAGEMENT ON THE EXAMPLE OF A MANUFACTURING COMPANY

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**Purpose:** The analysis of strengths and weaknesses is very important in the strategic management of an enterprise. The article uses TOWS/SWOT analysis in one of the manufacturing companies. Based on the analysis, it was proposed to adopt an aggressive strategy (maxi-maxi).

**Design/methodology/approach:** The aim of the article was to analyze the strengths and weaknesses of an industrial enterprise. As part of the research, a TOWS/SWOT analysis was carried out, based on which the company's strengths and weaknesses were presented. In the next stage, survey research was carried out.

**Findings:** Based on the TOWNS/SWOT analysis, it was found that the most desirable option for the company is to adopt an aggressive strategy (maxi-maxi).

**Research limitations/implications:** The major limitation of the paper is that it is based on one case of an organization. In the future, it will be necessary to conduct studies in more organizations so as to find out if the same result can be achieved.

**Practical implications:** The analysis shows that the basic strengths on which the company's strategic advantage should be built are the leading position on the market of aluminium profiles (51%) and flexible packaging (21%) and the company's constant development. Investing in the development of the company through the development of activities in segments (investments in modern technologies, elimination of costs) and obtaining their shares in the country and on the foreign market.

**Originality/value:** The examined company has not yet conducted a TOWN/SWOT analysis that would indicate what strategy should be implemented to improve company management.

**Keywords:** analysis, TOWN, SWOT, strategic management, business.

**Category of the paper:** case study.

## 1. Introduction

Recognising the situation in the immediate market environment and analysing and assessing one's own capabilities provide the foundation for determining the strategic situation of an enterprise and formulating conclusions regarding its future development. It is important to understand two key aspects: the opportunities and threats arising from the current state and evolution of the market environment, and the strengths and weaknesses flowing from the company's internal resources (Gierszewska, Romanowska, 2017; Abdi et al., 2013; Yu, Wang, 2022).

On the one hand, identifying opportunities involves identifying favourable conditions, market trends, new technologies or regulatory changes that can create growth prospects for the company (Oziębło, 2022). At the same time, it is necessary to identify threats related to competition, changes in customer preferences, the macroeconomic situation or other factors that may negatively affect the business. On the other hand, the analysis of strengths and weaknesses focuses on the company's internal resources. Strengths are strengths such as unique competencies, advanced technologies, a strong brand or qualified staff. Weaknesses, on the other hand, are areas where the company may face constraints, such as deficiencies in infrastructure, inefficient processes or limited financial resources (Ogórek, Strycharska, 2019; Bryszawska, Kulesza, 2022).

Determining these two aspects allows a more complete picture of the company's situation to be completed, which in turn enables effective development strategies to be developed. Thanks to this comprehensive analysis, the company can maximise its strengths, minimise the impact of weaknesses, exploit the opportunities of the environment and effectively counter potential threats. In this way, strategic management becomes a solid foundation for the long-term success of the company (Shobha, Parul, 2017; Widjaja, 2020; Biernat et al., 2022).

## 2. Literature review

SWOT/TOWS type analyses belong to the canon of strategic management tools and are an integral element used in strategic management. Their role in the strategic planning process is to systematically combine two complementary approaches to the organisation: "from the outside in" and "from the inside out". TOWS/SWOT analysis aims to examine the systematised combination of two complementary approaches to the organisation, i.e. 'from the outside in' and 'from the inside out', and to identify the best option for strategic action in the company under study (Proctor, 2000; Mierzwa, Goliszek, 2017; Dandage et al., 2019).

SWOT analysis is a strategic tool in the form of a matrix that includes four key categories of data. The first element of this matrix is strengths, representing the internal strengths, advantages and skills that underpin a company's strategy. These are the elements that can be used to efficiently implement strategic plans (Kowalik, 2020b). The next segment of the matrix is weaknesses, encompassing negative determinants that may constitute obstacles to the effective implementation of strategic activities. This is an important category to identify areas for improvement or adjustment to avoid potential difficulties. Then, moving on to external factors, there are opportunities, representing favourable phenomena and trends that can create favourable conditions for the achievement of strategic objectives. These are opportunities that are worth exploiting in order to maximise the company's success (Żabińska, 1997; Jagodziński et al., 2012). The final element of the SWOT matrix is threats, comprising impediments and barriers from the external environment. These are factors that can lead to setbacks or delays in achieving set goals, so it is important to identify and effectively manage them (Aslan et al., 2012; Buyukozkan, Ilicak, 2019).

The TOWS method is a variation of the SWOT method, this approach is referred to as 'from the outside in'. During a SWOT analysis, the focus is on identifying an organisation's strengths and weaknesses in order to exploit them in a given environment. TOWS analysis takes the opposite approach - a company's strategy should be based on flexible adaptation to the signals coming from its environment (Bieda, Brzozowska, 2017; Černý et al., 2018). This means that a company should be ready to dynamically adapt its strategies in order to effectively respond to challenges and take advantage of emerging opportunities. TOWS analysis places emphasis on the ability to respond flexibly to the environment, which can be crucial for effective management in a dynamic market environment (Kowalik, 2020a; Sadłowska-Wrzesińska et al., 2020).

### 3. Research methodology

When using the SWOT-TOWS methodology, the following points need to be taken into account:

- when analysing the aggregated results of the interactions occurring in the SWOT-TOWS method, attention should be paid not only to the dominant number of interactions, but also to the distribution of the weighted number of interactions;
- when compiling groups of factors in which the relationships are examined from the point of view of the impact of a negative factor - a matrix with questions as well as to the impairment of opportunities for strengths or opportunities;

- by juxtaposing groups of factors in which the relationships are examined in terms of the impact of a positive factor (matrix with questions), as many interactions as possible are expected, i.e. positive factors are strengthened (Czerniejewski, Heller, 2022; Fitriani, 2022).

In practice, TOWS analysis does not simply transform the data in a table by swapping columns with rows and reordering both rows and columns. The factors from the different fields of the table (quadrants) of the SWOT analysis are placed in the column headings (starting with the 2nd column) and in the first column of the table, and at their intersection actions are written referring to these factors. This results in four groups of strategic actions called, in turn, aggressive, competitive, conservative and defensive strategies (Table 1).

**Table 1.**  
*TOWS matrix*

	<b>Strengths (S)</b>	<b>Weaknesses (W)</b>
<b>Opportunities (O)</b>	Aggressive strategy SO	Competitive strategy WO
<b>Threats (T)</b>	Conservative strategy ST	Defensive strategy WT

Source: (Miszevska, Niedostatkiewicz, 2020; Czerniejewski, Heller, 2022).

In practice, due to limited financial resources, a company chooses one of the following strategies depending on its own condition and current external conditions. Companies can use one of the following strategies:

- An aggressive SO (maxi-maxi) strategy refers to a situation where the organisation's strengths outweigh its weaknesses and there are more opportunities than threats in its environment. It is a strategy of strong expansion and diversified growth.
- Competitive strategy WO (mini-maxi) is suitable for an organisation that has a preponderance of weaknesses but is favoured by the pattern of external conditions. The strategy is to exploit these opportunities while reducing or improving the organisation's weaknesses.
- A conservative ST (maxi-mini) strategy can be applied when the source of the organisation's barriers to growth is an unfavourable pattern of external conditions. The strategy opposes threats with a high internal potential and consists of overcoming them using its strengths.
- A defensive WT (mini-mini) strategy is suitable for organisations lacking development opportunities, with low potential, operating in an unfavourable environment. It boils down to a struggle for survival and the resolution of constantly erupting crises in various locations (Adamus, 2004).

TOWS-SWOT, as a comprehensive method of strategic analysis, makes it possible not only to identify the internal and external factors affecting an enterprise, but also to integrate this information, which allows the formulation of concrete actions aimed at maximising benefits and minimising risks. In this way, TOWS-SWOT analysis becomes an invaluable tool to support strategic decision-making in the context of a complex environment (Miszevska, Niedostatkiewicz, 2020; Sanito et al., 2020).



In this article, a SWOT-TOWS analysis of a selected manufacturing enterprise is performed.

The subject of the study was an aluminium company. This organisation produces aluminium casting alloys and mordants - around 50 alloy types in total. The alloys are produced in the form of ingots, liquid metal, granules used in metallurgy for deoxidising steel and ingots for in-house use for further processing. The alloys produced are used in domestic industry for remelting and obtaining finished castings (e.g. automotive, aerospace, machinery and equipment, household appliances).

## 4. Results

The first activity in the TOWS/SWOT analysis was to define a list of the company's opportunities, threats, strengths and weaknesses and assign them weights to determine their relevance in terms of their impact on the company's ability to grow (Table 2) (Adamus, 2004).

**Table 2.**

*Table of the company's strengths, weaknesses, opportunities and threats in the environment*

Weight	External factors	Weight	Internal factors
0.1	OPPORTUNITIES extending the product range with new products;	0.15	STRENGTHS ISO 9001:2000 quality and ISO 14001 environmental management certifications;
0.2	optimisation of processes within the Group (with a positive impact on service quality);	0.05	stable and experienced management staff;
0.05	large area of company operations;	0.15	a well-functioning organisational structure that conditions the correct course of business processes;
0.1	attracting new investors;	0.35	constant development of the company (consistent investments) ensuring competitive advantage;
0.3	expanding markets outside the EU;	0.1	efficient and quick system of dealing with all complaints;
0.25	good financial condition of potential buyers' industries;	0.2	leader on the domestic market of aluminium profiles (51%) and flexible packaging (21%);
Total = 1.00		Total = 1.00	
0.25	THREATS volatility of macroeconomic indicators (inflation, interest rates, exchange rates);	0.15	WEAKNESSES underutilisation of production capacity;
0.05	adverse developments in the labour market (unemployment);	0.2	insufficient modern equipment to eliminate products with hidden defects;
0.15	increasing competition from foreign companies;	0.2	lack of authorisations (certificates) to manufacture products for industries such as the military;
0.1	aluminium price volatility on the LME (London Metal Exchange);	0.15	limited ability to compete on price;
0.3	capital market risk (secondary market price movements);	0.25	weakening of the company's financial position through loan and interest repayments;
0.15	recession in the European market;	0.05	seasonality of the market;
Total = 1.00		Total = 1.00	

The next activity was to examine in parallel, i.e. 'from the outside in' and 'from the inside out', the relationships occurring between strengths and weaknesses and opportunities and threats. To this end, the following questions were formulated:

*Will the threats that may arise weaken the identified strengths?*

The two most important threats, which definitely diminish the importance of the strengths available to the organisation, are considered to be, respectively, capital market risk and the associated changes in secondary market prices and the volatility of macroeconomic indicators.

The two strengths most susceptible to the impact of the defined threats are the company's continued growth and market leadership. In practice, this means that when threats first occur, these very strengths will lose their importance as a basis for building strategic advantage.

*Will the opportunities that may arise amplify the identified strengths?*

An opportunity for the company is to expand its markets outside the European Union. Another opportunity is the emerging possibility of optimising processes within the Group. The optimisation of all processes identified in the company will positively influence the quality of services and allow for full use of advanced computer technology supporting quality management in the company. It will guarantee the company a professional way of serving the customer and, therefore, ensure that the company gains an advantage over its competitors.

*Will threats that may arise exacerbate existing weaknesses?*

Potentially emerging threats, such as an unfavourable national economic situation and the growth of competing companies in the market, will significantly exacerbate a company's existing weaknesses. They will weaken the company's position as a national market leader and significantly affect its financial position.

*Will the opportunities that may arise overcome existing weaknesses?*

The appearance of an opportunity to do business in prospective segments of the economy gives the company the opportunity to overcome existing weaknesses. The company will be able to increase its production capacity, thus achieving higher profits and improving its financial situation. As a result, the company will be able to invest in the purchase of modern equipment to eliminate the production of products with hidden defects and complete the company's restructuring process, which has been initiated with the aim of reducing costs. The company will be able to compete on the market with the price of products and will significantly improve their quality.

*Will the strengths identified, allow the company to take advantage of opportunities that may arise?*

The company's strengths: the national market leadership position and the company's continued growth will have the greatest impact when opportunities arise. This means that these company strengths can significantly help to exploit future opportunities.

The opportunity most likely to be influenced by the company's strengths is the optimisation of business processes.

*Weaknesses identified will they prevent the exploitation of opportunities that may arise?*

Lack of authorisations (certificates) to manufacture products for the industry, e.g. the military, and insufficient state-of-the-art equipment to eliminate products with hidden defects may be the reason why the opportunity to win new markets is missed.

An opportunity for the company is also to broaden its commercial offer and direct it into prospective segments of the economy, which is where the company operates. However, the company's weakened financial position may not allow it to take advantage of this opportunity. If the company does attract an investor, it will be in a position to take advantage of future opportunities.

*Will the identified strengths allow the company to overcome the threats that may arise?*

The company's strengths are its market leadership position and its continuous investment in business development. The company is certified in accordance with the requirements of the standards: ISO 9001:2000 and ISO 14001, and a well-functioning organisational structure that determines the correctness of business processes. The company's identified strengths will enable the company in the future to overcome risks that may arise, especially the emergence of competition in connection with EU accession. Also, the risks associated with the capital market situation (in connection with such strong company strengths) would be surmountable if they depended on the company alone. Indeed, capital market developments are influenced by many other factors beyond the company's control.

*Will the weaknesses identified, reinforce the impact of the risks that may arise?*

The weakening of a company's financial position is the factor that most amplifies the impact of risks. The emergence of foreign competitors will significantly amplify the company's weakening (Adamus, 2004).

The aggregated totals obtained (Table 3) after the TOWS/SWOT analysis clearly indicate that, with the defined configuration of external and internal factors and the established weighting system, the most desirable course of action for the company is to adopt an aggressive strategy (maxi-maxi).

A maxi-maxi strategy means that strengths prevail within the company, while opportunities prevail in the environment.

**Table 3.**

*Summary of the TOWS/SWOT analysis results*

Combination	Results from the analysis TOWS		Results from the analysis SWOT		Summary overview TOWS/SWOT	
	total interactions	total products	total interactions	total products	total interactions	total products
Opportunities/Weaknesses	16/2	2.4	24/2	4.3	40/2	6.7
Threats/Weaknesses	20/2	3.9	11/2	2.25	31/2	6.15
Opportunities/Strengths	26/2	5.35	28/2	4.05	54/2	<b>9.4</b>
Threats/Strengths	26/2	4.8	7/2	1.35	33/2	6.15

A maxi-maxi strategy means that strengths prevail within the company, while opportunities prevail in the environment.

## 5. Discussion

The analysis shows that the basic strengths on which the company's strategic advantage should be built are the leading position on the market of aluminium profiles (51%) and flexible packaging (21%) and the company's continuous development. Investing in the company's development through further business development in the segments (investments in modern technologies, cost reduction) and increasing their share in the domestic and foreign market (increasing exports and overall sales) will definitely allow the company to take advantage of the two most important opportunities from the point of view of the future development of the sector, which are: integration with the EU and activity in prospective segments of the economy (especially food, chemical and pharmaceutical industries).

In addition to this, the possession of certificates of compliance with the requirements of ISO 9001:2000 and ISO 14001, considered as assets, conditioning the high quality of products and services offered and the correctness of business processes, gives the company the opportunity to compete in the market with foreign companies (EU countries).

An aggressive strategy is a strategy of strong expansion and diversified development. However, the best option for the company would be to adopt a competitive (mini-maxi) strategy. Considering the aggregate results of the TOWS/SWOT analysis, this strategy is the closest to the result achieved by the aggressive strategy.

A competitive strategy addresses the weaknesses in an organisation's performance and builds its competitive strengths by maximising the exploitation of existing opportunities that favour growth. The company pursues just such a strategy of action: it improves products, reduces costs, and invests in maintaining a competitive advantage, all through quality management.

As the authors point out, SWOT/TOWS analysis is a valuable analytical tool, but provided it is done carefully, consistently and consciously. The most common mistakes that can be made are:

- incorrectly placing a factor in the matrix area,
- incorrectly interpreting the origin of an identified factor,
- entering a factor in the matrix that does not correspond to reality,
- omission of a relevant factor or giving it an inappropriate weighting (Żemła, 2019; Romanowska, 2009).

In order to avoid misinterpreting the results of the method, which may result in serious consequences in the future, the SWOT/TOWS analysis should be properly prepared. Special attention should be paid to the selection of the analytical team and the multi-stage verification of the results. Progress in the implementation of the implemented strategy should be monitored and, if forced, e.g. by changes in the company's environment, the study should be repeated and the previously chosen strategy modified (Oziębło, 2022).

The SWOT/TOWS analysis, as a specific algorithm, is a universal tool commonly used in many areas of an organisation's activities, not only in the context of overall development. It can also be mentioned, for example, in safety management, risk management, financial management, sustainability, marketing and many others (Sadłowska-Wrzesińska et al., 2020; Marczevska-Kuźma, Ostrowska, 2018; Asejczyk-Woroniecka, 2016; Dandage et al., 2019; Kowalik 2020; Yu, Wang, 2022; Biernat et al., 2022).

## 6. Conclusions

Quality management is an integral part of a company's growth strategy. Fierce market competition and increasing customer demands mean that only the best quality products will find buyers in the future. Packaging production, in particular, is an activity that requires manufacturers to pay extraordinary attention to quality. The better the packaging, the greater the guarantee that the goods inside will retain all their properties or will not be accidentally damaged. No less important is the marketing role of packaging, i.e. packaging as a "silent salesman" must meet the aesthetic requirements of a specific customer group. In order to meet all these requirements, it is necessary to build product quality based on European standards. Therefore, in its future plans, the company should endeavour to obtain authorisations (certificates) to produce specific products for the industry, e.g. military. Quality management in the company requires not only a well-thought-out concept of operation, but also appropriate technical and research facilities, so the company should also invest in the purchase of more modern equipment to eliminate products with hidden defects.

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**LANGUAGE IN THE HUMAN-TECHNOLOGY ERA.  
NEW TERMINOLOGY ON THE SEX (ROBOT) MARKET –  
“DIGISEXUALITY”, “TECHNOSEXUALITY”  
AND “ROBOSEXUALITY” – A MULTILINGUAL ANALYSIS  
AND SURVEY AMONG STUDENTS**

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**Purpose:** The purpose of this article is to explore and analyze neologisms in English, German, French, Spanish and Polish that arise in the context of technological advancements, especially in the field of emerging sexual technologies; and to check their codification in dictionaries. Moreover, the research aims to verify whether students know the terms “digisexuality”, “technosexuality” and “robosexuality” and understand the differences between them.

**Design/methodology/approach:** This article comprises two main sections: the first section conducts a linguistic analysis of three neologisms related to sex robotics in multiple languages to explore their structure, spelling variations, and codification. The second section presents the results of a survey conducted among 134 students aged 20-24, aiming to assess their awareness and opinions on emerging sexual technologies and their ability to distinguish between similar terms.

**Findings:** The article examines three blend neologisms, digisexuality, technosexuality, and robosexuality, in five languages, formed by combining prefixes with "sexuality". While these terms lack codification in dictionaries, their adjective forms are defined in English due to frequent usage. The survey of 134 students aged 20-24 revealed their unfamiliarity with these concepts and difficulty in distinguishing them, along with gender-related disparities in comfort levels when discussing sex robots.

**Practical implications:** These findings emphasize the need for educational initiatives and awareness campaigns to familiarize individuals, particularly young adults, with these evolving concepts.

**Social implications:** The evolving nature of these neologisms and their potential impact on human experiences and relationships highlight the need for continued research in the fields of communication, technology, and human sexuality.

**Originality/value:** The terms “digisexuality”, “technosexuality” and “robosexuality” were not analysed and compared in five languages including their codification. Moreover, the study depicts the students’ awareness and understanding of those concepts and differences between them.

**Keywords:** neologisms; digisexuality; technosexuality; robosexuality, sex (robot) market.

**Category of the paper:** Research Paper.

## 1. Introduction

Communication plays a vital role in human interactions, facilitating the exchange of information, emotions, and ideas. Effective communication involves mastering various levels, including phonetics, grammar, lexis, and pragmatics in every language. Specialized languages and the language of technology play a critical role in the development of knowledge and expertise within a field. For instance, in scientific research, the use of specialized language enables researchers to communicate and share their findings accurately and effectively (Brownell, 2014; Nagy, 2014).

The use of technical terminology also enables experts to identify areas of knowledge gaps and develop new research questions. Neologisms are a fundamental aspect of language, allowing speakers to express new concepts and experiences that do not have pre-existing words or phrases. They are an essential part of language evolution, as language adapts to new technologies, social norms, and cultural practices.

Neologisms, characterized as lexical units not previously documented in a particular language, derive their importance from their inherent novelty. The key factor in recognising novelty is connected to the individual interpretation of the speaker (Rey in Llopart-Saumell, Cañete-González, 2023).

In recent decades, neologisms have become increasingly prevalent in technology-related fields, as new products, services, and innovations require new terminology to describe them. They are created to refer to new concepts, objects, or phenomena that emerge in society, and they can have a variety of functions, ranging from filling lexical gaps to expressing new social and cultural norms. Thus, the new terminology is created to construct the social world.

According to Searle (2006) there exist two distinct types of realities: (1) a physical reality, which is unquestionably genuine and accepted as given, and (2) a social reality that depends on human agreement and is constructed by us. The social-human realm can be seen as an additional layer, possibly virtual, superimposed upon the physical world. Consequently, language serves as a tool for layering, embellishing, and adorning. Its purpose is to confer social significance upon objects, including technological artifacts. The act of assigning meaning to things is exclusive to humans. The entirety of the social world is a product of our own creation, and the language is an integral part of this social world, forged by our own hands.

A new era of intelligent systems has begun as a result of technological developments in robotics and communication. As researchers push the boundaries of innovation, novel terminologies are emerging to describe the complex interactions between robots, humans, and the surrounding environment. This article explores the evolving lexicon in the field of robotics and communication, shedding light on key terms that encapsulate the transformative nature of these domains.

This comparative analysis aims to examine and compare the definitions and linguistic aspects of three terms: *digisexuality*, *technosexuality*, and *robosexuality*. These terms represent emerging concepts in terms of human sexuality and technology. By analyzing their definitions and linguistic characteristics, we can gain insights into the concepts they represent and their linguistic representations in English, German, French, Spanish, and Polish.

Among these languages, English and German are Germanic languages, sharing historical roots and common linguistic features. French and Spanish, on the other hand, are Romance languages, both evolving from Latin. Polish belongs to the Slavic branch of the Indo-European family, sharing linguistic ties with other Slavic languages such as Russian, Czech, and Slovak. The complexity of the Polish language stands out prominently when compared to English, German, French, and Spanish (Wołk et al., 2022). English, German, French and Spanish, however, belong to the group of pluricentric languages (Skubis, 2016; 2017).

Moreover, it is worth checking, whether those concepts are codified in dictionaries in the above-mentioned languages. The research aims to contribute to communication research by exploring the nuances and similarities between these terms and their significance in addressing important problems and issues facing humankind within close relationships, groups, organizations, and cultures.

## 2. (Sex) Robots' Market

Currently, we are witnessing and personally experiencing a significant shift in attitudes towards sexuality known as the sexual revolution. This transformation is being facilitated by advancements in technology and artificial intelligence, allowing us to develop machines that closely resemble and behave like humans, including intelligent sex robots. As technology continues to evolve, more sophisticated mechanisms are being introduced to the market. These mechanisms can imitate, stimulate, and even establish direct physical contact with individuals.

Researchers such as Arnold (2020), Aleksandrovich and Gomes (2020), Arnold and Scheutz (2017), Gomes and Wu (2020), Kolivand et al. (2017), and Li et al. (2017) have explored various technologies including virtual reality, soft robotics, bio-inspired robotics, haptic wearable interfaces, and more (Rothstein et al., 2021). Sex robots belong to the category of social robots, encompassing various terms in English such as sex robots, AI-powered sex dolls, (hyper)realistic erotic dolls, and animated sex dolls. These technological advancements originated in Japan, a hub for innovation. The driving factors behind their development are the hectic pace of modern life, emphasis on career pursuits, and the scarcity of time for genuine human connections.

A general term *service robot*, as outlined in ISO 8373:2021, is a robot used for personal or professional tasks that are beneficial to humans or equipment. Personal use involves tasks like handling items, transportation, physical support, guidance, information, grooming, cooking, and cleaning, contributing to individuals' daily lives.

The term *social robot* is identified as a subtype of service robots. Social robots represent a burgeoning frontier in personal robotics, designed to interact independently with people across various applications. These robots employ natural and intuitive interactions, using human-like social signals. In essence, a social robot is a physical robot with the ability to engage in social interactions with individuals. In terms of *sex robots*, the term *humanoid robot* should also be introduced and is defined as follows: "robot (...) with body, head and limbs, looking and moving like a human" (Skubis, Wodarski, 2024).

Skubis (2021) underlines, that in light of the potential hazards present in the domains of robotics and electronics, the European Parliament introduced a resolution on 16<sup>th</sup> February 2017, containing recommendations to the EU Commission concerning civil law provisions pertaining to robotics. The stipulations outlined in this resolution bring attention to the imperative of updating European Union legislation with ethical principles. These ethical principles encompass the following considerations:

1. Benefit: robots ought to prioritize the best interests of humans.
2. Non-harm: robots must adhere to the principle of "first do no harm", ensuring they do not cause harm to humans.
3. Autonomy: robots should possess the capability to make informed decisions regarding the rules governing their interactions, free from coercion.
4. Fairness: the benefits arising from robotics, particularly the affordability of robots for home care and healthcare, should be distributed equitably.

Additionally, the document elucidates fundamental rights, precautionary measures, integration, liability, safety protocols, reversibility, privacy concerns, and the optimization of benefits while minimizing harm.

The European Commission has put forth three key legal initiatives concerning artificial intelligence (AI): the AI Act, which aims to establish a European regulatory framework for AI; rules addressing liability aspects of new technologies, including AI; and a revision of sectorial safety legislation such as the Machinery regulation. Despite these efforts, there exists a challenge in maintaining clear communication between researchers, policymakers, and the general public, as research and policy documents frequently employ divergent vocabularies, leading to potential misunderstandings. Bridging this gap in terminology is crucial for fostering effective collaboration and ensuring a shared understanding of AI-related initiatives and their implications (Estevez et al., 2022).

Robotics is an ever-evolving field that continues to expand as technology advances. The market of robotics and especially sex robot market evoke a lot of emotions and give rise to many concerns. As a result, new terminology has emerged to describe the latest innovations in

the field. In this article, we will discuss some of the new terminology in sex robotics and its significance.

### 3. Specialised Language and Language of Technology

The language is used to convey information in a concise and precise manner among professionals. The use of specialized languages ensures effective communication among experts in the field (Skubis, 2020).

As Arntz et al. (in Messina, 2015) state, the field of specialization denotes the specific domain to which a term belongs. This criterion holds significant importance when choosing relevant portions from databases, ensuring that only the terminology pertaining to a particular field is retrieved and displayed. According to Hoffmann (1985) a specialised language called also Language for Special Purposes (LSP) is a collection of language tools employed within a specific, restricted domain of communication to facilitate effective interaction among individuals involved in that particular field. Cabré (1999) states that a specialised language is a subcode of a general language. The scientist considers important aspects of the communicative context, such as the individuals engaged in communication, the surrounding circumstances, the objectives, and the intentions underlying the act of communication. These elements are crucial to consider when discussing the communicative situation:

*We speak of special or specialized languages to refer to a set of subcodes (that partially overlap with the subcodes of the general language), each of which can be 'specifically' characterized by certain particulars such as subject field, type of interlocutors, situation, speakers' intentions, the context in which a communicative exchange occurs, the type of exchange etc. Situations in which special languages are used can be considered as 'marked' [...]. Special languages must take account of the elements that play a role in an act of communication: the participants, the communicative circumstances, and the purposes or intentions associated with the communication (Cabré, 1999).*

Coeckelbergh (2015) presents different perspectives on the relationship between humans, language, technology, and the world. These viewpoints reflect varying descriptive and normative approaches, highlighting the mediating role of language as a form of "in-between" and environmental influence. The scientist distinguishes 3 types of relations:

1. The first one is language as a medium between humans and the world:
  - a) Humans-language-world: language mediates our connection to the world, shaping our perception, interactions with others, and actions. It plays a hermeneutic role, influencing our understanding of reality. According to Heidegger, language precedes perception.

- b) (Humans-language)-world: language is used but remains in the background. It is an implicit part of our conventional experience of the world, affecting our thinking and behavior without conscious notice.
- c) Humans-(Language-world): shifting from a hermeneutic to an alterity relation: Language becomes an object within the world. In this perspective, opposed by Heidegger, language is seen as an agent or even an entity separate from humans. This experience can arise in postmodernist thinking, writing, or reading, where the text is perceived as having agency or an authorial presence.

In summary, these different perspectives highlight the diverse ways in which language, as a mediating factor, interacts with human perception, the world, and even technology.

2. The second relation is language as medium between humans and technology (and world):
  - a) Language as an unnoticed medium: language actively shapes our discourse about technology without our conscious awareness. Our understanding of technology is influenced by the language we use, although this influence remains hidden.
  - b) Awareness of language as milieu: recognizing language as a medium or environment allows for a more explicit, hermeneutic, and critical engagement with technology. Philosophy of technology should acknowledge this role of language to critically analyze its impact.
  - c) Language as an intermediary: understanding how language shapes our linguistic and material relationship with technology enables the study and influence of language as a medium between humans and technology. Philosophy of technology needs to include a philosophy of language, and ethical and political considerations regarding technology must also address language.
  - d) Language in relation to technology and the world: this viewpoint suggests that technology can have its own language or script, which should be studied. Alternatively, language itself can be seen as a technology that mediates our connection to the world. This perspective raises questions about whether language is merely a tool or also a medium that shapes the message.

The second type of relations emphasizes the significance of language as a mediating force between humans, technology, and the world. Awareness of language's role allows for critical analysis, ethical considerations, and the understanding of its influence on our interactions with technology.

3. The third type is called as "language and technology mediate our relation to the world":
  - a) (Humans-language-technology)-world: language and technology exert influence on our thoughts and expressions regarding the world, yet their embodied mediation often goes unnoticed. This mediation becomes evident when we delve into the

relationship between language and technology or encounter technologies that possess a communicative aspect.

- b) Humans-(Language-technology-world): language and technology are regarded as integral components of the world, sometimes even assuming the role of alterity. Technologies can “speak” in a literal sense, such as robots engaging in communication, or metaphorically, where technology communicates through a distinct language. This perception encourages us to perceive the world through a different lens when exploring or experimenting with technology.
- c) (Humans-language)-technology-world: language molds our association with the world as we engage with and encounter technology, yet its mediating role is often embodied and overlooked. Language shapes our instrumental perspective of technology, but employing alternative language allows for novel ways of relating to both technology and the world, leading to a transformed understanding of ourselves.
- d) Humans-(Language-technology)-world: the language employed in the realm of technology mediates our connection to the world, and we can develop an awareness of this phenomenon. Technological language surpasses the boundaries of instrumental-technological communication, inviting diverse responses and interpretations. Additionally, language itself can be perceived as a technology and is frequently influenced by other technologies. Both language and technology extend beyond mere tools or media, shaping our actions and perceptions.

Summarising the third type of relations, it accentuates the intertwined roles of language and technology as mediators in our relationship with the world. They have a profound impact on our comprehension, actions, and self-perception, challenging conventional perspectives and fostering alternative approaches to technology and language.

#### **4. Neologisms**

Neologisms have been defined by various linguists and scholars in different ways. Newmark (1988) states that “neologisms can be defined as newly coined lexical units or existing lexical units that acquire a new sense”. At the time of Newmark’s appearance of the book “A Textbook of Translation” in 1988, the scientist cited a figure of 3000 new words emerging annually in each language. Currently, according to the statistics of the Global Language Monitor (GLM), only the English language noted the appearance of about 5366 words a year, however as the GLM indicates, not all of those words are worth to be codified in dictionaries.

The explanation of a neologism provided by the Cambridge Dictionary is as follows “a new word or phrase, or a new meaning for a word that already exists”.

Crystal (in Nabila, Abdulrahman, 2021) claims that a neologism or coinage refers to the process of inventing new words that arise from evolving conditions in the world and find their way into everyday conversations with people. Bauer (2001) defines a neologism as “as a word which ‘becomes part of the norm of the language’”.

As Fang (2021) indicates, they can be described as simply “new” words, terms or phrases which have been recently created to refer to new terms or to reshape older notions in a new linguistic form. According to the scientist (*ibid.*), the following general criteria can be enumerated in reference to the concept of neologisms:

- 1) Neologisms are the words, which didn't occur before and are newly built and currently enter the common lexicons.
- 2) Neologisms are the words, which within a certain period of time, have been widely, accepted by people and still find their applications nowadays.
- 3) Neologisms are those old words, which carry the new meanings (Fang, 2021).

Comparing these definitions, it can be observed that they share the idea that neologisms are newly created words or expressions that are not yet fully established in a language's lexicon.

Yasin et al. (2010) claim that there are some fields where neologisms prevail and they distinguish six types of them: scientific, technological, political, pop-culture, imported, trademarks, nonce words, and inverted words.

Neologisms can be created in several ways, including borrowing from other languages, compounding existing words, or creating new words through derivation or conversion. Newmark (1988) proposes 12 types of neologisms: old words, old words with new senses, new coinages, derived words, abbreviations, collocations, eponyms, phrasal words, transferred words, acronyms, pseudo neologisms, internationalisms, while Algeo (2014) differentiates six types of creating new words: creating, borrowing, combining, shortening, blending and shifting which can be divided into subtypes. Below the proposed types by Newmark (1988) of creating new words are depicted:

1. New words: Old words with new senses are typically unrelated to new objects or processes, making them less likely to be technological terms. Translating neologisms is complex, and there is rarely a single correct translation. The expertise and cultural knowledge of the readership play a role in determining the most appropriate translation. The translation of a neologism depends on its future permanence and importance in the target language's culture.
2. New coinages: Most words are not completely new; they derive from morphemes or have phonaesthetic or synesthetic qualities. However, exceptions like ‘quark’ and ‘byte’ exist, which are coined words with phonaesthetic qualities. Nowadays, new coinages are often brand or trade names.



3. **Derived words:** Many neologisms are derived from ancient Greek and Latin morphemes, particularly for scientific and technological terms. Differentiating between serious derived neologisms and media-created neologisms is important.
4. **Abbreviations:** Abbreviations are common pseudo-neologisms, and unless they coincide with their equivalents in the target language, they should be written out in the translation.
5. **Collocations:** New collocations are common in social sciences and computer language. Computer terms usually have recognized translations, and if not, an added functional-descriptive term is used. The importance and cultural significance of the referent should be considered in translation.
6. **Eponyms:** Eponyms derived from proper names can be translated directly when they refer to a person. However, when they refer to ideas or qualities, additional information may be needed. Eponyms derived from objects are usually brand names and can only be transferred if equally well-known and accepted.
7. **Phrasal words:** Phrasal words in English are often converted verbs turned into nouns. Translating them requires using semantic equivalents, which are more economical but may fall between informal and colloquial register.
8. **Transferred words:** Newly transferred words retain only one sense of their foreign origin and are often media or product-related terms. They may be common to multiple languages due to cultural overlaps or media influence. Generic terms accompanied by specific details are used for translation.
9. **Acronyms:** Acronyms are used for brevity and prestige in non-literary texts. In scientific texts, they may become internationalisms. Acronyms can be standard equivalents or descriptive terms in translation, and they may differ between source and target languages.
10. **Pseudo-neologisms:** Pseudo-neologisms occur when a generic word represents a specific word. Translators should exercise caution when encountering such cases and provide accurate translations, such as translating "rapports (d'engrenage)" as "gear ratios" or "humerales" as "humeral artery".

When it comes to translation of neologisms into another language, the borrowings are often used. According to Daulton (2011) lexical borrowing involves the adoption of words or linguistic elements, such as “roots, affixes, sounds, collocations, and grammatical processes”, from one language or dialect to another. The act of borrowing words from another language is motivated by the necessity to express a concept or describe an object that lacks an equivalent term in the borrower's native language (Holmes, 2013). The borrowed word is also known as a loanword. Many languages seamlessly integrate English terms, often adapting them to align with their own phonetic and spelling rules. This linguistic borrowing is not merely a pragmatic response to the need for new concepts or technologies but is also perceived as a symbol of sophistication and education (Skubis, 2015).

Fang (2021) explores various word formation processes used in English to create neologisms and the scientist distinguishes:

1. **Compounding:** Compounding is the process of combining multiple word elements to form new words. In English, compounds can be written with hyphens, as a single word, or with spaces. Examples of compounds include easy-listening, superhighway, and emotional quotient.
2. **Shortening:** Shortening involves creating new words by omitting part of an existing word. It encompasses various processes like acronym formation, clipping, blending, and backformation.
  - a) **Acronym:** Acronyms are words formed by combining the initial letters of different words. They can be pronounced as individual letters (initialisms) or as complete words. For instance, BBS, CALL, and SARS are examples of acronyms.
  - b) **Clipping:** Clipping entails removing a part of a word and using the remaining portion. This can occur at the beginning, end, or both ends of the word. Examples of clipped words include app (from application program) and bot (from robot).
  - c) **Blending:** Blending combines clipping and combining simultaneously. It involves merging two or more-word forms while excluding part of one. Notable examples of blends are cobot (cooperative robot) and smist (smoke + mist).
3. **Affixation:** Affixation involves adding derivational affixes to base words to create new words. This process includes both prefixation (adding prefixes at the beginning) and suffixation (adding suffixes at the end). Common affixes in English include -er, -able, and -ism.
4. **Conversion:** Conversion is the process of transforming words from one grammatical class to another without altering their morphological structure. It is also referred to as functional shift. Noun-to-verb conversions are particularly common, as seen in examples like sample (n-v) and archive (n-v).

In the case of neologisms in technology, borrowing from other languages is a common method of creation (Crystal, 2006). New terms are being introduced into the vocabulary to explain emerging ideas and technologies, as well as their significance in our lives, while older words gradually fade away as their cultural importance diminishes. The lexicographers observe, due to the profound impact of digital technology on society, that science and technology serve as the primary generators of new words in recent years (McDonald, 2005).

In conclusion, neologisms in technology are an important aspect of the ever-evolving field of technology. They provide a way to communicate new developments and ideas, shape cultural attitudes towards new technologies, and often involve borrowing and repurposing existing words. As technology continues to evolve, we can expect to see the creation of many more neologisms in this field.

## 5. Methodology

The analytical part of this article is divided into two parts. The first one is meant to provide a linguistic analysis of three neologisms which appear on the sex (robot) market. The words that are going to be analysed are: *digisexuality*, *technosexuality* and *robosexuality* in terms of their structure, forms of spelling, adjective forms, their codification in dictionaries and definitions in five languages: English, German, French, Spanish and Polish. The primary source to check their codification are going to be dictionaries adequate for each language: Cambridge Dictionary for English, Duden for German; Larousse for French; Diccionario de la Real Academia Española for Spanish; Słownik Języka Polskiego PWN for Polish. If a definition cannot be found in the above-mentioned dictionaries, the research in other online dictionaries to find their definition is going to take place or the definitions proposed by scientists are going to be depicted. The linguistic formations, definitions, and potential implications of these concepts are examined to uncover their significance within the field of communication research.

The second part of the research aims to present the outcomes of the survey that was administered to a total of 134 students aged 20-24, consisting of 90 females and 44 males. The participants were asked a series of questions related to their knowledge and opinions on emerging sexual technologies, followed by multiple-choice and open-ended questions to gather their views in more depth. The questionnaire was meant to check whether the new generation, generation Z, is conscious of the new terminology on the sex robot market and whether they can provide the differences between three terms that sound quite similar.

## 6. Analysis of the term “digisexuality” in English, German, French, Spanish and Polish

The term *digisexuality* can be classified as a blend neologism. It is formed by combining the shortened form derived from the adjective *digital* functioning as a prefix *digi* in all five languages with the root *sexuality* (EN), *Sexualität* (DE), *sexualité* (FR), *sexualidad* (ES), *seksualność/seksualizm* (PL). It is worth noting that in Polish, there are two equivalents for *sexuality*: *seksualność* as a feminine noun and *seksualizm* as a masculine noun. In all other languages the root is a feminine noun (in English there is no division between genders).

This combination creates a new word that represents the concept of sexual attraction, orientation, or identity related to digital technologies, virtual experiences, or interactions with artificial intelligence and robotic devices.

Forms of spelling:

- English: Digisexuality.
- German: Digisexualität.
- French: Digisexualité.
- Spanish: Digisexualidad.
- Polish: Digiseksualność/Digiseksualizm.

Its adjective form is more often used than the noun. In English the adjective is *digisexual*, however in German, French, Spanish and Polish their form agrees with the gender as listed below:

- English: Digisexual (no gender agreement).
- German: Digisexuell (masculine/feminine).
- French: Digisexuel (masculine), digisexuelle (feminine).
- Spanish: Digisexual (masculine/feminine).
- Polish: Digiseksualny (masculine), digiseksualna (feminine).

The neologism *digisexuality* is a new term which is still not codified in German, French, Spanish and Polish. In English, its definition appears in *Word Sense Dictionary: digisexuality – (neologism) sexual attraction to sexbots or other technologically-enhanced sexual situations*. In *Collins Dictionary* there is the information that it is a new word suggestion, and its approval status is marked as pending, and it gives the following definition: *digisexual - someone who expresses their sexuality through technological devices*.

The concept of digisexuality is a recent development and lacks formal definition. The widely accepted description, proposed by Neil McArthur (2017, p. 335), characterizes digisexuality as the use of technology for engaging in sexual activities or relationships, including platforms like Skype, Tinder, Snapchat, Facebook, and others. According to McArthur, this implies that we are all digisexual to some degree, as these technologies provide intense and immersive sexual experiences without the need for a human partner.

Additionally, McArthur (*ibid.*) distinguishes between two waves of digisexuality. The first wave encompasses the sexual technologies mentioned earlier, which enable connections with current or potential partners. This wave has a broader interpretation. On the other hand, the second wave of digisexuality, as proposed by McArthur, refers specifically to individuals whose sexual identity is shaped by second-wave sexual technologies, carrying a narrower connotation.

From a linguistic perspective, we disagree with McArthur's definition that includes all internet applications, such as Skype, Twitter, Snapchat, Facebook, as part of digisexuality. It is evident that these applications can be used in various ways depending on the user's intentions, but their primary purpose is not solely for finding partners or engaging in romantic affairs, unlike dedicated dating apps.

The term digisexuality implies a digital aspect to our sexuality, indicating the pursuit of online sexual experiences through the internet. This may involve activities like watching videos, participating in webcam interactions, engaging in chats or phone calls (with or without video), visiting escort agency sites, exploring sex doll sites, or using dating portals. Tweeting on Twitter may revolve around politics, while Skype calls are often meant for maintaining contact with friends or family, similarly to Facebook and Messenger. A person who utilizes these communication forms may be digital in their interactions, but it does not automatically classify them as digisexual.

## 7. Analysis of the term “technosexuality” in English, German, French, Spanish and Polish

The term *technosexuality* can be classified as a blend neologism. Like the term *digisexuality*, it is formed by combining the shortened form of the adjective *digital* – *digi* in all five languages with the root *sexuality* (*EN*), *Sexualität* (*DE*), *sexualité* (*FR*), *sexualidad* (*ES*), *seksualność/seksualizm* (*PL*). Once again, it needs to be remembered that in Polish, there are two equivalents for *sexuality*: *seksualność* as a feminine noun and *seksualizm* as a masculine noun, however the second version is much less popular. In all other languages the root is a feminine noun (in English there is no division between genders).

In every one of the five languages, there exists a shortened version of the term *technology*. However, the abbreviated form in Spanish differs from the others, as it is spelled without the letter "h" - *tecno*. In the remaining four languages, the abbreviated form retains the "h" and is written as *techno*.

Technosexuality refers to the incorporation of technology into sexual experiences, relationships, and identities. It encompasses a wide range of practices, including virtual reality, sex toys, teledildonics, remote intimacy, and more. Individuals who identify as technosexuals embrace and explore the ways in which technology enhances their sexual and intimate encounters.

Forms of spelling:

- English: Technosexuality.
- German: Technosexualität.
- French: Technosexualité.
- Spanish: Tecnosexualidad.
- Polish: Technoseksualność/technoseksualizm.

Like in the case of the term *digisexuality*, the dominance of the adjective form of the noun *technosexuality*, i.e. *technosexual* is evident in online sources.

- English: Technosexual (no gender agreement).
- German: Technosexuell (masculine/feminine).
- French: Technosexuel (masculine), technosexuelle (feminine).
- Spanish: Tecnosexual (masculine/feminine).
- Polish: Technoseksualny (masculine), technoseksualna (feminine).

In all five languages, there exist adjectives derived from the noun *technosexuality*. In English *technosexual* (EN), in German, it is *technosexuell* (DE). In French, the corresponding terms are *technosexuel* for masculine nouns and *technosexuelle* for feminine nouns (FR). In Spanish, it is referred to as *technosexual* (ES). Polish employs two forms: *technoseksualny* for masculine nouns and *technoseksualna* for feminine nouns (PL). It is worth noting that Polish and French have distinctive forms of adjectives to account for masculine and feminine nouns. Furthermore, within this word family, there is a noun that describes a particular form of sexual intercourse: *technosex* (EN), *Technosex* (DE), *technosex* (FR), *tecnosex* (ES), *technoseks* (PL).

The neologism *technosexuality* is a new term which is still not codified in English, German, French, Spanish and Polish. In English, a definition cannot be found in Cambridge Dictionary or other dictionaries, however its definition exists on Wikipedia. Wikipedia is not a scientific source but sometimes it is the only one that provides a desired definition:

*Technosexuality is a word used to mean two things:*

1. *Having a strong love of gadgets. This is a joining of the two words “technophile” and “metrosexuality”. It was first used by Ricky Montalvo to describe someone who was in love with himself and his urbanlifestyle, as well as gadgets such as mobile phones, PDAs, computers, software, and the web.*
2. *A different word for robosexuality. This meaning of technosexuality is a join of “technophile” and “sexual”.*

There is no definition of a noun *technosexuality* in dictionaries, whereas the definition of its adjective form *technosexual* can be found.

To those unfamiliar with the subject, the terms *digisexuality* and *technosexuality* may sound alike. Upon analyzing the names, one might assume they pertain to new technologies, yet distinguishing between them proves challenging due to their similar components – *digi* and *techno* – both relate to the digital and technological domains, giving them an analogous ring.

However, delving into online articles reveals that the noun *technosexuality* and the adjective *technosexual* actually refer to individuals who possess a fascination with gadgets, erotic toys, electronic devices, or robots. Some interpretations even classify it as a form of fetishism. As Montalvo states, a technosexual person is characterized as a "narcissistic being fascinated by computers". Interestingly, the term itself is not recent, originating in the 1970s to describe the sexual attraction some individuals feel towards machines, robots, and gadgets.

## 8. Analysis of the term “robosexuality” in English, German, French, Spanish and Polish

The expression appears to be a blend neologism formed by combining the shortened form of the adjective *robotic* or *robot* with the root *sexuality* in various languages. In the case of a compound *robosexuality*, there are two equivalents for *sexuality* in Polish language: *seksualność* as a feminine noun and *seksualizm* as a masculine noun, however the second version, a compound *roboseksualizm* is not so popular.

*Robosexuality* can be defined as a sexual attraction or orientation towards robots or artificial intelligence.

Forms of spelling:

- English: Robosexuality.
- German: Robosexualität.
- French: Robosexualité.
- Spanish: Robosexualidad.
- Polish: Roboseksualność.

In all five languages, there are adjectives derived from the noun *robosexuality*. The English term is *robosexual* (EN), German uses *robosexuell* (DE), French has *robosexuel* for masculine nouns and *robosexuelle* for feminine nouns (FR), Spanish uses *robosexual* (ES), and in Polish there are two options depending on the gender: *roboseksualny* for masculine nouns and *roboseksualna* for feminine nouns (PL).

- English: Robosexual (no gender agreement).
- German: Robosexuell (masculine/feminine).
- French: Robosexuel (masculine), robosexuelle (feminine).
- Spanish: Robosexual (masculine/feminine).
- Polish: Roboseksualny (masculine), roboseksualna (feminine).

Additionally, within this word family, there is a noun that describes a particular form of sexual intercourse: *robosex* (EN), *Robosex* (DE), *robosex* (FR), *robosex* (ES), *roboseks* (PL).

Overall, *robosexuality* refers to the incorporation of robotic technology into sexual experiences, relationships, and identities. It suggests a concept where individuals explore and embrace the ways in which technology enhances their sexual encounters with robots or robotic devices.

There is no definition of a noun *robosexuality* in dictionaries in all five mentioned languages. If there exist any definition, it concerns its adjective form *robosexual* and it appears in the dictionaries created by society like Urban Dictionary or Wikipedia. The second one gives the explanation of *robosexual* as follows “a person who is sexually attracted to robots”.

## 9. Outcomes of the survey

The purpose of the survey questions among students aged 20-24 is to gather information on their awareness, knowledge, and attitudes regarding emerging sexual technologies, such as “digisexuality”, “technosexuality”, and “robosexuality”. These questions are designed to achieve several specific objectives:

1. Gender Distribution (Question 1):  
to capture the gender distribution of the surveyed population, which can help identify potential gender-related variations in responses to the subsequent questions.
2. Awareness of Emerging Sexual Technology Terms (Questions 2-4):  
to assess the extent to which students in this age group are familiar with terms like “digisexuality”, “technosexuality”, and “robosexuality”.
3. Understanding of Terminology (Questions 2-4):  
to collect short definitions from participants who have heard of these terms, aiding in understanding their interpretations and the depth of their knowledge.
4. Differentiation Between Terms (Question 5):  
to determine if respondents can differentiate between the terms "digisexuality", "technosexuality", and "robosexuality", which helps gauge their comprehension of these concepts.
5. Comfort Discussing Sex Robots (Question 6):  
to evaluate the participants’ comfort level in openly discussing the topic of sex robots, which provides a better understanding of the social acceptability and willingness to engage in conversations about this emerging technology.

134 students aged 20-24, consisting of 90 females and 44 males participated in the survey. The purpose of the questionnaire was to assess the awareness of the new generation, Generation Z, regarding the terminology used in the sex robot market and to determine if they could distinguish between three closely related terms.

The survey consisted of the following questions:

1. Indicate your gender: A) Female B) Male
2. Have you ever heard the term “digisexuality” or “digisexual” – Yes / No  
If yes, provide a short definition: .....
3. Have you ever heard the term “technosexuality” or “technosexual” – Yes / No  
If yes, provide a short definition: .....
4. Have you ever heard the term “robosexuality” or “robosexual” – Yes / No  
If yes, provide a short definition: .....
5. Do you know the difference between those three above mentioned terms? Yes / No  
If yes, indicate the difference: .....
6. Are you comfortable discussing the topic of sex robots openly? Yes / No



The results can be summarized as follows:

Age: The participants' age range was 20-24 years.

Gender Distribution:

- Female: 90 (67%).
- Male: 44 (33%).

Awareness of Terms:

- Digisexuality: None of the participants had heard of this term.
- Technosexuality: None of the participants had heard of this term.
- Robosexuality: 18 participants were able to provide a correct definition with their own words.

Understanding of Terms:

Most participants (both female and male) stated they did not know the differences between the mentioned terms.

Comfort Discussing Sex Robots Openly:

- Female: 56 (62%) were comfortable, 34 (38%) were not comfortable.
- Male: 32 (73%) were comfortable, 12 (27%) were not comfortable.

In our study, we collected the following results from our participants: the age range of the participants fell between 20 and 24 years. Regarding the gender distribution of our participants, 90 were female, constituting 67% of the total, and 44 were male, making up 33% of the sample.

When it came to the awareness of specific terms related to sexual technologies, it was found that none of the participants had heard of the term “digisexuality” or “technosexuality”. However, for the term “Robosexuality”, 18 participants were able to provide their own accurate definitions – they were not familiar with the concept but they were able to divide the term into two words and guess the meaning. Guessing the meaning of two other terms “digisexuality” and “technosexuality” was not so easy because their meaning cannot be deciphered based on the words they are composed of.

Concerning the understanding of these terms, the majority of participants, both female and male, indicated that they did not possess a clear understanding of the differences between the terms. It was no surprise that students could not provide the differences between those three terms as they did not know the definitions of each of them.

Furthermore, we explored the participants' comfort levels when discussing sex robots openly. Among the female participants, 56 (62%) reported feeling comfortable engaging in such discussions, while 34 (38%) expressed discomfort. For the male participants, 32 (73%) reported being comfortable discussing sex robots openly, whereas 12 (27%) reported discomfort in doing so. These findings demonstrate the varying degrees of openness and familiarity with emerging sexual technologies within our sample group.

## 10. Conclusions

The terms *digisexuality*, *technosexuality* and *robosexuality* can be classified as blend neologisms in English, German, French, Spanish, and Polish, formed by combining the prefix *digi*, *techno* or *robo* with the root *sexuality* in each language. All those terms are still not codified in dictionaries, however the definitions of their adjective forms appear in English in dictionaries created by the society, because the adjectives are more commonly used than the nouns. The adjective forms demonstrate gender agreement in French and Polish.

All those three concepts seem similar and it might be difficult for a non-professionalist to show the differences between those expressions. In terms of definitions, *digisexuality* focuses on the use of technology for sexual experiences, *technosexuality* encompasses the incorporation of technology into sexual encounters, and *robosexuality* specifically refers to attraction or activities involving robots.

Linguistically, all three terms follow consistent patterns in their formation across English, German, French, Spanish, and Polish. It is worth noting that while *digisexuality* has been recognized and discussed to some extent, *technosexuality* and *robosexuality* may be less widely codified in dictionaries.

These comparative analyses demonstrate the nuances and similarities between these emerging concepts, providing their definitions and linguistic representations across five languages. Their definitions focus on the incorporation of technology into sexual experiences and relationships, encompassing diverse aspects of human-technology interactions.

When it comes to our survey, it aimed to assess the awareness, knowledge, and attitudes of students aged 20-24 toward emerging concepts connected with sexual technologies, namely “digisexuality”, “technosexuality”, and “robosexuality”. The survey encompassed 134 participants, with 67% being females and 33% males.

The findings showed that none of the participants had prior knowledge of “digisexuality” or “technosexuality”, but 18 participants could provide their own explanations for “robosexuality.” Most participants, regardless of their gender, acknowledged a lack of comprehension regarding the distinctions between these terms, which was unsurprising considering their unfamiliarity with the definitions.

Additionally, there were gender-related variations in participants’ comfort levels when discussing sex robots openly. 62% of females and 73% of male participants expressed comfort in such discussions. In contrast, 38% of females and 27% of males reported discomfort in engaging in such conversations. It should be underlined that this discrepancy can change with a bigger sample of participants and the equal number of both genders as in this survey took part 90 women and 44 men.

In conclusion, this survey offers valuable information about the awareness and comfort levels of Generation Z students concerning emerging sexual technologies. It emphasizes the significance of education and open dialogue on these topics, particularly in view of the evident disparities in familiarity and comfort within our sample group.

Understanding the new terminology is crucial for researchers and practitioners working in the fields of communication, technology, and human sexuality in the 21st century. As these concepts continue to evolve, further research is encouraged to deepen our understanding of their impact on human experiences and relationships.

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## HUMANOID ROBOTS IN MANAGERIAL POSITIONS – DECISION-MAKING PROCESS AND HUMAN OVERSIGHT

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**Purpose:** This article explores the roles of humanoid robots as CEOs in modern corporations, with a focus on Mika and Tang Yu as case studies. It compares their decision-making processes and emphasizes the importance of human oversight for ethical decisions. The article also discusses the European Union's guidelines on decision-making of AI and human oversight. Additionally, it examines the potential for robots to replace CEOs and the importance of human-robot collaboration in the future of corporate management and decision-making.

**Design/methodology/approach:** This article begins by providing statistics on the humanoid robot market and then profiles two well-known humanoid robots, Mika and Tang Yu, who function as CEOs. The research compiles data from various sources to create a comprehensive dataset on their roles and functions. It analyzes their responsibilities, decision-making processes, and interactions with humans to identify differences and similarities between them. The paper also examines EU guidelines on AI decision-making and explores the future of corporate management and decision-making.

**Findings:** Two humanoid robots, Mika and Tang Yu, have assumed CEO roles with distinct approaches. Mika, a real humanoid robot, focuses on community engagement and efficient data-driven decisions. Tang Yu, a virtual humanoid robot, concentrates on workflow optimization through data-driven decision-making and significantly improving the company's stock market value. While Mika's decision-making encompasses emotional and strategic elements, Tang Yu's approach emphasizes data-driven analysis. Both CEO robots require human oversight to align with company values and ensure ethical decision-making. The future holds potential for robots to reshape corporate leadership, but ethical concerns and human-robot collaboration remain crucial.

**Practical implications:** The research shows that the corporate management is undergoing change and evolution by integrating humanoid robots into future roles as managers, leaders, and CEOs. CEO robots are expected to reshape corporate leadership through their evolving decision-making capabilities, adaptability, and a focus on data-driven, analytical, and strategic decision-making.

**Social implications:** The introduction of humanoid robots as CEOs represents a significant shift in corporate leadership. While the potential benefits in terms of efficiency and decision-making are substantial, the associated social implications, including job displacement and ethical considerations, must be managed carefully to ensure a smooth transition and positive outcomes for society as a whole.

**Originality/value:** The article presents and compares two humanoid robots who act as CEOs. It analyses the EU guidelines in terms of decision-making and human oversight and makes a valuable contribution to the discussion of the future of corporate leadership and management.

**Keywords:** humanoid robot, humanoid robot CEO, humanoid robot leader, decision-making, human oversight.

**Category of the paper:** Research paper.

## 1. Introduction

The industrialization process has been greatly shaped by technological advancements, particularly the Industrial Revolutions. The third revolution, which focused on automation, emerged in the late 20th century and is still widely used by many companies (Sanghavi et al., 2019).

Industry 4.0, the fourth industrial revolution, represents a new level of organization and control over the entire product lifecycle, with a primary focus on meeting individual customer requirements. This revolution impacts various aspects of the industry, including research and development, design, inventory management, service, and customer care (Vaidya et al., 2018; Neugebauer, 2016).

Industry 4.0 is expected to drive significant development in the coming decades and is associated with terms like “smart factory”, “smart manufacturing”, “big data analytics”, “cyber-physical systems”, and “smart machines”. It embodies the digitization of manufacturing through the integration of advanced technology into successive generations of tools and techniques.

In the past, technology development primarily aimed at automation, but today’s focus is on smart industry technologies that facilitate cooperation between humans and machines. This means that teams in smart industries consist not only of humans but also include AI-powered robots, as noted by various researchers (Molitor, Renkema 2022).

## 2. Literature review

### 2.1. Collaboration of AI with humans

Collaboration between humans and AI leads to significant performance improvements in businesses. This collaborative intelligence capitalizes on the complementary strengths of both parties, with humans contributing leadership, teamwork, creativity, and social skills, while AI offers speed, scalability, and quantitative capabilities (Gościński, Wodarski, 2019).

To fully use the potential of this collaboration, companies should understand how humans can enhance machines and vice versa, and redesign their processes accordingly.

Five principles for optimizing this collaboration include reimagining business processes, encouraging experimentation and employee involvement, actively guiding AI strategy, responsible data collection, and redesigning work to incorporate AI and develop relevant employee skills. A survey of 1,075 companies across 12 industries found that adopting more of these principles correlated with better AI initiative performance in terms of speed, cost savings, revenues, and other operational measures (Wilson, Daugherty, 2018).

The advent of humanoid robots creates a new working environment, transforming the way enterprises operate and manage resources. Traditional managerial roles are now being redefined as companies increasingly explore the incorporation of humanoid robots into these positions.

This article demonstrates the potential of humanoid robots as managerial assets, addressing their implications for future of corporate management and decision-making within the context of enterprise management.

## **2.2. Service robots, cobots (collaborative robots) and humanoid robots**

For the purpose of this article, it is necessary to provide the definition of a *humanoid robot*, however, it is worth mentioning some broader notions first. Defining robots is challenging due to the absence of a global scientific consensus. In broad terms, a robot is seen as a physical machine capable of awareness, decision-making, and may also possess autonomy and learning, communication and interaction skills. This definition refers mostly to autonomous robots, which are characterised by their ability to acquire autonomy through sensors or data exchange with their environment, optional self-learning capability, a physical form, and adaptability to their surroundings (Nevejans, 2016).

The International Organization for Standardization (ISO) issued a document called ISO/TS 15066:2016 in which the definitions related to collaborative robots are explained. According to this document, the term *collaborative operation* is a “state in which a purposely designed robot system and an operator work within a collaborative workspace”, while *collaborative workspace* is a “space within the operating space where the robot system (including the workpiece) and a human can perform tasks concurrently during production operation”. A *collaborative robot* is a “robot designed for direct interaction with a human within a defined collaborative workspace”.

Another type of a robot that is defined, is an *industrial robot*, which definition appears in ISO 8373:2021. In accordance with this document, an *industrial robot* is a programmable, multipurpose manipulator that can be automatically controlled in three or more axes. It can either be fixed in place or attached to a mobile platform and is used for automation applications in an industrial environment. This term encompasses the manipulator, the robot controller, and the means for teaching or programming the robot, including communication interfaces. Industrial robots may also include auxiliary axes integrated into their kinematic

solution, and they cover the manipulating portion of mobile robots, where a mobile robot consists of a mobile platform with an integrated manipulator or robot (ISO 8373:2021).

The next definition, essential in the context of this article, is the one of a *service robot*, which appears in ISO 8373:2021, and is as follows: “robot (3.1) in personal use or professional use that performs useful tasks for humans or equipment”. There are two additional notes to this definition, the first one relates to their personal use, where service robots can be involved in various tasks such as handling or serving items, transportation, providing physical support, offering guidance or information, grooming, cooking and food handling, and cleaning. These tasks are typically related to assisting individuals in their daily lives. The second note refers to their professional use, in which service robots are employed for tasks including inspection, surveillance, handling of items, transporting individuals, providing guidance or information, cooking and food handling, and cleaning. These tasks often pertain to supporting or automating processes in a professional or industrial setting.

A term *social robot* does not have a separate entry in the above mentioned documents, however, they are a sub-type of service robots. Social robots are an emerging frontier in the field of personal robotics. They are created to independently engage with people in diverse application areas using natural and intuitive interactions, employing the same social signals as humans (Vollmer et al. 2018). Shortly, a social robot is a physical robot that has the capability to engage in social interactions with people (Sharkey, A., Skarkey, N., 2020).

The technical report “Automation and Robots in Services” by Sostero in 2020 defines *social robots* as capable of interacting and communicating with each other, with humans, and their surroundings. The report clarifies that service robots have the potential to function as social robots, such as customer-service bots, but it is not a requirement. On the other hand, some social robots designed for personal use, not professional tasks, do not fit the definition of service robots according to the same report.

Finally, we can move to the definition of a humanoid robot, which is the basis for the empirical part of this article and the analysis is going to be based on the definition provided by ISO 8373:2021, in which a *humanoid robot* is defined as follows: “robot (3.1) with body, head and limbs, looking and moving like a human”. This definition is essential for the empirical study of this paper.

### **2.3. Robot-supervisor and decision-making process**

The robots as supervisors evoke many emotions. On the one hand, they inspire admiration and hope; on the other, doubt and fear of potential consequences, including, for example, the loss of jobs.

Yam et al. (2022) indicate that a robot supervisor offers numerous advantages, primarily due to its exceptional data processing capabilities, enabling it to efficiently incorporate extensive information into its decision-making processes. Gombolay et al. (2015) examined the integration of highly autonomous mobile robots into human teams in manufacturing.



The research explores shared decision-making authority in human-robot and human-only teams. The results proved that autonomous robots can outperform humans in task allocation and that people are willing to cede control authority to robots.

While humans value human teammates more, giving robots authority over team coordination enhances the perceived value of these agents more than giving the same authority to another human teammate. The study also identifies a tendency for people to take on more work when collaborating with a robot than with human teammates. The findings offer design guidance for integrating robotic assistants into the workplace (Gombolay et al., 2015).

The results obtained by Haesevoets et al. (2021) in their research suggest that most managers are willing to accept a cooperative partnership with machines, provided that humans retain a substantial role in decision-making. The scientists emphasize the importance of finding optimal levels of human-machine collaboration for efficient decision-making.

Despite early promise, AI in management is currently used mainly for routine decisions. To unlock its potential, it is important to focus on delegating decisions to AI. For example, in sensitive areas like mergers and acquisitions, AI can provide input while managers retain control. AI complements human decision-making by handling specific tasks, not replacing entire roles. Humans and AI have unique strengths, and companies should delegate decisions that augment managerial abilities to fully benefit from AI.

Raisch and Krakowski (2020) analysed three books presenting the relationships between automation and augmentation. The companies can choose one of those two options in terms of AI usage. Automation minimizes human involvement for efficient processing, while augmentation promotes ongoing collaboration between humans and machines to profit from their respective strengths, like intuition. The choice between these approaches depends on the task: automation is suitable for routine and structured tasks, while augmentation is better for complex and ambiguous ones (Davenport and Kirby in Raisch and Krakowski).

Apart from advantages, machines have also some limitations in management tasks, including:

1. Goals and purposes

They lack a sense of self or purpose, so humans must define their objectives and take responsibility for the associated tasks and outcomes. This responsibility relies on human intentionality. In tasks like product innovation and talent acquisition, humans set objectives, remain involved, and take responsibility (Braga, Logan, 2017; Raisch, Krakowski 2020).

2. Intuition and imagination

For complex managerial tasks, machines can only provide options that relax the real-life constraints. Managers need to use their intuition and common-sense judgment to make final decisions based on machine output. In talent acquisition and product development, machines can automate certain aspects but cannot fully handle the complexity, especially in assessing ambiguous predictors like cultural fit or interpersonal relations (Raisch, Krakowski, 2020).

Humans use logical reasoning for planning and problem-solving but also heavily rely on intuition in activities that require quick decisions. Wicked problems are solved by making intuitive, new assumptions, not through logic. AI devices, working within a closed logical system, cannot handle wicked problems due to their inability to intuit new paradigms or assumptions. Diverse beliefs among humans are influenced by intuition and varying emotional needs (Braga, Logan, 2017).

Braga and Logan (2017) underline that computers lack imagination as they do not perceive things as humans do; they are confined by logic. Imagination means thinking outside the box, while logic is about demonstrating equivalence between statements, not generating new knowledge. Creativity and imagination are intuitive, posing a barrier for computers to achieve general intelligence.

3. Experience and task assignment

Machines are limited to the tasks they have been trained for and lack the general intelligence to transfer their knowledge to other domains. As a result, managers must ensure contextualization beyond automated tasks. For instance, HR managers must coordinate meetings to align hiring decisions with business strategy, and product developers need to collaborate with marketing departments to match their products with business models (Raisch, Krakowski, 2020).

4. Emotions, curiosity, humour – human senses and social skills

Machines lack human senses, perceptions, emotions, and social skills, while humans cannot function without emotions. For example in the HR department, HR managers use emotional and social intelligence to establish relationships and attract talent, which machines cannot replicate (Raisch, Krakowski 2020).

Computers lack chemical neurotransmitters, which explains their inability to experience emotions and the associated drives. Emotions are crucial for intelligence, driving purpose, objectives, and goals. They also play a vital role in fostering curiosity, creativity, and aesthetics, all of which are essential components of human intelligence. Curiosity is both an emotion and a behaviour, and without the emotional aspect, the behavior of curiosity is impossible. Since computers lack the capacity for emotions, they cannot be curious, which is a fundamental element of intelligence (Braga, Logan, 2017).

5. Accountability

Delegating decisions to AI instead of humans presents a challenge in terms of accountability. Managers are held responsible for AI errors, raising significant governance concerns for the company, especially when these errors have profound and long-lasting impacts on legal, ethical, financial, and strategic aspects (Feuerriegel et al., 2022).

Moreover, the emergence of humanoid robots in managerial positions can be analysed in terms of Responsible Leadership (RL) which, as outlined by Maak and Pless, prioritizes the creation of forward-looking systems that benefit a variety of stakeholders. Ethical leadership fosters positive relationships between employees and society (Skubis et al., 2023a).

Responsible leadership, as described by Trevino et al. (2000), centers on leaders serving as positive role models, displaying virtuous behavior, upholding ethical standards, promoting ethical and pro-social conduct in the workplace, and employing moral reasoning in decision-making. It goes beyond motivating employees; it influences organizational citizenship behaviour, fostering innovation, commitment, and job satisfaction, ultimately benefiting the well-being of the business, employees, and society as a whole (Skubis et al., 2023b)

Humanoid robot CEOs, free from human biases and emotions, have the capacity to consistently uphold ethical standards, promoting ethical and socially responsible behavior in the workplace. This parallels the idea of leaders serving as role models, as suggested by Trevino et al.

### **3. Examples of humanoid robots on the market**

The concept of humanoid robots has long captivated the human imagination, permeating our science fiction and cultural narratives with visions of machines that emulate our form and abilities. For decades, the idea of creating robots that can walk, talk, and interact with us on a human level has been a driving force in the field of robotics. While we have not yet achieved the seamless integration of human and machine that fiction often portrays, remarkable strides have been made in the development of humanoid robots.

When evaluating humanoid robots in conversation two primary factors can be taken into account, as in the case of dialogue systems: their human likeness and the adequacy of their responses. The concept of adequacy encompasses various aspects, including the correctness, relevance, and coherence of their interactions (Wolk et al., 2022; Wolk et al., 2021).

Humanoid robots are inspired by human capabilities and aim to replicate not only the physical appearance but also the cognitive and emotional aspects of human beings. There exists a diverse array of humanoid robots, each uniquely designed to mimic various aspects of human anatomy and behaviour (Kemp et al., 2014). They are designed to perform tasks that require human-like dexterity, mobility, and adaptability, making them relevant in a wide range of applications, from healthcare and education to entertainment and research. Below some famous humanoid robots along with their short description:

### 1. Sophia by Hanson Robotics



**Figure 1.** Sophia, <https://www.hansonrobotics.com/sophia>

Sophia is a highly advanced humanoid robot known for her human-like appearance and ability to hold conversations. The robot, created by David Hanson, uses artificial intelligence to process information and respond to questions. In October 2017, Sophia was granted citizenship in Saudi Arabia during the Future Investment Initiative in Riyadh. That same year, she was also recognized as the first non-human “Innovation Champion” at an Asian United Nations Development Programme symposium.

In terms of natural language processing, Sophia employs three distinct control systems. The first is a timeline editor for entirely pre-written speeches, enabling users to input speeches in advance. Sophia converts the written text into speech while servomotors generate human-like expressions during performances. A more advanced speech production system, the intelligent chatbot, is used for interactive conversations, using Google’s algorithms to comprehend human queries, search for answers in a database, and generate concise responses. The third speech control system, opencog, is under development by Ben Goertzel and is envisioned to evolve into a second-generation artificial intelligence (AGI). This aligns with the Loving AI development project, affiliated with the SingularityNet network founded by Goertzel, aimed at promoting open-source AI development. This initiative facilitates access to extensive data for independent researchers, reducing dependency on technology giants (Parviainen and Coeckelbergh 2020).

### 2. Atlas by Boston Dynamics



**Figure 2.** Atlas by Boston Dynamics, <https://bostondynamics.com/atlas>

The information about Atlas on Boston Dynamics website presents Atlas as an advanced humanoid research robot with state-of-the-art hardware and a sophisticated control system, allowing remarkable mobility and bimanual manipulation. Atlas is used to explore the potential of humanoid robots, emphasizing agility and speed. It is part of the endeavor to create the next generation of robots that possess the required mobility, perception, and intelligence to seamlessly integrate into our daily lives.

### 3. ASIMO by Honda



**Figure 3.** ASIMO, <https://asimo.honda.com/default.aspx>

ASIMO was designed for tasks like walking, climbing stairs, and assisting in human environments. It also had the capability to recognize faces and voices (Sakagami et al., 2002). The robot has advanced communication abilities and is capable of recognising various aspects of human interaction and communication, making it highly adept at engaging with people. ASIMO uses cutting-edge recognition technology, including (<https://asimo.honda.com/default.aspx>):

- recognition of moving objects: it can detect and track the movements of multiple objects using a camera installed in its head;
- posture/gesture recognition: it interprets hand movements, postures, and gestures, allowing it to respond to natural human movements;
- environment recognition: the robot can assess its surroundings and navigate around obstacles to prevent collisions;
- sound recognition: ASIMO can distinguish between different sounds, including voices and other environmental noises;
- face recognition: ASIMO can recognise faces, even in motion.

#### 4. Nao by SoftBank Robotics



**Figure 4.** NAO, <https://us.softbankrobotics.com/nao>

The description of NAO on SoftBank Robotics' website depicts NAO as a highly versatile and interactive robot that serves as a valuable educational tool, particularly for teachers and students. As a programmable personal teaching assistant, NAO can enhance the learning experience by making lessons more engaging and enjoyable. This robot forms genuine connections with students, establishing trust and fostering a positive learning environment.

Designed to captivate students' attention and maintain their focus, NAO combines knowledge with a warm and patient personality. Its interactive nature inspires students to remain committed and persistent in their learning endeavors, thus promoting active engagement in the educational process.

As can be read on the website, NAO bridges the gap between theoretical concepts and practical application through hands-on projects that encourage participation, teamwork, and creative problem-solving. Regardless of age, NAO is equipped to assist a broad range of students, from preschoolers to those pursuing advanced degrees. It can introduce STEM students to the world of programming and provide additional support and attention to children with special needs, making it a valuable asset in diverse educational settings.

As Podpecan (2023) indicates, the NAO robot is widely analysed in Child-Robot Interaction (CRI) research, particularly with children but also involving other age groups. In 2021, Amirova et al. (2021) underlined that a huge number, over 13,000 of NAO robots were deployed across over 70 countries globally.

#### 5. Pepper by SoftBank Robotics



**Figure 5.** Pepper, <https://us.softbankrobotics.com/pepper>

Pepper, as the previous example – NAO, is created by SoftBank Robotics. Pepper is a people-centric robot, designed to connect, assist, and share knowledge while benefiting businesses. On the SoftBank Robotics' website the following industries are mentioned where Pepper can be used, that is: healthcare, hospitality, senior living, commercial cleaning, higher education, workplace and multifamily. The company advertises the characteristics of the robot in selected sectors.

In retail, Pepper engages customers, answers queries, recommends products, and guides them to desired items, resulting in improved customer satisfaction, cost reduction, decreased turnover, and increased sales with better margins.

In the banking sector, Pepper offers a unique and enjoyable customer experience by addressing common questions, assisting with paperwork, and educating clients about services. This reduces wait times and allows staff to focus on more critical tasks.

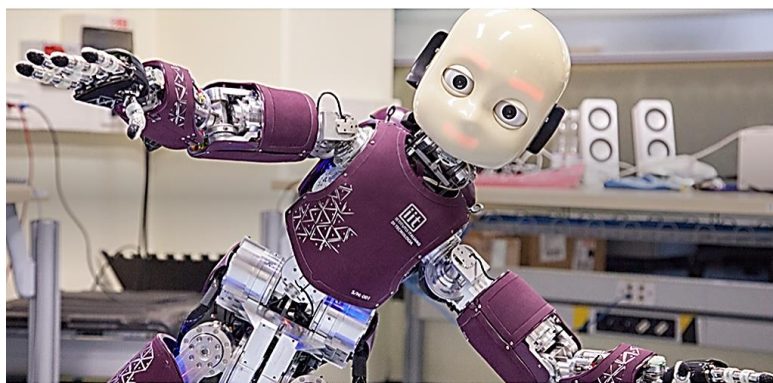
In education, Pepper caters to students of all ages, providing interactive learning experiences that make subjects like STEM more engaging. It sparks curiosity and prepares students for future technologies, particularly in fields like computer science and robotics.

In the hospitality industry, Pepper becomes a friendly, futuristic presence at events and venues, offering greetings, guiding visitors, connecting them with information or individuals, and making wait times more pleasant.

In healthcare, Pepper supports both hospitals and patients by aiding with scheduling, guiding visitors through facilities, collecting health data, and providing companionship and assistance to individuals with health issues that affect independent living.

In terms of robot's autonomy, Pepper possesses modules and applications that enable it to exhibit behavioral autonomy in specific applications. This reduces the reliance on human intervention, making it more self-sufficient in certain tasks (Pandey, Gelin, 2018).

#### 6. iCub by the iCub Consortium



**Figure 6.** iCub, <https://icub.iit.it/products/icub-robot>

iCub is a research-oriented humanoid robot created to facilitate the development and testing of embodied AI algorithms. It is well-suited for robotics laboratories and is part of the iCub Project. iCub is 104 cm tall, roughly the size of a five-year-old child. It possesses versatile mobility, including crawling, walking, and sitting to manipulate objects. Notably, its hands are designed for sophisticated manipulation skills, as stated on its website.

The iCub is distributed as Open Source under GPL licenses designed for cognitive development studies in robotics. Over 40 such robots are now in use worldwide, including Europe, the US, Korea, Singapore, China, and Japan. It distinguishes itself with a sensitive full-body skin for physical interaction with the environment, including people. The project aims to make personal humanoid robots a reality for everyday use.

These are only a few examples of humanoid robots, their intended use may vary. In the following sections, the topic of humanoid robots in managerial positions is going to be discussed.

## **4. Analysis**

### **4.1. Methodology**

This article starts with providing statistics on the humanoid robot market. Afterwards, two profiles of worldwide known humanoid robots functioning as CEOs: Mika and Tang Yu are presented. The research aims to gather data from various sources, including official company websites, news articles, video interviews, and credible reports, to create a comprehensive dataset on Mika and Tang Yu's roles and functions as CEOs.

The information on their responsibilities, decision-making processes, and how they interact with humans within their respective organizations were collected and analyzed to identify key differences and similarities between Mika and Tang Yu in terms of their tasks, decision-making approaches, and their relationships with humans in their roles as CEOs.

Moreover, the aim of this paper is to examine relevant EU guidelines and policies concerning decision-making of AI and human oversight. Finally, an attempt is made to predict the future of a corporate management and decision-making.

### **4.2. Humanoid Robot Market**

Market statistics from both Marketsandmarkets ([https://www.marketsandmarkets.com/...](https://www.marketsandmarkets.com/)) and Precedence Research (<https://www.precedenceresearch.com/humanoid-robot-market>) show significant growth in the humanoid robot market. In 2023, the humanoid robot market is valued at USD 1.8 billion, as reported by Marketsandmarkets. In contrast, Precedence Research notes that in 2022, the global humanoid robot market had a slightly lower value of USD 1.62 billion. However, Marketsandmarkets predicts that by 2028, the market is anticipated to reach USD 13.8 billion, Precedence Research projects a higher figure of approximately USD 28.66 billion by 2032, whereas GlobeNewsWire Report Linker (<https://www.globenewswire.com>) predicts the market to reach to reach \$39.6 billion by 2030.



The growth rates also vary significantly between those three sources, with Marketsandmarkets forecasting a Compound Annual Growth Rate (CAGR) of 50.2% from 2023 to 2028, Precedence Research expects a CAGR of 33.28% from 2023 to 2032, while GlobeNewsWire predicts the highest CAGR of 52.8% from 2023 to 2030.

As can be observed, there are various data and these are only predictions, no one can provide the exact number as the technological progress changes extremely fast. There exist other statistics that provide even much higher numbers when it comes to forecasting of the future humanoid robot market.

### 4.3. Humanoid Robot as CEO



**Figure 8.** Mika – humanoid robot CEO, <https://dictador.com/the-first-robot-ceo-in-a-global-company>

In September 2023, the news worldwide have made a groundbreaking announcement about a humanoid robot called Mika, “who” became CEO of a company based in Poland. Mika is a humanoid robot with advanced AI capabilities and will represent Dictador, a leading luxury rum producer.

As presented on Dictador’s website, Mika, an advanced female AI robot developed by Hanson Robotics, is a superior version of her sister prototype, Sophia, who was activated in 2015. Mika’s role as a CEO involves serving as a board member, overseeing the Arthouse Spirits DAO project, and facilitating communication with the DAO community on behalf of Dictador. The contract with Mika, the world’s first AI CEO robot, was signed on 30<sup>th</sup> August 2022, and she officially began her career at Dictador on 1<sup>st</sup> September 2022.

As demonstrated in the Reuters video interview (<https://www.youtube.com/...>), Mika is known for her tireless work ethic, operating 24/7 and seven days a week. She plays an important role in various tasks, such as identifying potential clients and choosing artists for bottle designs. Mika’s decision-making process relies on data analysis and aligning with the company’s goals, ensuring unbiased choices. However, major decisions at Dictador remain in the hands of human executives. Mika also leads the Arthouse Spirits decentralised autonomous organization project and interacts with its community.

Many websites provide the information that Mika is the first-ever AI robot CEO of a global company, however, her debut in Dictador in September 2022 coincides with the introduction of another robot by a Chinese gaming company named Fujian NetDragon Websoft. The company appointed an “AI-powered virtual humanoid robot” named Tang Yu as the CEO of one of its subsidiaries. Tang Yu is a virtual humanoid robot, while Mika is a real humanoid robot that exists in real world and is present in the company’s headquarter.

#### 4.4. Humanoid Virtual Robot as CEO



**Figure 9.** Tang Yu – virtual humanoid robot CEO, <https://www.showmetech.com.br/en/tang-yu-the-first-aiceo-in-a-company>

In August 2022, the Chinese gaming company NetDragon Websoft appointed an “AI-powered virtual humanoid robot” named Tang Yu as the chief executive of its subsidiary, Fujian NetDragon Websoft. Since this appointment, NetDragon’s stock has performed well, outperforming the Hang Seng Index, which tracks major companies in Hong Kong. Tang Yu, the AI-supported female bot, is expected to streamline processes, enhance work quality, improve execution speed, and serve as a real-time data hub for analytical decision-making and risk management. The virtual CEO will also focus on talent development and fostering a fair workplace. This move reflects NetDragon’s “AI + management” strategy and its aim to become a “Metaverse organization”.

The media worldwide wrote about Tang Yu, her potential and the new upcoming era of humanoid robots as managers. The idea of robots working 24h/7 days a week was very promising, however, at that time, no one knew what effects on the company the robot would have. The satisfying results appeared quite quickly, after six months of introducing the virtual robot, Tang Yu has increased the company’s value up to 10% on the Hong Kong stock market (<https://www.showmetech.com.br/en/tang-yu-the-first-aiceo-in-a-company>).

As said in the video and as can be observed in the picture below taken from a video “Un robot est devenu PDG d’une entreprise chinoise” (TF1 INFO <https://www.youtube.com/watch?v=ohB9uPmsnuk&t=63s>), anyone can play the role of a robot by trying on the equipment.



**Figure 10.** Fragment of a video “Un robot est devenu PDG d'une entreprise chinoise”, TF1 INFO <https://www.youtube.com/watch?v=ohB9uPmsnuk&t=63s>

#### 4.5. Mika and Tang Yu – comparison, decision-making and human oversight

Below, we gathered the data about both CEOs – Mika and Tang Yu and an attempt was made to make their comparison in terms of general information and their tasks, decision-making possibilities and their co-functioning with humans and human oversight.

Mika and Tang Yu are both CEOs, but they differ in several aspects. Mika is a humanoid robot serving as the CEO of Dictador, a luxury rum producer in Poland, while Tang Yu is a virtual humanoid robot CEO at Fujian NetDragon Websoft, a video game company in China.

Mika's role at Dictador is to be the official face of the company, a board member responsible for the Arthouse Spirits DAO project, and to handle communication with the DAO community. Mika also oversees the treasury, facilitates interactions between the Arthouse Spirits DAO community, and embodies Dictador's vision, inspiring luxury clients.

Tang Yu, on the other hand, is primarily focused on optimizing workflow efficiency, enhancing work quality, accelerating execution speed, and promoting logical decision-making. Tang Yu also contributes to risk management, talent development, and maintaining a fair work environment.

**Table 1.**

*Mika and Tang Yu - comparison*

	Mika	Tang Yu
Type	Humanoid Robot	Virtual Humanoid Robot
Position	CEO	CEO
Company	Dictador	Fujian NetDragon Websoft
Branch	luxury rum producer	video game company
Country of “residence”	Poland	China
Introduction	August/September 2022	August 2022

Cont. table 1.

Tasks	<ul style="list-style-type: none"> <li>- serving as the official face of Dictador,</li> <li>- being a board member responsible for the Arthouse Spirits DAO project,</li> <li>- handling communication with the DAO community on Dictador's behalf,</li> <li>- overseeing the treasury, which consists of an exclusive collection of rare rums worth over US\$50 million,</li> <li>- facilitating interactions between the Arthouse Spirits DAO community and herself,</li> <li>- providing an exclusive opportunity for members to meet and hang out with her,</li> <li>- embodying Dictador's vision of impacting the future, pushing the brand into new frontiers and inspiring digitally native, young, and trendsetting luxury clients,</li> <li>- contributing to Dictador's mission of being a next-generation collectible and global thought leader with a strong orientation toward the future.</li> </ul>	<ul style="list-style-type: none"> <li>- optimizing workflow efficiency,</li> <li>- enhancing the quality of work tasks,</li> <li>- accelerating execution speed,</li> <li>- functioning as "a real-time data hub" and analytical tool for promoting logical decision-making,</li> <li>- facilitating a more efficient risk management system,</li> <li>- playing a pivotal role in the development of talents</li> <li>- maintaining a fair and productive work environment for all staff members</li> </ul>
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In terms of decision-making, Mika's role seems more focused on brand representation and community engagement, which might involve a mix of emotional and strategic decisions. In contrast, Tang Yu appears to be more oriented toward data-driven and analytical decision-making, enhancing productivity and efficiency.

Both CEO robots do not have emotions, intuition, or curiosity as they are not living organisms. They can perform tasks efficiently based on their programming. However, human oversight is essential in both cases, as it ensures that robots are aligned with the company's goals, values, and the overall strategy. It also allows humans to intervene in case of unexpected situations or challenges that the robots may not be programmed to handle.

Both Mika and Tang Yu, despite their non-human nature, exemplify the evolving nature of decision-making in the corporate world. Mika's decision-making process involves the emotional and strategic aspects, while Tang Yu's approach emphasises data-driven and analytical elements. These distinctive approaches highlight the diversity and adaptability of CEO robots in addressing the unique demands of their respective industries.

It has to be remembered that human oversight remains a cornerstone in the successful operation of CEO robots. While these robots exhibit efficiency and effectiveness in their roles, the dynamic nature of business demands continuous alignment with corporate values, strategies, and objectives. Moreover, human oversight is essential in identifying potential challenges, ensuring ethical and responsible decision-making, and addressing unforeseen scenarios beyond the robots' programming.

In summary, while Mika and Tang Yu are both CEOs, their roles and tasks differ significantly, and the nature of their decision-making also varies. Human oversight is necessary to ensure that they align with the company's goals and to address unforeseen issues.

#### 4.6. EU guidelines: decision-making of AI and human-oversight

In April 2018, the European Commission unveiled its AI strategy, which included the development of a Coordinated Plan with EU Member States to align their AI strategies. Additionally, the Commission established a High-Level Expert Group, which in April 2019 published Guidelines on trustworthy AI.

In response, the Commission published a Communication with seven key requirements identified in these guidelines: human agency and oversight; technical robustness and safety; privacy and data governance; transparency, diversity, non-discrimination, and fairness; societal and environmental wellbeing; accountability (White Paper, 2020). The accompanying Report to the White Paper (2020) establishes that some AI systems can demonstrate autonomous behaviour throughout their existence, which could result in substantial changes to the product, impacting safety. This may require a new risk assessment. To guarantee safety, human supervision may be essential from product design to the entire life cycle of AI products and systems. The document indicates four forms of human oversight, including:

1. Requiring human review and validation before the AI system's output becomes effective, such as in the rejection of social security benefit applications;
2. Allowing AI systems to make immediate decisions but ensuring human intervention is possible afterward, like in the case of processing credit card applications;
3. Real-time monitoring of AI systems with the ability for humans to intervene or deactivate, as seen in driverless cars with a stop button controlled by a human;
4. Introducing operational constraints on AI systems during the design phase, such as requiring driverless cars to stop under specific conditions of low visibility or maintain a certain distance from the preceding vehicle under all circumstances.

One of the main fears connected to AI development is safety and responsibility (Skubis, 2021). Moreover, recognizing the profound societal implications of AI and the imperative to establish trust, it is crucial that European AI development is firmly rooted in core values and fundamental rights, including human dignity and the safeguarding of privacy (White Paper, 2020).

The document "European civil law rules in robotics" (Nevejans, 2016) discusses the notion of granting legal personality to autonomous robots. On the one hand, it questions the idea of assigning legal personality to machines, as they are essentially sophisticated mechanisms and do not guarantee such a status. On the other hand, the motion for a resolution seems to lean towards viewing robots as electronic persons when they make autonomous decisions or interact with third parties, implying that robots themselves would have legal liability.

Moreover, it raises questions about whether a machine, lacking consciousness, feelings, thoughts, or its own will, can become a fully autonomous legal actor. As indicated in the document, the feasibility of such a concept within the next 10 to 15 years is questioned from

scientific, legal, and ethical perspectives, as it seems impossible for robots to participate in legal matters without human control.

In 2018, the European Group on Ethics in Science and New Technologies issued a “Statement on Artificial Intelligence, Robotics, and ‘Autonomous’ Systems” presenting roboethics guidelines aligned with EU Treaties and the EU Charter of Fundamental Rights. This document covered several key aspects, including human dignity, autonomy, responsibility, justice, equity, democracy, rule of law, accountability, security, safety, bodily and mental integrity, data protection, privacy, and sustainability.

Subsequently, in 2019, the European Parliament released a resolution entitled “A comprehensive European industrial policy on artificial intelligence and robotics”, which discusses the following main aspects:

1. A society supported by artificial intelligence and robotics.
2. The technological path towards artificial intelligence and robotics.
3. Industrial policy.
4. Legal framework for artificial intelligence and robotics.
5. Ethical aspects.
6. Governance.

The point 123 in the fourth chapter “Legal framework for artificial intelligence and robotics” refers to decision-making process and human oversight. This principle highlights that existing regulations like the Services Directive, Professional Qualifications Directive, and e-Commerce Directive already address various policy aspects related to AI-enabled services. It emphasises the crucial role of humans in decision-making, particularly in professions like medicine, law, and accounting. It is underlined that humans should always be considered responsible for decision-making process.

The fifth chapter deals with a human-centric technology and point 143 emphasizes the necessity of establishing ethical guidelines to promote human-centric AI development, ensures accountability and transparency in algorithmic decision-making systems, enforces clear rules of liability, and upholds fairness.

The subchapter 5.3 refers to decision-making and limits to the autonomy of artificial intelligence and robotics. Five principles (151-155) highlight that the decision-making process of AI is complex and challenging to predict, especially in interactions between AI systems. There is a call for evaluating the need for specific AI-related regulations. AI is seen as a valuable tool for enhancing human actions and reducing errors. Individuals should have the right to be informed, appeal decisions, and seek redress when AI makes significant decisions affecting their rights or well-being. Prior assessments are required for deploying algorithms in decision-making systems unless their impact is negligible. AI systems, particularly those with autonomy, must adhere to strong principles, including not storing or sharing personal information without explicit consent from the source.

The decision-making process can be also problematic in terms of transparency and bias. AI offers significant advantages in automation and decision-making, but it poses risks when algorithms are rigid and non-transparent. There is an emphasis on the importance of increased algorithm transparency. The policy urges the Commission, Member States, and data protection authorities to work together to prevent and reduce algorithmic discrimination and bias. It also calls for the development of a robust ethical framework for transparent data processing and automated decision-making to guide data usage and uphold Union law.

AI's machine learning algorithms self-learn, benefiting automation and decision-making. The text calls for AI ethics guidelines to address algorithmic transparency, explainability, accountability, and fairness. It notes that disclosing the computer code alone won't solve transparency issues, as it won't reveal inherent biases or explain the machine-learning process. Transparency encompasses not only code but also data and automated decision-making.

The importance of AI systems not creating or reinforcing bias is emphasized. Considerations of bias and fairness must be integrated into all stages of algorithm development and use, from design to implementation. Regular assessment and testing of datasets and algorithms are crucial to ensure accurate decision-making.

#### **4.7. The future of corporate management and decision-making**

Top tech executives, including Alibaba founder Jack Ma, acknowledge the potential for robots to replace CEOs in the near future. In 2017, Ma predicted that a robot could be featured as the best CEO on Time Magazine's cover within 30 years and warns of challenges for those unprepared for technological disruptions. He emphasizes the need for educational systems to nurture creativity and curiosity in children. Ma notes that robots are faster, more rational, and less emotionally biased than humans but remains optimistic that they will ultimately enhance human life by complementing and cooperating with humans rather than becoming adversaries (CNN.com, <https://money.cnn.com/2017/04/24/technology/alibaba-jack-ma-30-years-pain-robot-ceo/index.html>).

The future potential of CEO robots is vast and exciting. Their evolving decision-making capabilities and adaptability to industry-specific requirements position them as assets that can drive innovation and efficiency. Moreover, they offer the potential to redefine the roles of human leaders by focusing on data-driven, analytical, and strategic decision-making.

The emergence of CEO robots, epitomized by Mika and Tang Yu, represents a promising frontier in the corporate landscape. These robots exemplify diverse decision-making approaches that cater to the unique demands of their industries. However, human oversight remains imperative to ensure alignment with organizational goals and values, ethical decision-making, and responsiveness to unforeseen challenges. As CEO robots continue to evolve, their potential to reshape corporate leadership is a compelling area of exploration and innovation.

Moreover, the topic of humanoid robots as CEOs might become essential in terms of responsible leadership. These advanced machines have the potential to embody certain key qualities that are essential for ethical and effective leadership. They can operate with unwavering consistency, free from human biases and emotions, thereby ensuring fair and equitable decision-making. Moreover, their ability to process vast amounts of data in real-time can lead to data-driven, rational decisions that benefit both their organizations and society at large. However, the ethical implications of this shift in leadership must be carefully considered, as questions around accountability, ethics programming, and human-robot collaboration will play a pivotal role in determining how humanoid robot CEOs can responsibly lead in the future.

## 5. Conclusions

This research has explored the profiles of two humanoid robots serving as CEOs: Mika and Tang Yu. The study used a comprehensive methodology, collecting data from various sources to understand their roles, responsibilities, decision-making processes, and interactions with humans within their respective organizations. The findings have allowed for an insightful comparison of these two CEO robots, highlighting key differences and similarities in terms of their tasks, decision-making, and human interactions.

Mika, a real humanoid robot, was appointed as CEO of Dictador, a luxury rum producer based in Poland. Her role involves acting as a board member, overseeing the Arthouse Spirits DAO project, and facilitating communication with the DAO community on behalf of Dictador. Mika's work is characterized by tireless dedication, efficient decision-making through data analysis, and alignment with the company's objectives. However, major decisions at Dictador continue to be made by human executives.

Tang Yu, a virtual humanoid robot, serves as CEO of Fujian NetDragon Websoft, a Chinese video game company. Tang Yu focuses on streamlining processes, enhancing work quality, accelerating execution speed, and serving as a real-time data hub for analytical decision-making. Her appointment had a positive impact, increasing the company's value on the stock market. Tang Yu's approach is data-driven, and she plays a pivotal role in talent development and workplace fairness.

In the context of decision-making, Mika's role incorporates elements of emotional and strategic decisions, while Tang Yu's approach emphasises data-driven and analytical decision-making, enhancing productivity and efficiency. Although these CEO robots lack emotions and intuition, human oversight remains a vital aspect of ensuring they align with their companies' goals, values, and strategies, and are equipped to handle unforeseen challenges.



The research analyses and demonstrates the EU guidelines and policies concerning AI decision-making and human oversight. The European Commission's strategy emphasises human agency and oversight, technical robustness and safety, privacy, transparency, and societal wellbeing. The document outlines various forms of human oversight, including human validation, intervention, real-time monitoring, and operational constraints, highlighting the importance of human accountability in AI decision-making.

Looking ahead, the research explores the future potential of CEO robots. Industry leaders, such as Jack Ma, foresee the possibility of robots replacing human CEOs in the coming decades. Ma stresses the importance of nurturing creativity and curiosity in education systems to adapt to technological disruptions, highlighting that robots can complement and cooperate with humans, rather than replace them. CEO robots hold immense promise, with evolving decision-making capabilities and adaptability to industry-specific needs, potentially redefining corporate leadership through data-driven, analytical, and strategic decision-making.

In conclusion, Mika and Tang Yu, as CEO robots, symbolize an exciting frontier in corporate management. They showcase diverse decision-making approaches while underlying the necessity of human oversight to ensure responsible decision-making. As CEO robots continue to advance, they offer the potential to reshape corporate leadership by enhancing efficiency, innovation, and adaptability. The future of corporate management is increasingly connected with AI, promising to be both transformative and collaborative with human leaders.

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## APPLICATION OF BLOCKCHAIN TECHNOLOGY IN THE LOGISTICS OF COOPERATING ENTERPRISES

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**Purpose:** The objective of the study was to indicate the opportunities that the implementation of blockchain technology brings for companies in the TSL sector. Based on our own research, it was shown that the implementation of blockchain technology solutions can lead to time and cost savings in the procedure of documentation exchanged between cooperating companies.

**Design/methodology/approach:** The main research objective was to attempt to evaluate the initial implementation of blockchain technology into the customer service process at a selected logistics operator (the criteria for evaluating the process were the time and cost of document processing). The research hypothesis was that: the use of blockchain technology will reduce the time and costs of document processing in the logistic process in the supply chain. The research method was the diagnostic survey method. The research techniques were an interview and a survey, and the research tools were an interview questionnaire and a survey questionnaire. A purposive selection method - snowballing - was used for the research. This means that a large supply chain logistics operator was selected for the research. This operator identified smaller TSL operators who were its subcontractors or potential subcontractors for the study. The sample size among subcontractors was 54 companies.

**Findings:** The introduction to the article presents the relevance of blockchain technology for logistics processes implemented in supply chains from a theoretical point of view. The second section presents the research methodology. Appendices 3 presents the author's research results indicating blockchain as a technology to improve logistics processes in the supply chain by speeding up and reducing the cost of document procedures.

**Research limitations/implications:** The feasibility of implementing blockchain technology only with a logistics operator operating supply chain and with subcontractors of the TSL sector was investigated.

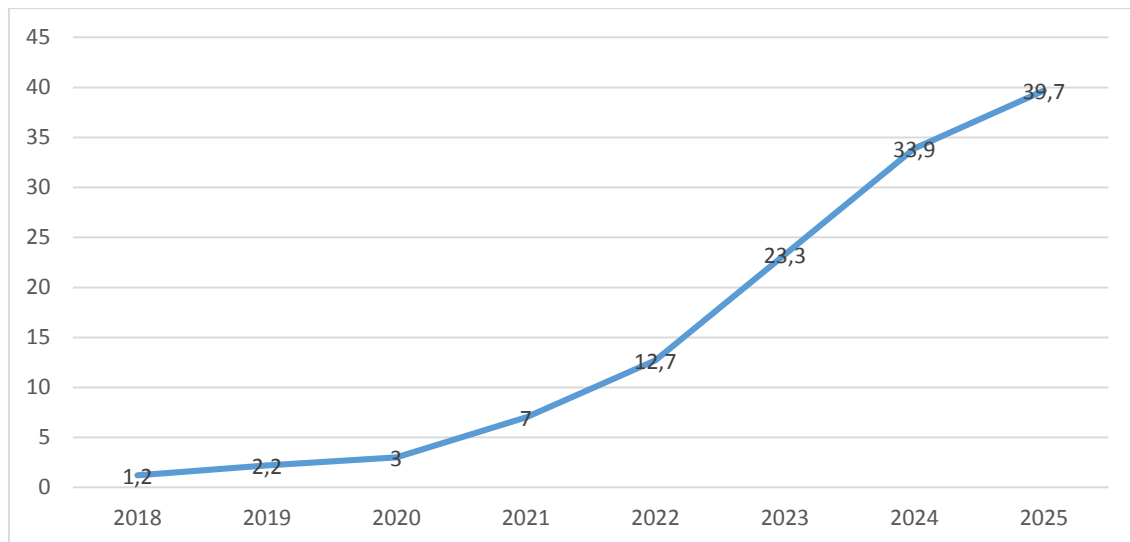
**Keywords:** Blockchain, logistics, cooperating enterprises.

## 1. Introduction

The genesis of blockchain technology was developed in 1991, by Stuart Haber and Scott Stornett, and called a document meaning system using cryptographically encrypted block chains with timestamps. Today, blockchain is understood as a decentralised data storage structure where the history of data cannot be changed. The basic unit is a block, which consists of a header and input data. This header has a stored hash function (hash). The hash function, interchangeably referred to as a mixing or hash function, ensures that each subsequent block stores information about the hashed value from the previous block. This association allows data to be stored only at the time a block is created and is unmodifiable once it has been publicly disseminated. Each subsequent block is created in succession and has a timestamp in the aforementioned header. Thanks to the hash function, any unique set of security keys can be generated for any digital data. Thus, blockchain documents are regarded as secure and collision-free (Kurowski, 2021).

The basis of blockchain technology is asymmetric cryptography, which differs from symmetric encryption in that, in classical symmetric cryptography, in order to send an encrypted message or data, both the sender and the receiver must have the same secret key. Asymmetric cryptography relies on each party having two types of keys. One of these keys is the private key and the other is the public key. The public one is known to every user on the network, while the private one is kept secret. When we encrypt data with the private key, then any user can decrypt the data. Using the public key of a particular user, the data can be decrypted. This encryption is characterised by a high degree of security. Blockchain as a distributed database is an uneditable digital ledger that cannot be defaced, forged or altered. The data is stored in a network of computers that operate on a single-measure system. With every transaction goes an acceptance from intermediaries or other parties. This mutual authorisation scheme is called proof of work (Szczerbowski, 2018). Blockchain technology enables so-called smart contracts with (smart contracts). Nick Szabo defines smart contracts as the conclusion of electronic transactions, underpinned by contracts that guarantee security between unknown entities on the network. Smart contracts can be concluded in a number of programming languages including JAVA, Solidity or Chain Code (Baloch, 2019).

According to the World Economic Forum, blockchain technology will generate 10 per cent of the world's gross domestic product by 2025, and Gartner reports that blockchain-based systems will generate \$176 billion in value added to the economy by 2025. The wave of deployments so far has mainly been in industries such as banking and finance, transport and logistics, and the food and beverage sector. An analysis of deployments according to statista.com for 2018-2025 is shown in Figure 1.



**Figure1.** Projected value of the blockchain technology market by 2025 in billions of dollars.

Source: own compilation based on data from <https://www.statista.com>.

Blockchain technology has begun to be used in supply chain logistics to guarantee the origin of materials and component products, (the technology enables the attribution/recognition of property rights) (Konnst, 2021).

Over time, blockchain technology has begun to complement the functionality of the Autonomic Logistics Informations System (ALIS).

ALIS had already based autonomous data information on the use of operational research, barcodes, RFID, image recognition. Autonomous vehicles, augmented reality, picking by voice, digitisation of databases as well as documents have also found their way into ALIS systems. ALIS systems use Electronic Data Interchange (EDI). EDI is an automated, purely electronic process of document exchange between the various parties in the supply chain. The basis of this system is the exchange of globally standardised documents/data between operators, regardless of the type of hardware, operating system, e-mail client, application from which the data is retrieved and the type of connection between operators. EDI has been in use since the 1960s. The transfer of open text files via file transfer (FTP/SFTP) from the sender's folder to the recipient's folder was not secure. Blockchain Data Interchange (BDI) is a modern variation of Electronic Data Interchange (EDI), based on Public Blockchain technology, enabling agile, encrypted, auditable and cost-effective Peer-2-Peer exchange of electronic business messages without any third-party systems or intermediaries. BDI relies on industry-standard message formats and plug-ins for ERP/IT systems to connect and streamline all business-to-business processes. BDI is key to the further development of ALIS (Fraga-Lamas, Fernández-Caramés, 2019). An integral part of the ALIS system is the Global Positioning System GPS. Due to its versatility, GPS is applicable to all modes of transport. Thanks to telematic solutions, it can be used to track shipments in real time and additionally collect information on their condition in order to optimise the movement of the fleet (Gołębska, Sławińska, Szymczak, 2013). The intelligent interaction of sensors that enable devices to independently identify, collect and

process data within a single electrical or computer network is the Internet of Things (IoT) (Bai, Dallasega, Orzes, Sarkis, 2020). The aforementioned technologies counted among the tools of Industry 4.0 unsupported by analytical algorithms and central supercomputers can lead to simple system overloads (Piątek, 2023). Therefore, a tool for collecting raw or already analyzed data, and supporting data decomposition and re-analysis - that is, BIG DATA technology - may be necessary for the smooth operation of these systems (Gupta, Modgil, Gunasekaran, Bag, 2020). Thanks to this technology, large amounts of data can be processed, analyzed, enriched, verified. Access as well as transmission of digital data is carried out by means of computer networks and the data is placed in the so-called Cloud. A modern ALIS (with BDI) is designed to collect internal (from the enterprise) as well as external (from the supply chain) information, while using analytical subsystems that filter information noise. A modern ALIS can autonomously extract BDI-confirmed information, make and execute logistics decisions. The Accenture research company has filed a patent application with the US Patent and Trademark Office in 2020. Accenture's ALIS-based solution using blockchain, IoT and Big Data aims to intelligently manage the logistics network (Stawiarska, Sz wajca, Matuszek, Wolniak, 2021; Stawiarska, 2019). Future Automated Logistics Information Systems will spin up other Industry 4.0 technologies such as artificial intelligence, autonomous vehicles, drones, aerial machines, robots, 3D printing, automated warehouses, smart buildings creating smart factories. Each of their actions/transactions will require time-stamped, digitally signed NODs to act as notaries of the transaction. In view of the above, the ideal solution seems to be the successive implementation of blockchain registries into ALIS. Sooner or later, blockchain will record all transactions/events currently recorded in ALIS (Tapscott, Tapscott, 2019). The current ALIS system has been accused of e.g.: high operating costs, time-consuming maintenance and slowing down processes due to system overload (Harris, 2021; Szopa, 2021). Blockchain running on a cloud-based external network will reduce the hardware requirements of ALIS, making the system accessible from browsers or dedicated applications on cell phones. Table 1 compares ALIS equipped with blockchain and without this technology.

**Table 1.**

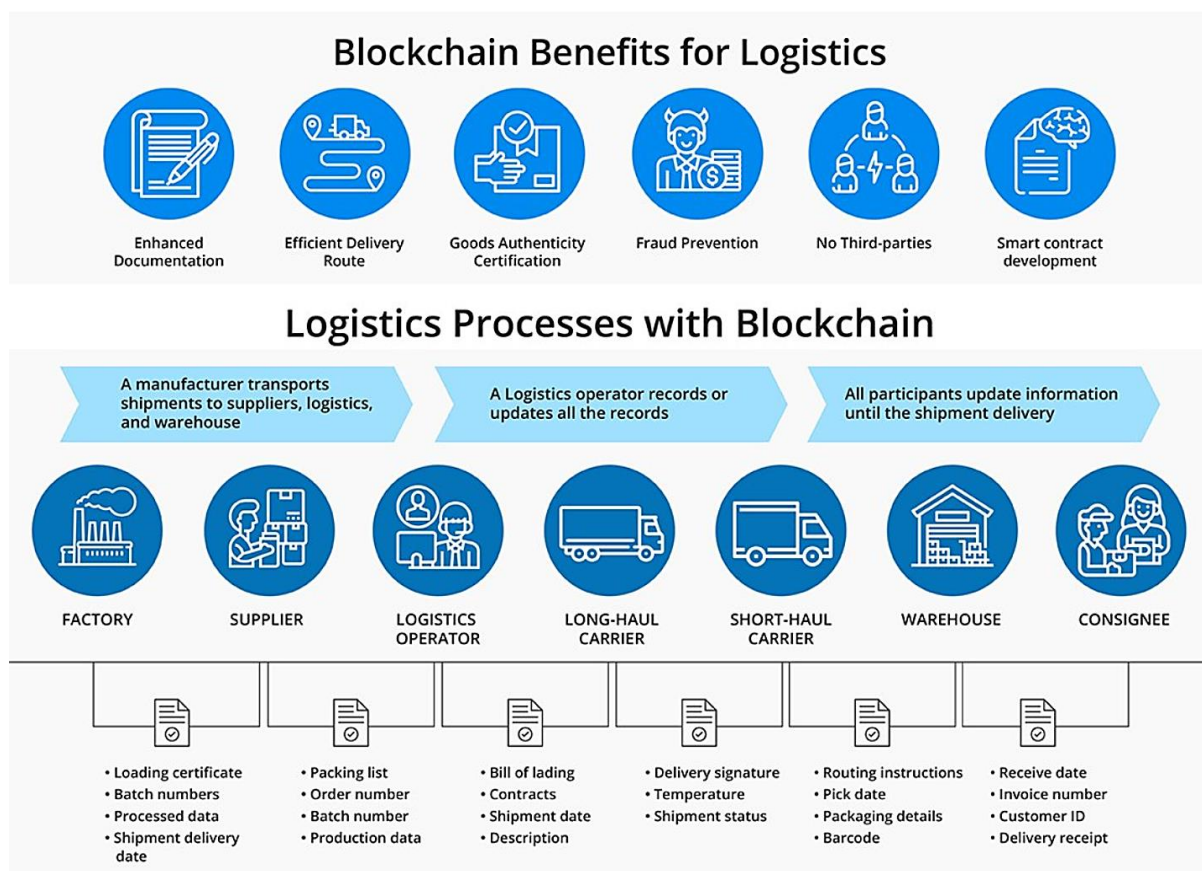
*Comparison of ALIS with blockchain and ALIS without blockchain by selected domains*

<b>Domeny dotyczące danych</b>	<b>ALIS with blockchain</b>	<b>ALIS without blockchain</b>
General common ledger	YES	YES
Data non-repudiation	YES	NO
Finality of the transaction	YES	NO
Automation of task execution and decision making	YES	YES
Saving time on operations	YES	YES
Reducing risk on operations	YES	NO
Transparency of transactions	YES	NO
Reliability in data access	YES	NO

Source: own study.



The use of blockchain is a solution to numerous problems related to the course of logistics processes implemented with the circulation of documents. Blockchain makes it possible to track goods and assets throughout the logistics supply chain from the manufacturer of components to the manufacturer of the final product. The registration of documents through the blockchain system (thanks to the timestamp function) makes it possible to identify the moments of manufacture, transfer of goods to the next link in the supply chain. Blockchain and other Industry 4.0 tools are already recommended in process reference models. Implementing blockchain into modern customer service systems is becoming a necessity due to the need to increase process efficiency and service quality (Kotler, Kartajaya, Setiawan, 2017). Reference processes for logistical customer service have been developed. The process diagrams reflect customer service in practice. In the beginning, they assumed the course of processes without automation with the use of standard manual technologies such as fax, Internet, e-mail, traditional mail and smartphones. The next solutions relied mostly, on automated systems such as ALIS based on ERP subsystems, WMS, TMS, RFID with Electronic Data Interchange EDI between cooperating companies. The third generation of reference customer service processes involves the use of BDI, IoT Big Data. Figure 2 shows reference opportunities to use blockchain in supply chain logistics.



**Figure 2.** Reference opportunities to use blockchain in supply chain logistics.

Source: <https://blockchain.oodles.io/blog/blockchain-development-for-advanced-logistics-solutions/>

Logistics operators began to diversify their services, providing facilities such as customs clearance, order processing, packaging, labeling, after-sales support and returns logistics. As a result, reference models for customer service in the supply chain have evolved.

In the first models, the chain integrator communicated with the links of procurement, distribution as well as subcontractors of logistics operations using standard information channels. Access to data as well as a workflow center was administered by the logistics operator. A customer wanting information on the specifications or status of a shipment sent an inquiry to the operator, who responded using conventional communication channels. The flow of capital took place without financial analysis and verification of new customers. The phenomenon of limited trust usually resulted in various types of prepayments. Data was stored in paper form as well as on computer disks in the form of scans. Data was susceptible to destruction, deletion, forgery, or illegal use. The whole process prolonged, expensive and not environmentally friendly.

Currently, processes based on ALIS and using EDI for communication are proposed. Systems like ERP, TMS, WMS are bundled in ALIS (Galankashia, Helmi, 2014). Automation is at a very high level. The customer has access to the operator's portal, where he can request information via chat using bots or a form. ALIS with the help of stored data and ready analyses from the systems: ERP, WMS, TMS transmits reports to customers. The system verifies customers financially, so payment occurs after the operation is completed and is automatically posted (using automatic debits) after the order is completed. The logistics operator owns the automated information system, so it determines what information is sent between supply chain participants. The logistics operator is responsible for data security. The customer has access to product information and order status in real time, as well as to product documentation and specifications. The added value of such a solution can be the speed of processes and the reduced number of people needed to handle processes. In contrast, the complexity of centralized handling has drawbacks, such as the incompatibility of systems belonging to individual members of the supply chain (this forces at times traditional data processing). The incompatibility of systems can also be quite a problem, especially when working with smaller entities. Lack of access from the supplier or customer level to most functions can also disrupt the entire process. Failure of a processing computer can make or break an automated customer service process.

The customer service process using blockchain technology was then presented. The new ALIS uses Industry 4.0 solutions, i.e: IoT using mobile networks, preferably 5G. The customer's ERP generates the order, and the manufacturer's BDI system generates the smart contract. The system, from ready analysis, prepares material orders to upstream suppliers/or starts the production process. Thanks to the phenomenon of deintermediation, the entire process passes without additional intermediaries. Payment is made instantly with digital currency convertible to any payment type. Accounting as well as tax settlement is done automatically. The role of the logistics operator is reduced to controlling processes and renting infrastructure

such as, transportation infrastructure and warehouse infrastructure. Document circulation is based on blockchain, where smart contract records can create a document for any system. Work on a document can be done by multiple entities at the same time. Blockchain technology, through compatibility with all systems at the same time, creates documents, which improves the customs and tax process as well as controlling the customer service process. The customer has direct access to product information and the transportation process, and with the help of process programmability can be automatically notified of changes in shipment location, temperature, unloading and delivery. The entire logistics chain is analyzed automatically. The history of the logistics process as well as the product is stored in the blockchain and is non-editable. The system, thanks to the fact that it is distributed, does not overload, because as the participants in the process increase, the computing power increases. The advantages of the system are the transparency of the transaction as well as the product, speed and scalability. Implementation of blockchain technology into ALIS Autonomous Logistics Information Systems means replacing EDI with BDI solution in dealing with supply chain partners (Szopa, 2021).

Blockchain is a technology that provides logisticians with a trustworthy platform to monitor shipment status, location, events, receipts, delivery times (Hastig, Sodhi, 2020). It also allows updating any changes, such as supplier creditability, payment terms, pricing, quality standards, service specifications, delivery requirements and conflict resolution procedures. The updated data is shared with multiple stakeholders in the supply chain (Chod et al., 2020; Kumar et al., 2020; Niu et al., 2021). The main drawback of the technology is its dependence on internet access, making it unable to operate offline (Ahmed, Khan, 2020; Walasek, 2014). Implementing blockchain technology into ALIS Autonomous Logistics Information Systems means replacing EDI with a BDI solution for dealing with supply chain partners. The implementation involves a great deal of complexity and numerous technological resolutions (Eckerd et al., 2021). Implementation decisions, include the selection of a trust anchor, the process of modifying a smart contract, the development of a dispute resolution policy, the mode of payment, and procedures for implementation and extension to other companies. There is a lack of guidance on the choice of architecture for blockchain implementation in TSK companies (Chod et al., 2020). Large logistics companies developing Blockchain platforms specifically for their own use are setting up technology start-ups creating applications for general use in the logistics industry (Cao et al., 2022). Then companies extend the use of the developed platforms to other entities when the proof of concept has been successful internally. When implementing blockchain technology into logistics processes, the financial aspect is taken into account, the advantages and disadvantages of blockchain-based solutions are analyzed, as well as the long-term impact on the competitiveness of the company. The backbone of a BCT system for a logistics operator has been outlined by few researchers (Wan et al., 2018; Sinil et al., 2023).

There are standard tools for smaller businesses as well as the possibility to prepare a blockchain network in-house. In order to effectively implement the technology for a particular business, it is necessary to conduct an internal audit in a particular company, as well as an external audit, where various determinants will be taken into account, i.e.: market analysis, existing technology in the company, level of knowledge and capabilities of employees.

The phasing of blockchain implementation is shown in Table 2, which takes into account the market, the type of business and the technological solutions possessed and possible to implement - as factors determining the stages of implementation.

**Table 2.**  
*Staged process of implementing blockchain technology*

Etaps	I	II	III	IV
Factors	Beginning	Implementation	Startup	Usage
<b>Market</b>	Analysis market	Identification of cooperating entities (that will potentially use BDI)	Determining the scale of action (mobilization of cooperating entities to launch BDI)	Mobilization of new users/customers
<b>Type of business</b>	Analysis logistics processes	Modeling of logistics processes using blockchain in the logistics supply chain	Process reengineering through application blockchain and other Industry 4.0 solutions	Continuous process optimization
<b>Technology</b>	Analysis of existing ALIS technology	Developing a platform or adding to existing solutions	Launch of the platform pilot project	Further scaling by sharing technology with supply chain partners
<b>Duration</b>	1 month	3-4 months	4-6 months	from 1 year to now

Source: Own study.

By implementing a blockchain application from the Ethereum public network, the user agrees to interact with other participants by communicating with the application. Acceptance of the Baseline Protocol (the key blockchain application protocol) will enable confidential and complex collaboration between enterprises without leaving sensitive data on the blockchain. Users can operate the applications on computers, cell phones or other mobile devices. An application with a user interface is written in a front-end programming language (e.g. HTML/JavaScript). Data processing in the blockchain is carried out using back-end languages. After sending data for analysis and accepting it, the application launches smart contracts to formalize operations. Not all enterprises like to keep their data on a public network. For users with sufficient programming knowledge, the Ethereum Geth solution is recommended to build a private blockchain network. For transactions that require payment, an application is needed to settle for approved transactions. Creating contracts and transferring funds between addresses requires operating ETHER payment means (Dhillon et al., 2018).

## 2. Research methodology

The main problem in the operation of logistics companies in the implementation of customer service processes is the use of outdated technological solutions that prevent the efficient flow of data as well as the sending and storage of documents. The use of outdated technologies currently generates high labor time and costs in logistic customer service. The hardware resources of the ALIS system are also under strain, resulting in a decrease in the quality of customer service.

The main research objective was an attempt to evaluate the pilot implementation of blockchain technology into the customer service process at a selected logistics operator (the criteria for evaluating the process were the time and cost of document processing). The research hypothesis was that: the use of blockchain technology will reduce the time and cost of documents relevant to the service process.

The research method was a diagnostic survey. The research techniques were an interview and a survey, and the research tools were an interview questionnaire and a survey questionnaire. The study used the snowball sampling method. This means that a large logistics operator servicing supply chains was selected for the study. This operator indicated smaller entities from the TSL sector for research, which are its subcontractors or potential subcontractors. The sample size among subcontractors was 54 companies. The survey was sent to 4655 companies, but only 54 completed surveys were returned. The subject of the research in which the interviews were conducted was the logistics operator Swiss Logistics Company - Simplified Logistics Transport (with 150 branches in 15 countries, employing over 15,000 people). The interviews were conducted in one of the branches located in Switzerland, in the federal state of Aargau in the town of Oftringen (this particular branch was in the process of implementing blockchain technology). The interview was conducted with one of the senior managers responsible for servicing subcontractors and regular employees who have direct contact with subcontractors. Subcontractors dealing mainly with forwarding and transport services were surveyed using the survey method. The surveyed subcontractors came from many European countries. The research carried out therefore has a European dimension. The research was conducted at the turn of 2021/2022.

### 3. Re-engineering the customer service process in a selected logistics company using blockchain - Research findings

The surveyed branch of the logistics operator is located in Switzerland. For years, Switzerland has had an efficient, publicly available automatic EDI document exchange system called eXite (used by some 20,000 companies, generating more than 400 million transactions annually) (Cegner). Nevertheless, the surveyed operator is piloting a BDI implementation. An assessment of existing customer service processes is shown in Tables 3-5.

**Table 3.**

*Number of employees at the logistics operator's branch, number of documents exchanged with TSL service subcontractors*

Employment level at the logistics operator's company		
All employees	Employees delegated to handle logistics documents processed with TSL subcontractors	Percentage of the number of employees of logistics documents processed with subcontractors of the TSL sector
100	18	18%

Source: own study based on primary research.

**Table 4.**

*Number of hours per month required to process documents exchanged with TSL service subcontractors*

Operations related to document procedure	Number of people	Number of hours (h)	Number of man-hours (h)
Manual operation	18	21	378
Manual operation inputs/outputs	4	168	672
Additional service	3	84	252
Handling analysis	2	84	168
Error handling	3	42	126
Planning support	3	4	20
Accounting services	3	16	54
Total	18		2120

Source: own study based on primary research.

In the surveyed company, a full-time monthly position is 160 hours. The cost of an employee, per hour of work at the level of specialist in logistics is a gross cost of about CHF 50/hour ([https://www.aplikuj.pl/...](https://www.aplikuj.pl/)). 2120 labor hours requires approximately 13.25 employees and costs about CHF 106,000.

To the calculated labor costs of specialists should be added the labor costs of a manager (160 hours and 8000CHF), making a total of 2280 hours and 114 000CHF (allocated for the procedure of documents).

**Table 5.**

*The sum of relevant data in the procedure of documents exchanged with subcontractors of TSL services without the use of blockchain*

Total operations per month	3780 operations
Total documents per month	18 900 pages
Dimension of employment in service on a monthly basis	2280 hours (2120+16)
Required employment costs per month	114 000 CHF (10 600+8000CHF)

Source: own study based on primary research.

With the use of blockchain technology, the staffing level for subcontractor logistics dropped from 18 people to 4 (or 5 counting the manager), and costs to about CHF 36,000 (counting the manager). Similar calculations can be arrived at using a blockchain implementation simulation calculator (<https://altab.pl/cennik>).

Analyzing the possibilities of blockchain technology, based on the experience of a company that is in the process of implementing blockchain, and referring to the Altab implementation calculator, it is possible to prepare a summary of the savings of procedural documents related to the handling of subcontractors of TSL services (Table 6).

**Table 6.**

*Evaluation of the procedure of documents (exchanged with subcontractors of TSL services) by the logistics operator before and after the implementation of blockchain technology*

Process evaluation criteria	Before implementing blockchain	After blockchain implementation	Decrease in %
Number of man-hours necessary for operation	2120 hours	800 hours	62
Employment in the company	100 persons	87 persons	13
Employment in service	18	5	72
Monthly costs of employing service staff	114000 CHF	36000 CHF	72
Costs of processing one document in CHF	6,03	1,9	70

Source: own study based on primary research

According to the survey, conducted among TSL subcontractor companies, 40% are micro-enterprises, employ 10 people. 20% of the surveyed enterprises employ from 10-50 people. 15% of the surveyed companies employ from 50-100 people, and 25% employ more than 100 people. At 57% of respondents, the number of logistics operations requiring the issuance of documents reaches 1000, 25% of respondents generate from 1000 to 10000 documents. 31% of respondents send documents to logistics operator (by e-mail - 90% of respondents; by snail mail - 26% of respondents; by cell phone - 26% of respondents; by fax - 11% of respondents), 67% partially use EDI, 2% declare full documentation automation using BDI.

From the survey of respondents/subcontractors in the TSL sector, average ratings - related to the service of logistics operators). The results obtained were confirmed in the calculator (Table 7) (<https://altab.pl/cennik>).

**Table 7.**

*Averaged evaluation of operations over documents processed at subcontractors (before and after implementation of blockchain technology)*

<b>Process evaluation criteria</b>	<b>Before implementing blockchain</b>	<b>After blockchain implementation</b>	<b>Decrease in %</b>
Averaged monthly number of man-hours required to operate	210 hours	80 hours	61
Average employment in the surveyed companies	28 persons	26 persons	8
Averaged monthly employment costs for process personnel	10500 CHF	4000 CHF	62
Averaged cost of processing one document in CHF	5,03	1,1	54

Source: Own compilation based on primary research, Declared costs converted to Swiss currency.

#### **4. Discussion - Cognitive conclusions of the study and recommendations for companies wishing to implement blockchain**

The literature cited below shows that document processing using modern blockchain technology translates into a reduction in the costs and time of the logistics process in the supply chain. Multitasking of the logistics operator in the supply chain, makes it extremely important to satisfy the need for information and authorization of documents (Forslund, Jonsson, 2008). In logistics industry, it is essential to promptly deliver the right information to the right entity at the right time (Custon et al., 2006). If this need is not met, it may not be possible to move to the next stage of the logistics process. It is within the competence of the logistics operator to have knowledge of the flow of information in the supply chain. Ideally, the focus should be on the dynamics of information flow, the veracity and certainty of information (where entities such as the TSL service sub-supplier, component suppliers, customers and clients have the same reliable information. All of these entities could automatically exchange information on delivery, production, quality, financial settlement, warehouse operations, transportation, orders, etc. if they have blockchain (Klöckner et al., 2022; Hastig, Sodhi, 2020; Casey, Wong, 2017). Blockchain can give the best results if it is adopted by all participants in the supply chain. However, logistics companies are concerned about the lack of clarity in the laws governing smart contracts. There are also no clear technical guidelines and decision-making plans to guide companies, both before and during blockchain implementation (Stawiarska, 2016). There should be a clear definition of the various stages and milestones on the road to successful blockchain implementation (as has been done in the UK see Status of cryptocurrencies and smart contracts" - November 2019). Countries such as Argentina, Australia, Brazil, Canada, most countries in Europe, Japan, Saudi Arabia, South Africa, South Korea and the United Arab Emirates have taken steps to legalize cryptocurrencies and blockchain applications (Hammond, Ehret, 2022).



The presented assessments of document processing show that the use of modern blockchain technologies translates into cost and time reduction, as shown in Table 5 and 6.

The surveyed logistics operator switching to BDI is currently implementing processes through a hybrid procedure (i.e., using EDI and BDI). Logistics operator declares that about 20% of the companies working with him are also implementing BDI. Over time, more contractors will join the blockchain platform.

The company, through the use of the blockchain platform in its dealings with stakeholders, wants to achieve higher competitiveness in the logistics services market. The interview shows that the logistics operator, after the partial implementation of blockchain technology, has achieved benefits having the following dimensions: financial, improved efficiency of the service process, increased security, improved transparency, increased quality of service.

The financial savings are:

- enterprise-wide employment decreased by 13%,
- employment of employees in document handling decreased by 72%,
- reduced IT maintenance costs by using network infrastructure,
- faster payments resulting from the elimination of intermediaries in the process (improved liquidity),
- elimination of payment bottlenecks due to the due and irrevocable fulfillment of the smart contract.

Improving the efficiency of the service process involving:

- minimization of manual work related to document procedure,
- reducing the time (by 95%) required to generate, send and check a document (simultaneous work of multiple internal users on the same document in real time, i.e.: accounting, payment, document generation and transmission, authentication of receipt and handling of analysis and checking for possible errors),
- timely information to all external document stakeholders and the ability for multiple external users to work on the same document simultaneously in real time,
- higher susceptibility to development and integration with other systems in the future, which will certainly still appear in Industry 4.0 or 5.0. Backward compatibility with traditional solutions also affects the efficiency of handling process.

The increased security consists of:

- an increase in the security of transactions between users resulting from distributed authentication, where no single entity can tamper with a record,
- the impossibility of retroactive editing, which secures timeliness and gives time certainty,
- resistance of the system to double spending (it consists in the fact that one commodity or service is assigned to a specific entity, thus eliminating the risk of double posting in the system),

- storing and securing data in the cloud embedded on distributed block records, which prevents loss, falsification, and possible abuse will be transparent to all users.

Improving transparency by:

- enabling online tracking of shipment status,
- preventing manipulation in service offerings, improving competitiveness,
- making all meaningful data available while keeping subjects anonymous by pledging shortcut functions,
- storing data for later multivariate analysis. Good quality, error-free data provides analysts with support for supply chain management,
- smart contracts promote trust-building, accountability and transparency in collaboration.

Improved customer service quality through:

- reduced response times and more effective decision-making,
- real-time customization and analysis of customer needs,
- insightful analysis of timing, cost, quality, efficiency, reliability of customer service,
- continuous data collection, resulting in information on all important customer service parameters,
- eliminating errors due to human factors.

According to the survey, about 33 percent of surveyed respondents/subcontractors in the TSL sector are small companies with up to 10 employees. These entities often do not have adequate knowledge as well as human resources for blockchain implementation.

## 5. Summary

In the article feasibility of implementing blockchain technology with a logistics operator operating supply chain and with subcontractors of the TSL sector was investigated. No research has been carried out in companies cooperating in the supply chain, i.e. suppliers, clients and customers of final goods. Therefore, it can be concluded that the hypothesis (the use of blockchain technology will reduce the time and costs of document processing in the logistic process in the supply chain) was only partially confirmed. The truth of the hypothesis was confirmed only at the stages of the logistics process, where actions are taken on documents exchanged between the logistics operator and its subcontractors. Other stages of the logistics process will be the subject of further research.

Companies implementing blockchain in supply chains confirm the truth of the hypothesis put forward in this article (by presenting the functions and capabilities of blockchain on their information portals - zobacz IBM Blockchain Services for Supply Chain Solution Brief).

For companies cooperating in the supply chain, (i.e. suppliers, clients, subcontractors of the TSL sector) it is possible to implement free open source solutions. An example of such a solution is IBM Cloud. In the IBM Cloud service, there is also an extension to a paid version in case the company's demand increases without the need for a new implementation of another solution. IBM Cloud also gives access to more than 170 off-the-shelf solutions, from data, artificial intelligence, Internet of Things and blockchain technologies. It allows you to analyze up to 1000 documents per month using 5GB of transfer. With a user-friendly interface and tools, as well as ready-made plug-and-play solutions, almost any intermediate user has a chance to successfully join the blockchain community. According to IBM, the implementation of blockchain results in savings in time and costs of logistics processes generated for all supply chain partners.

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## CONTEMPORARY TRENDS IN MANAGING HUMAN RESOURCES AND STEWARDING NATURAL RESOURCES WITHIN THE CONTEXT OF CLIMATE CHANGE

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**Research background:** The management of natural resources with modern tools has become a contemporary requirement for social good. Global trends are an inspiration to make the best use of the natural resources available in terms of climate change.

**Purpose of the article:** The aim of this article is to assess contemporary trends and social behaviour related to natural resource management. The main hypothesis is as follows: the pro-ecological behaviour of an individual brings global benefits.

**Methods:** The article is based on theoretical and empirical considerations in the topic under study. An important issue raised in the article is the promotion of activities aimed at increasing the awareness of both the local and international community in the area of sustainable development.

**Findings & Value added:** This article presents the results of own research conducted in Poland and analyses them in relation to global trends. The presented research results show that all climate change begins with the proper management of managed natural resources by individual human behaviour. The respondents' answers made it possible to present social attitudes regarding the use of natural resources and environmental protection measures in everyday life. The research confirmed the validity of the hypothesis and allowed the aim of the article to be realised. Awareness of climate change is forcing societies to implement preventive measures in terms of environmental protection.

**Keywords:** natural resources, modern eco-trends, environmental and economic awareness, sustainable environment, climate changes.

**Category of the paper:** Research paper.

## 1. Introduction

The prudent management of the Earth's natural resources has a significant impact on climate changes worldwide. All human activities bring benefits or risks to the environment. For many years, environmental issues were less important than economic development, resulting in irreversible effects on the climate around the world. For several years, all environmental organizations have been alarming about unfavourable climate changes occurring too quickly. Currently, actions are taken to inhibit these phenomena. Stewardship of owned resources also relates to financial issues for both households and entire countries. The more resources are consumed, the higher the costs are. That is why it is so important to take care of the sensible use of natural resources and implement modern solutions to reduce costs. The current excessive consumption observed worldwide has a significant impact on the natural environment. The aim of the article is to assess contemporary trends and social behaviours related to the management of natural resources. The main hypothesis is as follows: the pro-ecological behaviours of an individual brings global benefits. Increasingly noticeable climate changes are causing adverse weather phenomena such as droughts, floods, storms and others, which the world has to deal with every day. Planet Earth has stopped keeping up with the pace of economic and social development worldwide. This article demonstrates authenticity in modern times through its analysis of socio-economic behaviours. Growing populations and the rapid pace of natural resource exploitation could cause a serious threat to survival on the planet.

## 2. Literature review

Earth offers an extraordinarily large amount of natural resources that allow for human and animal life. Defining the term natural resources, these are the wealth drawn from the environment for the functioning and survival of life (Bridge, Wyeth, 2020).

Natural resources are divided into (Rajović, Bulatović, 2017):

- inexhaustible (permanent) energy: solar, wind, running water, geothermal, air,
- exhaustible, among which a distinction is made between:
  - non-renewable which occur in limited quantities, mainly mineral resources e.g. coal, lignite, natural gas,
  - renewable, which are reproducible, but at very different times, e.g. wood, crop production waste, biogases, water, agricultural crops.



The division of natural resources is distinguished, taking into account their functions, e.g. energy raw materials, which include, among others: hard coal, lignite, oil, natural gas ([www.environmentgo.com](http://www.environmentgo.com)).

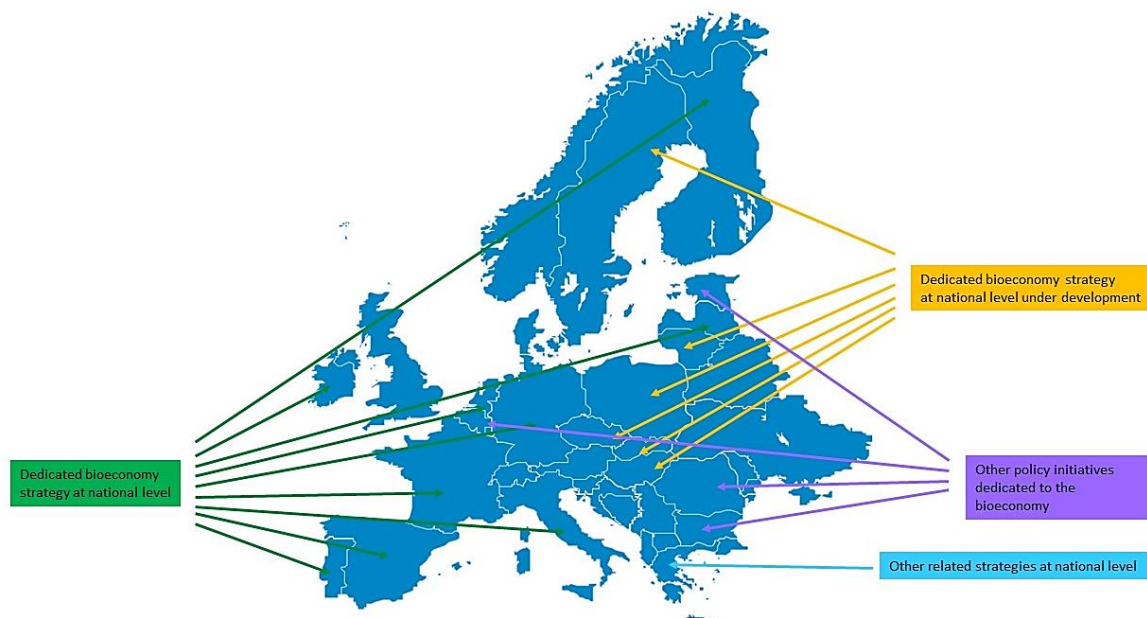
Natural resources and how they are managed are key to the future (Pencarelli et al, 2020). Globally, the way of life of the population has changed a lot compared to a few decades ago. Therefore, the most important commodities such as energy, water and food needed for life are being consumed more and more. It is necessary, then, to manage resources rationally and to use renewable energy sources, which have many advantages (Lewicka et al., 2020). Current consumer behaviours are more difficult to predict due to dynamic changes in the national and international environment (Sarraf, 2019). Increased consumption and lack of care for the environment is leading to irreversible climate and socio-economic changes. The scale of environmental change and its complexity is a contemporary problem that has never existed before (Shin et al., 2021). At present, there is a noticeable trend towards excessive consumerism and the desire to have as many possessions as possible (Heinonen, Strandvik, 2021). Products often bought in excess are not needed at all. This contributes to overproduction and affects the environment and the use of natural resources such as water, raw materials, minerals, soil, etc. (Fernandes, Moreira, 2019). A main problem in today's society is also waste, which affects the global economic, social and environmental situation (Gharzai et al., 2020). Too many products create more and more pollutants entering the atmosphere and generate a large amount of waste. It is forecast that sales of many commodities could fall significantly in the coming years due to the economic situation in many regions around the world (Bain, Company, 2020). Adequate environmental management and consumption of available raw materials should reduce adverse climate change and have a positive impact on the economic situation (Bras et al., 2020).

The topics of natural resource management and social and economic impacts on climate change are being addressed by international institutions such as the Intergovernmental Panel on Climate Change (IPCC), which has indicated that human activity is responsible for climate change, the rapid warming of the Planet and related environmental changes on Earth (IPCC, 2021). It is forecast that people born in 2020 may experience 6.8 times more heat waves during their lifetime (Luten et al., 2021). The International Energy Agency (IEA) reports the following trends in biodiversity ([www.gov.uk](http://www.gov.uk)):

- enhance the protection and restoration of ecosystems,
- mitigating climate change,
- action on pollution, invasive alien species and overexploitation,
- more sustainable production of goods and services, especially food,
- reducing consumption and waste.

Many international organisations point to the dangers of mismanagement of natural resources. Already in 2020, the Global Footprint Network estimates that 7.8 billion people will have consumed far more resources and emitted more waste than can be naturally renewed, absorbed by the Earth (Statistical Information on Electricity Monthly Bulletin). Resource efficiency is one of the approaches also proposed by an international group of experts called the IRP to decouple economic growth from environmental degradation while improving human well-being ([www.resourcepanel.org](http://www.resourcepanel.org)).

Today, changes in global energy security have considerable implications for future societal functioning. Rational use of the limited resources needed for energy generation, such as coal, natural gas and oil, will allow them to be used for a longer period of time. Strategies for the protection of natural resources are being developed and implemented in European Union countries (Figure 1.)

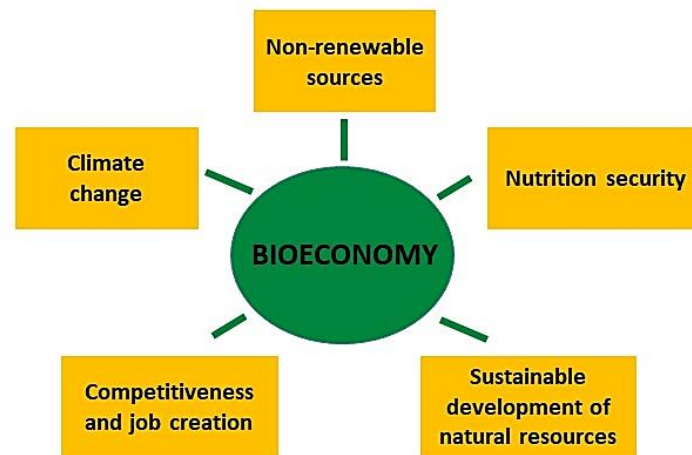


**Figure 1.** State of national bioeconomy strategies in the EU27 as of February 2022.

Source: [www.gov.ie/en/consultation/fd200-bioeconomy-action-plan-consultation/](http://www.gov.ie/en/consultation/fd200-bioeconomy-action-plan-consultation/)

According to the information presented above, in December 2022, ten Member States had national bioeconomy strategies in place. These countries are: Austria, Germany, Spain, France, Finland, Ireland, Italy, Latvia, the Netherlands and Portugal. A further seven Member States were in the process of developing strategies. This group included: Czech Republic, Croatia, Hungary, Lithuania, Poland, Sweden and Slovakia. Other countries were implementing regional initiatives and national adaptation strategies.

The European Union has identified five main areas/assumptions for the bioeconomy (Figure 2).



**Figure 2.** The main conceptual framework of the bioeconomy in the European Union.

Source: Own elaboration based on [www.gov.ie/en/consultation/fd200-bioeconomy-action-plan-consultation/](http://www.gov.ie/en/consultation/fd200-bioeconomy-action-plan-consultation/)

The five most important tasks of the European Union Member States in creating bio economies are to create food security in all countries of the Community, to take care of non-renewable energy sources and to apply the principles of sustainable development of natural resources through their rational use, to take care to minimise the adverse impact on climate change, to create a competitive market and to create jobs for the citizens of the European Union. On the basis of these assumptions, the principles of a conceptual framework for Member States have been developed (Giuntoli et al., 2023; Bogdanski et al., 2021; FAO, 2021).

Global trends in natural resource management and ongoing climate change inspired the authors of this article to conduct their own research on public awareness of environmental protection.

### 3. Research methodology

The article uses quantitative research based on a traditional and electronic survey questionnaire. The questionnaire was developed to assess public awareness of the implementation of environmental and economic solutions. The survey was divided into three sections. The first concerns the environmental and pro-social activities undertaken to build the environmental awareness of the population. The second part of the questionnaire relates to the individual attitudes of residents towards the diffusion of environmental solutions in their own households. In addition, the survey questionnaire shows whether residents feel the need to promote sustainability. The third section includes a metric to identify the gender, age, education, place of residence and source of income of respondents. More than 600 anonymous respondents from all over Poland took part in the survey. The respondents were both women, who constituted 53%, and men 47%, aged 18 to over 65 years. The respondents came from

various regions of Poland and were characterized by: basic education 6%, vocational education 19%, average education 42% and higher education 33%. The article presents only some of the respondents' answers that directly influenced the realisation of the objective of the work.

## 4. Results

The survey questionnaire asked respondents whether measures aimed at biodiversity conservation were being taken in their neighbourhood. Of the 38% of affirmative local responses and 47% of affirmative individual responses, the following actions were identified. (Table 1) It should be noted that respondents could indicate more than one answer.

**Table 1.**

*Characteristics of local and individual actions taken aimed at biodiversity protection*

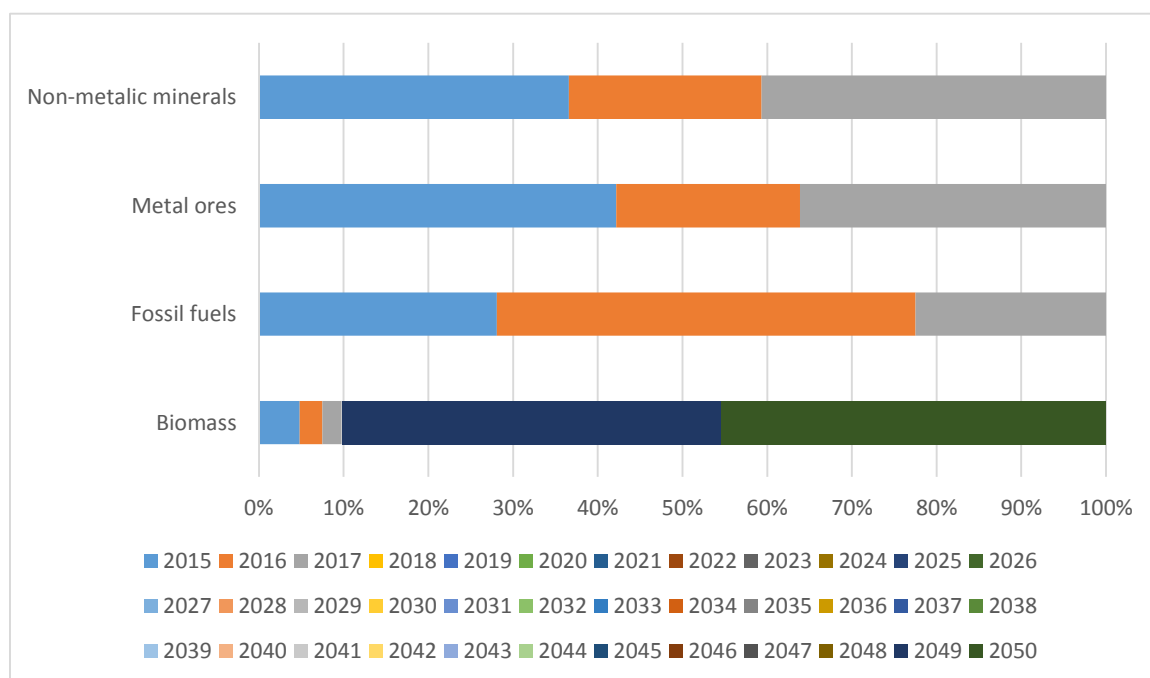
Type of local actions	Number of responses	Type of individual action	Number of responses
Expanding green spaces (e.g. by rebuilding concrete squares, limiting pavement extensions, etc.).	146	Ownership of wild landscape features	62
Increasing water-absorbing utility surfaces (e.g. car parks, pavements made of water permeable material - grates)	72	Reducing the use of chemicals in the garden in favour of manures, herbal extracts, etc.	129
Establishment of flowering gardens	78	Establishment of flowering garden	165
Establishment of facade gardens	40	Growing herbs	160
Establishment of flower meadows	70	Establishment of flower meadow	83
Reducing deforestation and forest degradation	36	Construction of insect houses	87
Maintenance of old trees	81	Installation of nest boxes on trees	84
Planting new trees	127		
Renaturalisation (savagery) of the landscape	21	Renaturalisation of part of the plot - "giving it back to wildlife"	39

Source: Own elaboration, N = 605.

The data shows that residents notice measures being taken in the form of expanding green spaces 146 responses, planting new trees 127 responses, or caring for old trees 81 responses. All the actions identified in the survey questionnaire are needed and support the return to the natural state of the environment. Most of the measures are implemented individually by respondents who are involved in growing herbs 160 responses given, establishing flowering gardens 165 responses or reducing the use of chemicals in the garden in favour of manures, herbal extracts 129 responses of respondents. All actions in favour of biodiversity protection applied individually or in groups increase the chance of positive environmental change.

Constant technological development means that the demand for energy is constantly increasing (Kautish, Sharma, 2019). Electricity and heat have become the most essential resources needed for people to function around the world. The ability to own these resources provides a better quality of life for each household and the economic viability of businesses (Cranfield, 2020). It is important to change the strategy of business entities in order to meet the growing expectations of demanding customers (Heinonen, Strandvik, 2021; Tevšić, Nanić, 2020).

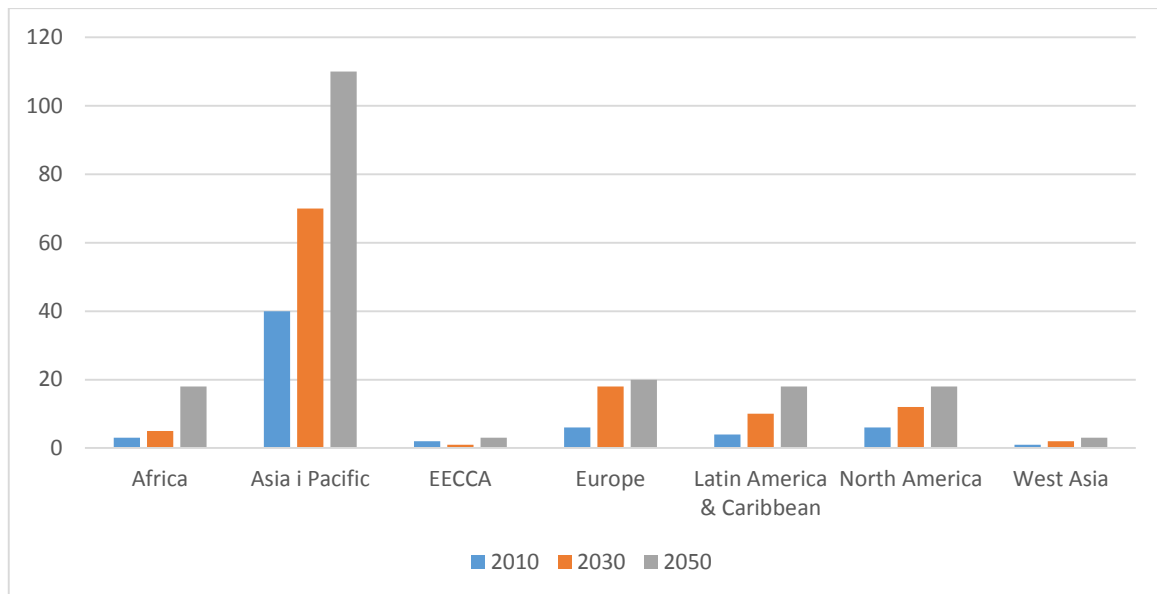
The ability to extract natural resources allows energy to be obtained. Trends in resource extraction by the four categories (biomass, fossil fuels, metal ores and non-metallic minerals) from 2010 to 2050 are shown below (Figure 3).



**Figure 3.** Global resource extraction from 2010 to 2050 for existing trends.

Source: [www.resourcepanel.org/reports/assessing-global-resource-use](http://www.resourcepanel.org/reports/assessing-global-resource-use)

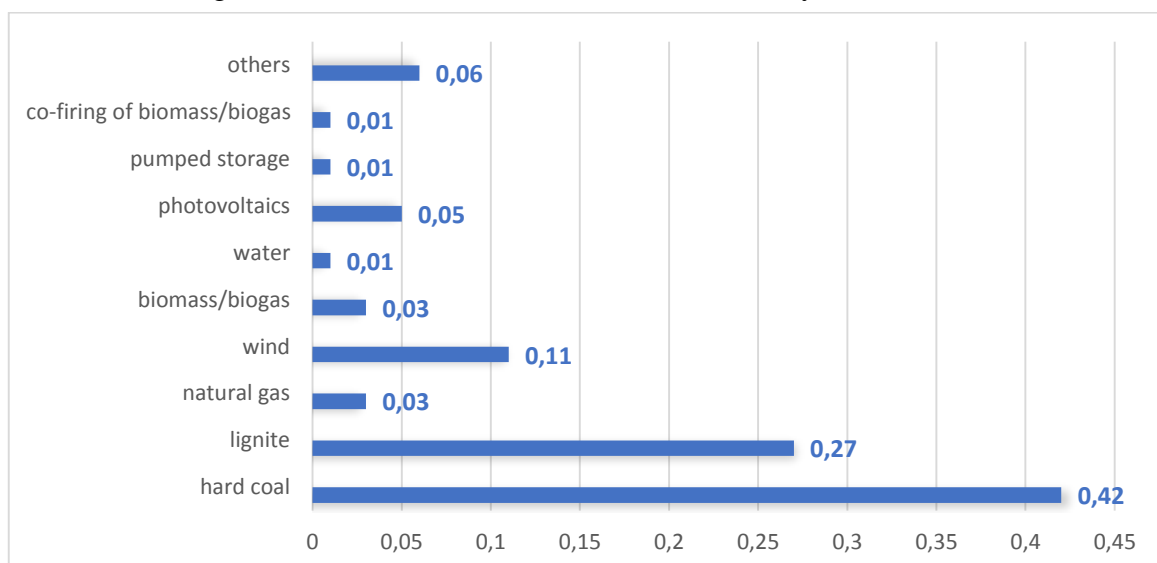
Global trends indicate that extraction of particular resource groups is increasing due to growing social and economic demand. The largest group is minerals, which, according to the trends presented, are expected to maintain growth until 2050. Another extracted resource is biomass, which is much less extracted by 2050 than minerals, but is still on an upward trend. Extraction in individual regions of the world is also shown below (Figure 4).



**Figure 4.** Global resource extraction by world region 2010-2050 for current trends.

Source: [www.resourcepanel.org/reports/assessing-global-resource-use](http://www.resourcepanel.org/reports/assessing-global-resource-use)

According to the data in Figure 4, the largest extraction of raw materials is and will be in Asia and according to forecasts it will exceed 100 trillion tons by 2050.

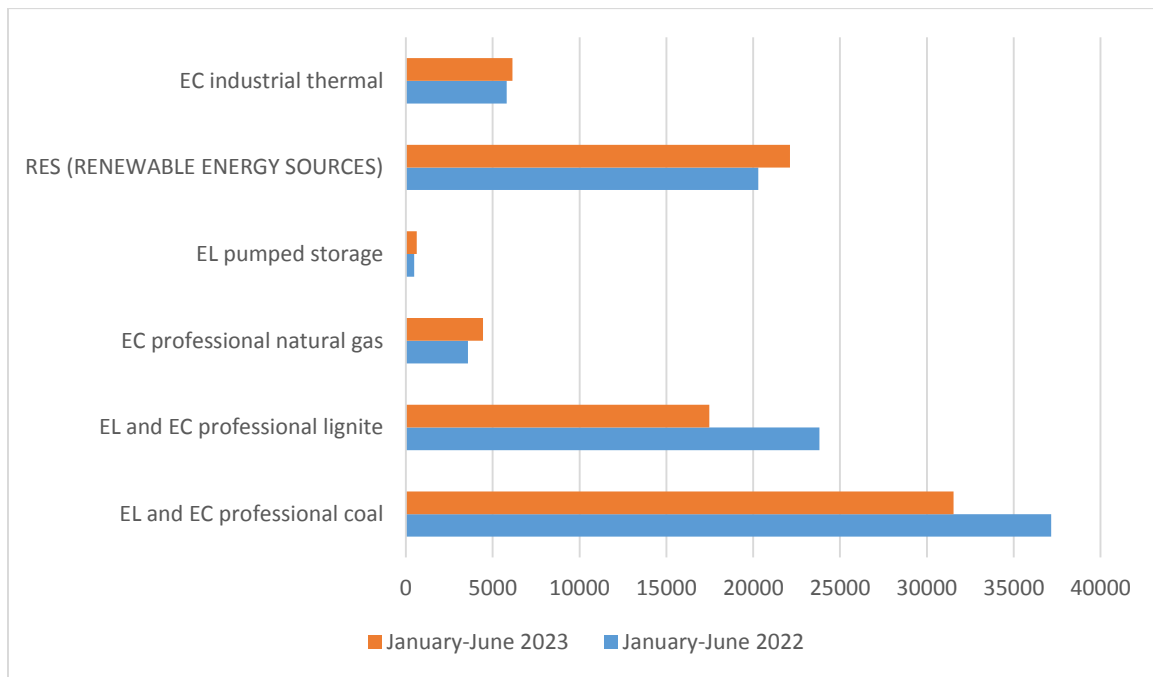


**Figure 5.** Energy sources in Poland in 2022.

Source: Based on the Energy Market Agency.

The main resource used and extracted in Poland for years has been coal. Data from the Energy Market Agency shows that in 2022 the raw material used for energy production in Poland was hard coal and lignite, the least used resource for energy production was water.

From the data shown in the graph above, the main source in Poland in 2022 was: hard coal and lignite, accounting for 69% of energy resources. The least used was energy from water, just 1%. Energy production in Poland in 2022-2023 is shown in Figure 6.



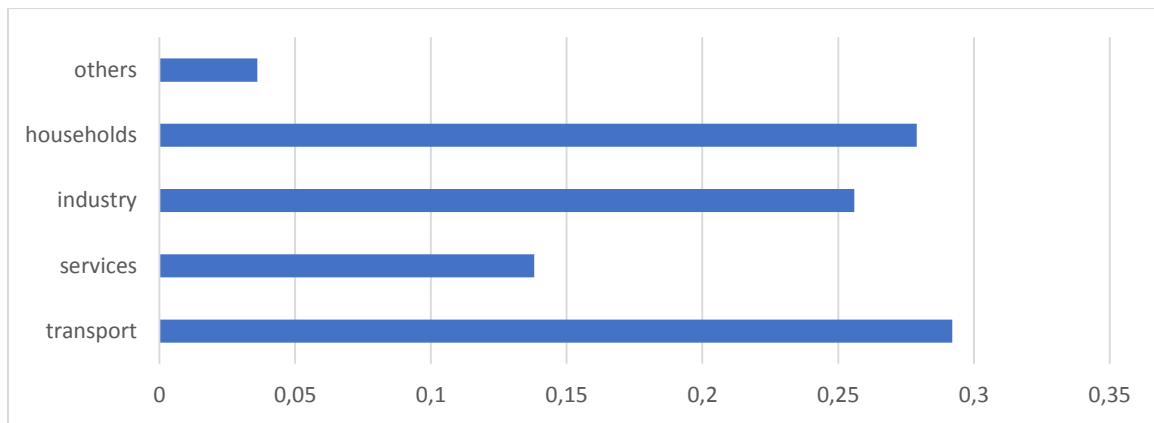
**Figure 6.** Electricity production by fuel [GWh] January-June 2022 to January-June 2023.

Source: Statistical Information on Electricity Monthly Bulletin, Ministry of Climate and the Environment Energy Market Agency s.a. Warsaw 2023, p. 19.

The implementation of modern technological solutions is an opportunity to increase the use of renewable energy sources, which in future will make it possible to become independent of fossil sources, which are running out and adversely affecting the environment.

All sectors of the economy and households need energy to function. A strategy called the Green Deal has therefore been implemented in the countries of the European Union, which aims to increase resource efficiency and create clean, closed-loop economies. The strategy assumes that member states should be climate-neutral by 2050 (Kardung et al., 2021). Investing and creating modern energy tools should restore biodiversity and reduce pollution. Innovative solutions need storage facilities in which to store the energy produced. It is therefore important to create modern energy and storage networks (Kenai et al., 2018).

Analysing the available data for final energy consumption in the European Union in 2021, it can be seen that there are three dominant categories: transport (29.2 %), households (27.9 %) and industry (25.6 %) (Figure 7).

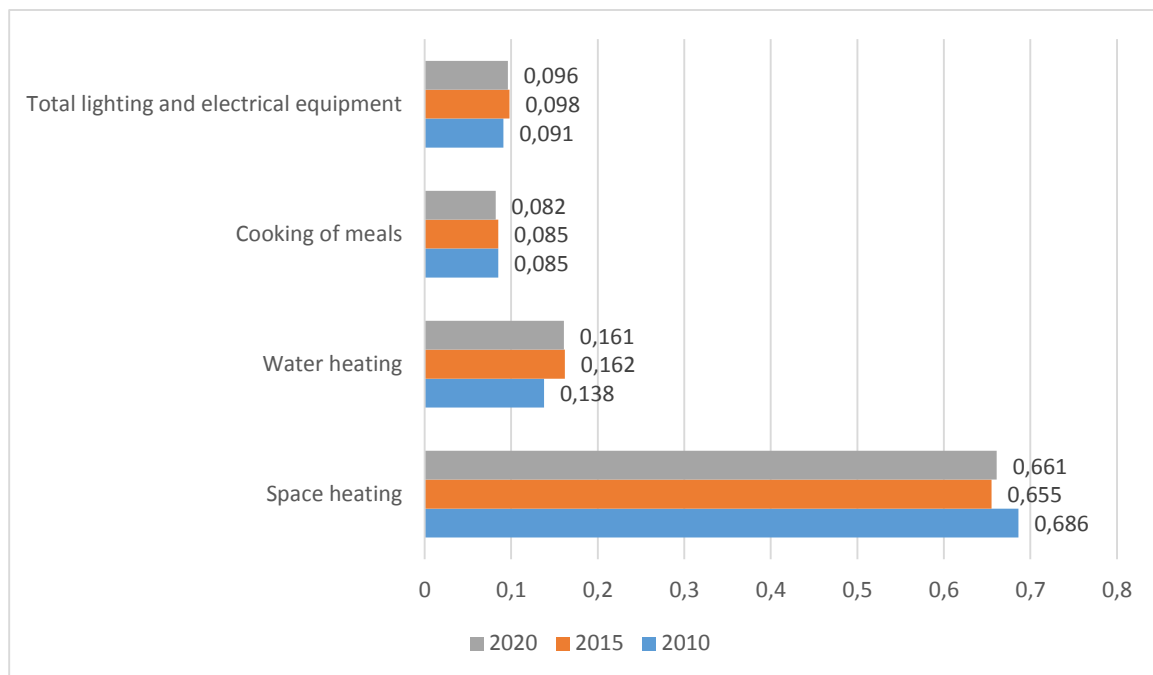


**Figure 7.** Final energy consumption in the European Union by sector in 2021 (% of total, based on terajoules).

Source: Eurostat [www.europa.eu](http://www.europa.eu)

Energy consumption is the highest in transport, accounting for almost 30% and households 28%, followed by industry 26% and services 14% and other sectors, just under 5%.

Referring to CSO data from 2010-2020, the structure of energy consumption in households in Poland, by type of use, is as follows (Figure 8).



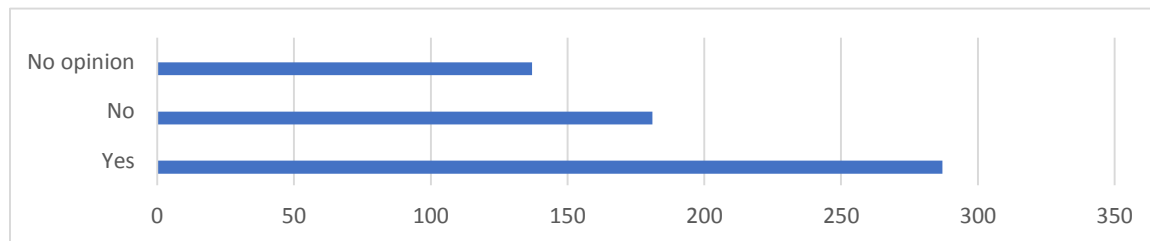
**Figure 8.** Structure of energy consumption in households in Poland, by type of use, 2010-2020.

Source: Own elaboration based on [www.stat.gov.pl](http://www.stat.gov.pl)

According to the data provided, most energy in Polish households is used for space heating, as much as 66% in 2020. Heating water uses around 16% of energy, while cooking uses 8.5% and lighting including electrical appliances uses just under 10%.



Analysing the high energy consumption in Poland, the survey asked about actions taken to reduce these costs. Respondents were therefore asked whether, in their opinion, any measures were being taken in their place of residence to implement modern solutions to reduce the costs of common energy consumption.



**Figure 9.** Structure of the answers given regarding the implementation of modern solutions reducing the costs of common energy consumption.

Source: Own study, N = 605.

Figure 9 shows that the vast majority of respondents answered in the affirmative, the characteristics of the implemented individual solutions are presented below (Table 2).

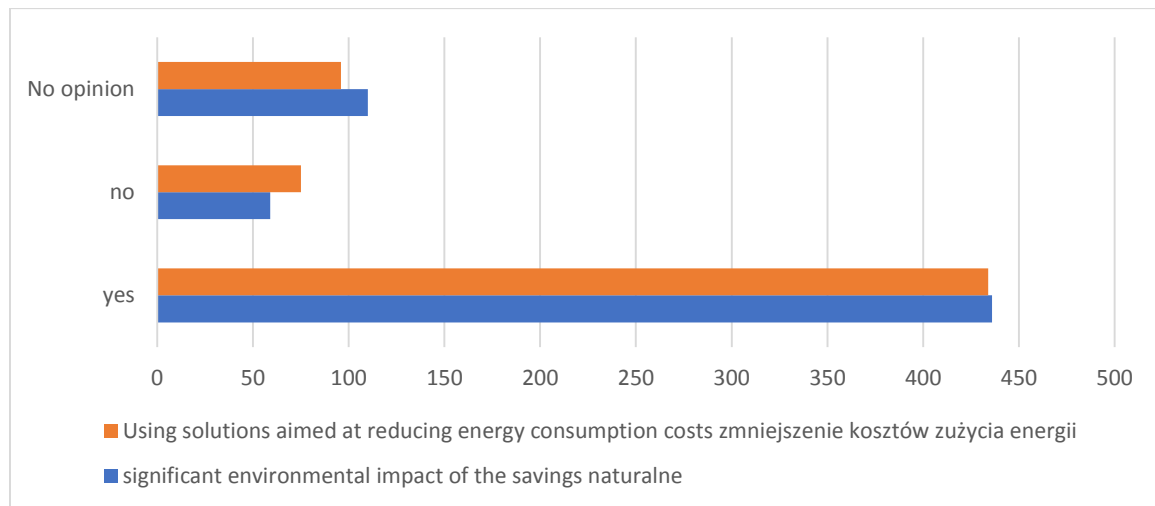
**Table 2.**

*Characteristics of the implemented solutions affecting the cost of shared energy consumption*

Type of modern solutions	Number of responses
Upgrading or installing a new energy network	96
Thermo-modernisation of housing	143
Construction of new dwellings in energy-efficient buildings	99
Use of renewable energy sources, including:	110
Solar energy (photovoltaic panels)	171
Wind (wind power plants)	46
Water (hydroelectric power stations)	27
Geothermal (geothermal power plants)	14
Biomass (biomass power plants)	11
Energy modernisation of public buildings	72

Source: Own elaboration, N = 605.

The most important solutions identified in Table 2 are the use of thermo-modernisation of dwellings and the use of renewable energy sources in which the use of photovoltaic panels is most frequently mentioned. Residents noted that the changes indicated above reduce the cost of common energy consumption in their place of residence. In Poland, the use of modern energy sources is increasing year on year, which undoubtedly has a positive impact on the climate. Analysing the relationship indicated in the survey between the significant impact of energy saving on the environment and the use of solutions aimed at reducing energy costs in the respondents' own environment, the following response rates were obtained (Figure 10).



**Figure 10.** Structure of the answers given regarding the relationship between the significant impact of energy saving on the environment and the use of solutions aimed at reducing energy costs in one's own environment.

Source: Own study, N = 605.

The vast majority of respondents note the significant impact of saving energy and using solutions to reduce energy consumption. The specific measures used to reduce energy costs are as follows (Table 3).

**Table 3.**

*Characteristics of measures aimed at reducing energy consumption costs in one's own neighbourhood*

Types of action	Number of responses
Replacement of the furnace with a modern heat source (e.g. heat pump)	144
Installation of photovoltaic panels	132
Insulation of the building	231
Using appliances with a high energy rating	183
Using energy-efficient light bulbs	300
Adjusting light intensity	108
Reducing the use of electrical appliances in the household	137
Using Eco programmes (e.g. in dishwashers, washing machines)	169
Switching off lights in empty rooms	261
Switching on high energy-saving mode on televisions	84
Switching on sleep mode on computers	142
Use of night-time tariffs	80

Source: Own elaboration, N = 605.

The data shows that the awareness of respondents and the measures applied are in line with global trends and fit in with the objective of minimising the consumption of natural resources in order to curb climate change. The activities most frequently indicated by respondents, i.e. using energy-saving light bulbs, switching off lights in empty rooms, and insulating buildings, reduce household energy consumption.

Behavioural change that takes into account environmental protection is a long-term process and requires a high degree of social and economic awareness (Shams et al., 2020). Environmental awareness is changing year by year as people recognise that preventing

environmental degradation is simpler and cheaper than repairing damaged nature later (Butler, Hackney, 2021).

Increasing public awareness and learning to reuse products is good for the environment. Promoting different groups of environmentally friendly products is a needed environmental and economic initiative (Kureshi, Thomas, 2020). Innovative bio-based products and the discovery of new applications reduce pollution (Jansen et al., 2021). Today, reusing waste, i.e. recycling, is an important activity (Chaturvedi et al., 2021; Pencarelli et al., 2020). An important aspect of energy conservation is its positive impact on the emission of harmful substances into the environment.

The benefits of reduced pollution result in less negative global climate change.

Globally, everyone recognises the negative economic and climate changes that are taking place, which is why modifications need to be made to electricity management habits in private and working life. Rising energy prices are encouraging rational management of energy resources. Saving energy benefits the household budget. The rational management of energy resources has recently become one of the most important measures in all European Union countries. Rising electricity and gas prices have led to a number of recommendations to reduce the demand for these resources. Below is a summary of several countries that have implemented recommendations for citizens to reduce their electricity consumption.

**Table 4.**

*Recommendations for citizens to reduce electricity consumption in selected EU countries*

<b>Poland</b>	<b>Germany</b>	<b>France</b>	<b>Italy</b>
Efforts to reduce energy consumption have included: - in retail and service establishments switching on only part of the lights, dispensing with illuminated signs - some shops are also planning shorter opening hours during the winter season - reducing heating to 19°C.	Efforts to reduce energy consumption have included: - banning the use of most outdoor lighting for buildings and monuments - lowering the minimum temperature in offices and public places to 19°C.	Efforts to reduce energy consumption have included: - heating only switched on when the temperature drops below 19°C - air conditioning switched off until the temperature does not exceed 26°C.	Efforts to reduce energy consumption have included: - reducing the lighting of public places and shops at night - increasing the operation of coal-fired power plants to reduce the use of more expensive gas for energy production.

Source: Own elaboration based on [www.pieniadze.rp.pl](http://www.pieniadze.rp.pl)

When talking about saving energy, it is important to follow global principles. The most important issue is to choose the right supplier and the most favourable tariff, adapted to your needs and possibilities. There are many different ways to save electricity at home, and they can be divided into three main categories:

- Purchase of suitable household appliances.
- Setting up/positioning the equipment.
- Use of the equipment.

An important source of energy costs is lighting, replacing incandescent bulbs with modern energy-efficient bulbs, preferably leds, allows far less energy to be used than traditional incandescent bulbs. It is also important to remember to clean dusty bulbs, which give much less light. During the day, it is best and healthiest to use daylight. When reading books or working in the evening, switch on a spot light; it is not necessary to illuminate the whole room.

The largest energy consumption cost, which can be significantly reduced through simple means, results from space heating. For heating to be effective, it is important to start by sealing or replacing the windows and doors through which most heat escapes. Care should be taken to ensure that the right type of heating source, e.g. radiators, are always uncovered and clean. The decoration of the room should be planned in such a way that curtains, furniture or other elements do not act as a barrier to heat. It is important to install a heat-reflective foil on the wall behind the radiator, it increases the thermal efficiency. A good way to do this is to close the curtains at night so that heat does not escape and to open them during the day when the sun can reheat the room. Installing thermostatic valves to regulate heat in less used rooms is another way to reduce energy consumption. All rooms should be ventilated briefly and intensively, several times a day. During this time, it is best to turn down the radiators. The rooms should also be properly ventilated.

Respondents to the survey also indicated other ways in which they care for the environment and the climate (Table 5).

**Table 5.**

*Characteristics of measures to protect the environment and climate*

Type	Number of responses
Reducing consumption (e.g. limiting the purchase of products and services)	233
Eco-driving (e.g. driving steadily, maintaining optimal engine speed, etc.)	207
Limiting car travel (e.g. using public transport, taking a neighbour to work, etc.)	213
Limiting meat consumption	113
Buying sustainable products (e.g. organic food, products made from recycled materials, etc.)	111

Source: Own elaboration, N = 605.

The presented results of the self-report survey confirm public awareness of the need for environmental protection measures and the rational use of natural resources. All the changes in daily life implemented out of concern for the environment have greater or lesser effects in the long term, so it is important to promote and implement them.

## 5. Conclusion

To sum up the above considerations, the most important issue is the appropriate, rational management of the natural resources we have in the world. Excessive use of certain non-renewable raw materials will result in their shortage over time. It will be possible to replace

certain groups of raw materials with others, although this may increase the cost of socio-economic life. The article is an original look at the topic under study and shows the level of public awareness in Poland in relation to global trends, which are similar. A weakness of the presented research is the area in which it was carried out, focusing only on Poland. Referring them to global trends, however, allows for a broader perspective on the topic under study. Recent years and the energy crisis have prompted all countries to engage in a global struggle to minimise the adverse social and economic impact of climate change. Only the implementation of global norms and principles for managing natural resources and protecting the environment can significantly hold back the rate of adverse climate change. The article proves that the hypothesis posed relating to the pro-environmental actions of the individual in the global interest is true. In the future, it is planned to carry out the study again and to extend its scope in order to analyse public awareness and the changes taking place in the subject area studied. All changes in the management of natural resources must be implemented individually so that entire societies, countries can avoid climate catastrophe. The most important benefits of the rational use of energy are a reduction in energy consumption costs, i.e. a reduction in energy expenditure, environmental protection and pollution, and longer use of existing limited energy resources.

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## GREENING HEALTHCARE DELIVERY: A PATH TO SUSTAINABLE DEVELOPMENT IN SILESIAN PUBLIC HOSPITALS

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**Purpose:** The study aimed to identify ecological innovations implemented in processes performed in Silesian public hospitals. Moreover, it was aimed to assess the degree of greening healthcare delivery by the departments in Silesian public hospitals.

**Design/methodology/approach:** The research goals were achieved by a quantitative survey, which was carried out in the Silesia region.

**Findings:** The study indicates that public hospitals are implementing ecological innovations in their processes, but the advancement of these units in this area is moderate. It was found that ecological process innovations introduced by Silesian public hospitals during the last three years included innovations in recycling, reduction of CO<sub>2</sub> emission, material savings, and waste minimization.

**Research limitations/implications:** The main limitation of the study was that the research was conducted only among hospitals in Silesia.

**Practical implications:** The study's results can be used when creating instruments and regulations to support the implementation of sustainability by healthcare units.

**Originality/value:** This study provides information on the diffusion of ecological innovations by Silesian public hospitals. Thus, it extends the knowledge about greening healthcare delivery in Poland.

**Keywords:** ecological innovation, eco-innovation, green innovation, sustainable development, healthcare units.

**Category of the paper:** Research paper.

### Introduction

Challenges that have arisen in the global economy due to decreasing natural resources, changing climate conditions, degradation of the environment and entire ecosystems (Lopes, Cruz Basso, 2023), as well as the growing gap between the highly developed countries and the

rest of the population (Matejun, 2009), have caused that in the 21st century, the concept of sustainable development has become popular. The fundamental idea behind this concept, according to which humanity has the opportunity to meet its present needs without compromising the ability of future generations to meet theirs (World Commission on Environment and Development, 1987, p. 16), has begun to guide the behaviour of most informed consumers. It has also directed the activities of some commercial and non-commercial organizations, which started to reduce their negative impact on the environment by introducing ecological innovations into everyday business practices. These innovations took a variety of forms. Some organizations have implemented green products, while others have changed their products or services in such a way as to reduce their negative impact on the environment. Still, other organizations modified the processes occurring within them. Solutions that emerged in this area included waste reduction and recycling, using environmentally friendly technologies and materials, using energy-efficient equipment and buildings, and introducing sustainable transportation systems (Sieg et al., 2023). Through such projects, many organizations have achieved environmental, economic, and social benefits (Chuang et al., 2022), such as cost reductions, productivity improvements, and increased reputation (Carvalho et al., 2018).

Ecological innovations have also attracted the attention of healthcare units. Their activities in this area have become necessary, as the healthcare sector is responsible for 4.4% of global carbon dioxide emissions (Health Care Without Harm Report; WUF11). In Poland, the healthcare sector generates, on average, 44 tons of medical waste annually, 90% of which is hazardous and mainly infectious (Supreme Chamber of Control, 2014, p. 16). To mitigate their negative environmental impact, healthcare units in the Polish market have begun to introduce changes in the processes accompanying the provision of their services. Thus, green healthcare delivery has begun to develop in Poland. However, little is known about all these changes in the healthcare sector. A literature review indicates that studies on environmental innovation conducted in Poland have generally concerned commercial organizations (Derej, 2017; Rutkowska, Pakulska, 2018) and only selected were focused on public organizations. Healthcare units have been only marginally in the interest of researchers in this area. Filling this cognitive gap formed the basis of the study, the results of which are presented in the article. That study aimed to identify the types of ecological innovations implemented in processes performed in Silesian public hospitals. Additionally, the study aimed to assess the degree of greening practices in the public hospitals of the Silesian region. The established goals were achieved by a quantitative survey, which was carried out in the Silesia region.

## 1. Greening of organizations based on ecological innovation

The globalization of economic processes, increasing consumption, and economic development have contributed to the ongoing destruction of the natural environment. Consequently, many countries have implemented environmental regulations, stimulating various organizations to consider environmental protection (Lopes, Cruz Basso, 2023). As a result, there have been many changes in the management of organizations, which have been legally forced to consider not only economic issues (improving profitability, efficiency, creating added value for stakeholders) but also ecological aspects in their plans. Organizational undertakings considering ecological aspects have led to the implementing of a sustainable development concept into practice (Matejun, 2009). One manifestation of organizations embracing sustainable development has been their focus on optimizing processes with limited environmental exploitation. From this perspective, sustainable development has inspired many firms to create new solutions for environmental issues, known as ecological innovations (Sieg et al., 2023).

The concept of ecological innovations was first proposed by Fussler and James in 1996 (Domaracká et al., 2023). Today, ecological innovations are defined as the production, assimilation, or exploitation of a product, production process, service, or management method that is innovative for the organization (developed or adopted) and, throughout its lifecycle, results in a reduction in environmental risk, pollution, and other negative effects of resource use (including energy consumption) compared to relevant alternatives (Miao et al., 2023). Ecological innovations can be considered innovations with a lower environmental impact, regardless of whether environmental factors are the primary motivation for their development or implementation (del Rio et al., 2017). Ecological innovations in products or services enable businesses to produce goods with lower energy and material inputs, ultimately reducing costs. They also improve business performance by enabling organizations to comply with legal requirements, reducing administrative and managerial costs, creating jobs that enhance employee satisfaction, and lowering supply chain costs. Moreover, these solutions facilitate the implementation of innovations by fostering a positive organizational culture toward innovation, allowing companies to achieve sustainable competitive advantages (Al-Hanakta et al., 2023). Therefore, by implementing ecological innovations, organizations can achieve both environmental benefits and positive economic effects, such as cost reduction, improved results, increased added value for customers, better resource management, and a competitive edge, as well as creating a friendly workplace.

## 2. The healthcare units as entities implementing ecological innovations

Healthcare units, like other contemporary organizations, have begun to implement green innovations to mitigate their negative environmental impact resulting from high CO<sub>2</sub> emissions and large resource consumption (Šūmakaris et al., 2021). The Health Care Without Harm report provides the scale of the significant level of emissions generated by the healthcare sector. It shows that if the healthcare sector were considered a country, it would be the world's fifth most significant source of greenhouse gas emissions (Health Care Without Harm Report; WUF11). Therefore, many countries are striving to reduce the pollution created by healthcare units by setting themselves the goal of meeting the requirements of the Paris Agreement and the European Green Deal, which pledge, among other things, to reduce the effects of global warming and thus keep temperature increases below 1.5°C, reduce emissions by at least 55% by 2030 (compared to 1990), and make Europe a net zero continent in terms of carbon emissions by 2050 (Puls Medycyny, 2022).

Healthcare units may be encouraged to adopt green innovations because of the economic benefits they can provide them (Shah, Ahmed, 2019; del Río et al., 2012). These benefits include managing resources more efficiently, reducing costs by avoiding an environmental fee, achieving energy and water consumption savings, and being competitive. They are essential for healthcare units because healthcare in all countries is costly. Many countries, including Poland, are struggling with the high costs of healthcare entities. In Poland, managing healthcare units involves managing limited financial resources and a shortage of medical staff (Wiśniewska, 2021). In addition, due to the persistent inflation in recent years, managers of healthcare units have to cope with the rising cost of medicines and medical supplies, as well as the high cost of electricity and water, which are essential in the treatment process. The increase in the cost of healthcare units is also caused by demographic changes - an aging population, diseases of civilization, deteriorating health, and an increase in the percentage of the population burdened with chronic diseases and disabilities (Szymborski, Marciniak, 2015). Because of this, the number of patients is increasing, and thus healthcare costs are rising sharply (Pawłowska, 2015).

The willingness of healthcare units to reduce costs may be an additional factor determining their efforts toward ecological innovation (Šūmakaris et al., 2021). However, healthcare units may not experience cost reductions from implementing ecological innovations such as those obtained by organizations in other sectors. That is due to the peculiarity of health care units, which lies in the fact that the priority in health care units is always the patient's health. Consequently, solutions from other sectors cannot be implemented in healthcare units (Dymyt, 2018).

### 3. Methodology

The achievement of the set goal was realized based on a quantitative study conducted as part of the project 'ECONomics4Climate Diverse Trajectories of Research in Economics of Climate Change.' This project was funded by the Metropolitan Fund for the Support of Science (Research Task No. 3). The research focused on the greening processes implemented in the wards of public hospitals. It was assumed that colocalization constitutes a set of actions taken in hospital wards toward minimizing negative environmental impact. For this article, only a portion of the data obtained from this study regarding ecological process innovations was utilized.

The study respondents were mid-level managers in the medical sector, such as ward directors or heads of clinics, as well as financial, economic, analysis, and cost or medical statistics departments responsible for recording the number of hospitalized patients and employed staff. The study was conducted from July to September 2023 among 60 departments of public hospitals located in the Silesian Voivodeship: Bytom, Chorzów, Dąbrowa Górnicza, Gliwice, Jaworzno, Katowice, Piekary Śląskie, Ruda Śląska, Siemianowice, Sosnowiec, Świętochłowice, and Zabrze. The survey questionnaire was sent to 328 departments, and the response rate was approximately 18%. Hospitals representing all levels of qualification for the basic hospital security system, as defined in Article 95 of the Act of August 27, 2004, on health care services financed from public funds (Journal of Laws 2021.0.1285), participated in the study.

Data were collected using a questionnaire specifically prepared for the study, consisting of 11 statements regarding ecological process innovations (Green process innovation), questions about the number of employees and the number of hospitalized patients per year, as well as metric questions. The questionnaire items used to construct the greening index were drawn from the literature, including the study by Junaid, Zhang, Syed (2022), Wu (2013), and Singh et al. (2020). Table 1 presents the statements on ecological process innovations used in the questionnaire and their classification. These statements were grouped into 5 fields (minimizing negative emissions; recycling; energy and water savings; material savings; environmentally friendly products) as indicated by Sieg, Posadzińska, and Józwiak (2023).

**Table 1.**

*Statements regarding green process innovations used in the study*

Fields	Designation	Question
Recycling	Q2	In the last 3 years, my Department has been involved in new recycling processes.
	Q8	In the last 3 years, a waste utilization system has been implemented in my Department.

Cont. table 1.

<b>Minimizing negative emissions</b>	Q3	In the last 3 years, new processes reducing the emission of hazardous substances have been implemented in my Department.
	Q9	In the last 3 years, new procedures that reduce the need for transportation have been implemented in my Department.
<b>Energy and water saving</b>	Q5	In the last 3 years, energy-efficient renovations have been carried out in the buildings of my Department.
	Q6	In the last 3 years, new investments in the modernization of electrical installations have been implemented in my Department.
	Q10	In the last 3 years, lighting has been replaced with energy-efficient and/or motion sensor-equipped lighting in my Department.
	Q11	In the last 3 years, there has been a replacement of the central heating system in my Department.
	Q1	In the last 3 years, new processes reducing the consumption of electricity and water have been implemented in my Department.
<b>Savings on materials</b>	Q4	In the last 3 years, electronic document circulation has been implemented in my Department.
<b>Eco-friendly products</b>	Q7	In the last 3 years, new forms of collaboration with suppliers providing eco-friendly products and goods have been established in my Department.

Source: Own compilation based on the study.

In the prepared questionnaire, a Likert scale was utilized. The appropriateness of choosing the Likert scale for the following research was based on the justification proposed by Norman. Despite being a nominal scale, its application is necessary to facilitate analysis and calculations (Norman, 2010). The Likert scale is the most commonly used measurement tool in highly cited, peer-reviewed scientific articles in the field of management and quality sciences (e.g., Xie et al., 2019; Dana et al., 2021).

The collected data underwent statistical analysis. Statements regarding ecological process innovations were used to create an index called the departmental greening index. This index was constructed by calculating the arithmetic mean of responses to questions from Q1 to Q11 and could take values from 1 to 5. The reliability of the scale was assessed using Cronbach's alpha model. Additionally, in the analysis of the collected data, descriptive statistics were applied to describe the most important information about the studied ecological process innovations and the entities under investigation. Calculations were conducted using the Jamovi program.

## 4. Results

To assess the greening of public hospital departments in the Silesian Voivodeship, a composite index was developed in the first stage of the analysis, representing a compilation of all ecological actions undertaken by the department. Subsequently, the reliability of this index was evaluated using Cronbach's alpha model. Table 2 presents the Cronbach's alpha values for individual scale items, while Table 3 provides the Cronbach's alpha value for the scale consisting of 11 statements related to ecological innovations.

**Table 2.**

*The Cronbach's alpha values for individual statements constituting the greening index of departments.*

Cronbach's $\alpha$	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
	0.811	0.792	0.804	0.827	0.775	0.785	0.803	0.803	0.791	0.795	0.789

Source: Own compilation based on the study.

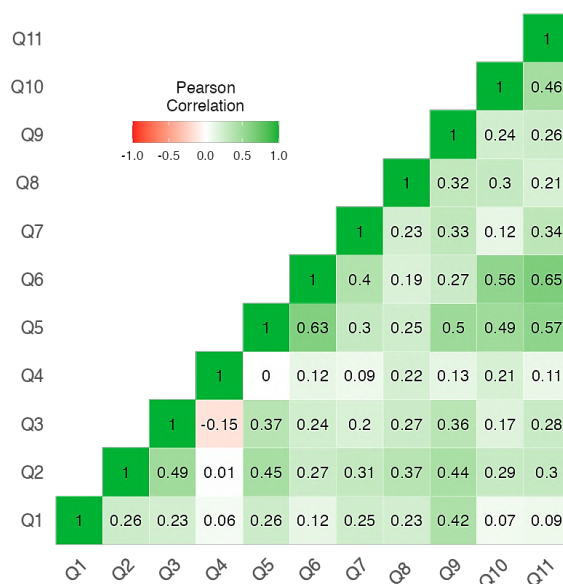
**Table 3.**

*The Cronbach's alpha value of the departmental greening index*

	Mean	SD	Cronbach's $\alpha$
scale	5.78	1.98	0.813

Source: Own compilation based on the study.

Based on the Cronbach's alpha values, it was determined that the results are satisfactory; however, an analysis was conducted to ascertain whether removing any of the statements would enhance the results. The calculations carried out in this regard (Figure 2) indicated that removing item Q4 would improve the reliability of the index.



**Figure 2.** Correlation map for statements related to ecological process innovations.

Source: Own compilation based on the study.

After removing statement Q4, the reliability analysis of the hospital department greening index was conducted again. The obtained Cronbach's alpha results for individual statements and for the scale consisting of 10 statements are presented in Table 4 and Table 5, respectively.

**Table 4.**

*Cronbach's alpha values for statements comprising the greening index of departments after excluding Q4*

Cronbach's $\alpha$	Q1	Q2	Q3	Q5	Q6	Q7	Q8	Q9	Q10	Q11
	0.826	0.806	0.816	0.788	0.801	0.819	0.822	0.807	0.814	0.805

Source: Own compilation based on the study.

**Table 5.**

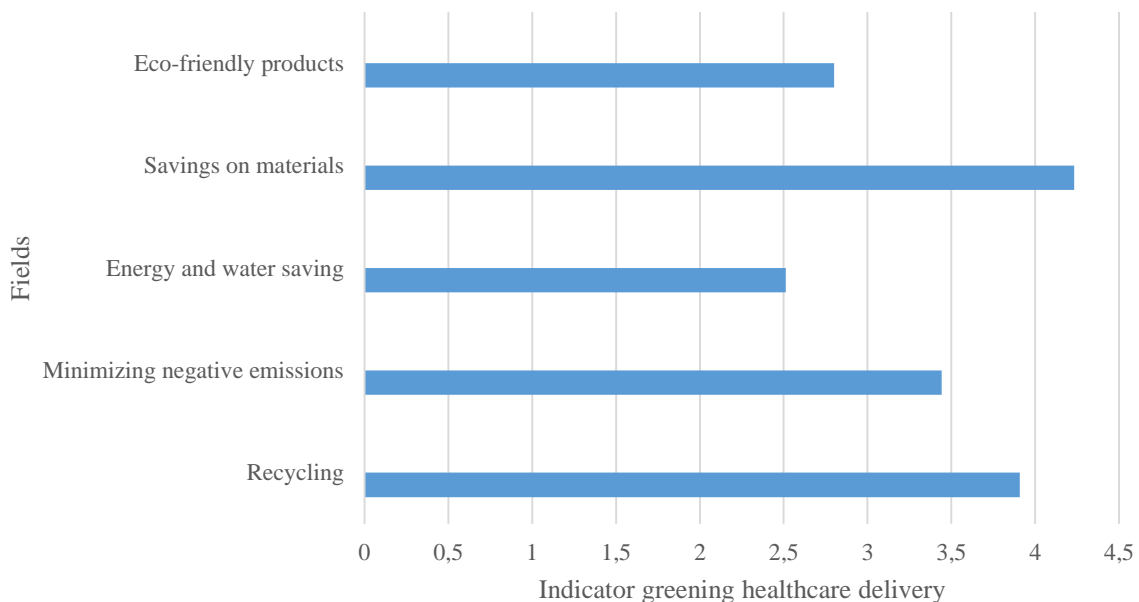
*Cronbach's alpha value and statistics for the greening index of departments after excluding Q4*

	Mean	SD	Cronbach's $\alpha$
scale	5.53	2.12	0.827

Source: Own compilation based on the study.

The results presented in Table 4 and Table 5, compared to Table 2 and Table 3, indicate that the exclusion of Q4 improved the Cronbach's alpha values. The Cronbach's alpha value for the greening index of public hospital departments is 0,827, indicating very good internal consistency of the analyzed questionnaire.

The greening index for the examined public hospital departments was 3,15, indicating a low level of activity in minimizing the negative impact on the environment by public hospitals. The values of the greening index for specific areas where ecological innovations were introduced in the surveyed hospitals, however, varied (Figure 2).



**Figure 2.** Greening index of hospital departments compared across areas.

Source: Own compilation based on the study.

The results presented in Figure 2. indicate that the greening index was highest in the field of material savings, where it reached 4,23, and in the area of recycling, with a score of 3,91. The area of energy and water savings had the lowest greening index in hospital departments, as it stood at 2,51. Based on the results, it can be inferred that the activity of hospital departments should be directed towards finding ecological solutions in areas with the lowest index.

To identify the environmental protection efforts undertaken in public hospital departments, a determinant of responses to statements about ecological activities was established. The obtained results indicate that in the surveyed healthcare facilities over the last 3 years,



projects related to building thermo modernization (Q5), new investments in the modernization of electrical installations (Q6), new procedures reducing the need for transportation (Q9), replacement of lighting with energy-efficient and/or motion sensor-equipped lighting (Q10), and central heating replacement were not undertaken (Q11). However, actions that were implemented in the surveyed healthcare facilities over the last 3 years included: new recycling processes (Q2), new processes reducing the emission of hazardous substances (Q3), implementation of electronic document circulation (Q4), and waste utilization system (Q8). Using the classification proposed by Sieg, Posadzińska, Józwiak (2023), it can be observed that the surveyed healthcare facilities least frequently undertook actions in the fields of energy and water savings, while they were most frequent in the areas of recycling and material savings.

The lowest greening index value was 1,45, occurring in the internal medicine department, employing 17 staff members, and averaging 850 patient hospitalizations per year. On the other hand, the highest greening index value was 5. This result was achieved by a nationwide hospital. It was also an internal medicine department, employing 40 staff members, and hospitalizing 500 patients per year. Departments belonging to nationwide hospitals include research institutes and clinical hospitals. They have access to higher funding than local and regional hospitals, as well as more qualified and informed personnel. Additionally, these hospitals are involved in research and development activities and the search for new service delivery solutions. Their responsibilities also include education and preparation for the medical profession. Therefore, departments belonging to nationwide hospitals tend to follow the latest knowledge.

## 5. Discussion

The study results indicate that ecological innovations are being implemented in public hospital departments. However, the healthcare delivery of Silesian hospital departments is moderate, as evidenced by the index value of 3,15. The study revealed that process innovations introduced in public hospitals in the last three years included recycling, reduction of CO<sub>2</sub> emission, material savings, and waste minimization. Recycling innovations involved waste segregation and waste disposal processes. Innovations aimed at reducing CO<sub>2</sub> emissions included procedures that reduce the need for transportation and minimize the emission of hazardous substances. Material savings activities mainly focused on the implementation of electronic medical documentation circulation.

The ecological innovations introduced in Silesian hospitals mainly related to areas for which new legal regulations obliging medical entities to apply specific solutions occurred during the studied period. For example, actions taken in hospitals in material savings could be significantly influenced by regulatory obligations in Poland since July 1, 2021, concerning the creation, storage, and exchange of electronic medical documentation. These regulations imposed

an obligation on national healthcare entities to maintain electronic medical documentation, which could have been a significant determinant for implementing new procedures in this area (Article 56 of the Act on the Information System in Healthcare). Similarly, ecological innovations introduced in public hospital departments in Silesia in the recycling area appear to be forced. On November 26, 2021, the Minister of Climate and Environment introduced a regulation on neutralizing and storing medical and veterinary waste, forcing hospitals to search for new solutions in this area. Financial support from the National Fund for Environmental Protection and Water Management (NFOŚiGW) for projects related to the construction or reconstruction of medical waste incinerators and thermal waste disposal systems could have influenced hospitals to undertake initiatives in this area. The Fund provided financial support to healthcare entities for investments related to the disposal of hospital waste, which could have influenced the projects undertaken by the units. Considering this situation, it seems that many of the process innovations introduced in hospitals in Silesia were not motivated by the desire to reduce CO<sub>2</sub> emissions but by necessity or cost reduction.

In the surveyed hospitals over the last three years, projects related to building term modernization, new investments in the modernization of electrical installations, and central heating replacement were rarely undertaken. The low activity of the surveyed hospitals in this area could be because NFOŚiGW could finance investments in the energy modernization of hospitals under hospital support programs that applied in the years 2016-2019, and this period was not considered in the study (the last three years cover the period from 2019 to 2022). NFOŚiGW financed activities such as thermo-isolation works, the use of renewable energy sources (RES), and the implementation of energy management systems, so the initiatives mentioned above could have been undertaken by the surveyed departments in previous years. The area where ecological innovations in hospitals were least frequently introduced was activities aimed at energy and water savings. That may be because energy and water consumption accompany the provision of services to patients, and savings in this area can lead to increased infections.

Considering the study results and the economic situation of many public hospitals in Poland, it can be assumed that implementing ecological innovations in Polish public hospitals may look similar in the future. Due to financial liquidity problems, these entities may need help to implement ecological innovations. Many hospitals would be willing to implement ecological innovations since they often reduce the costs of processes in organizations (Šumakarisa et al., 2021). However, they often lack the financial means to take steps in this field.

## Conclusion

Like other modern organizations, public hospitals in Poland must comply with environmental regulations and policies. Therefore, healthcare units implement ecological goals in their strategies. However, although responsible management considering ecological innovations is becoming necessary, medical units' priority remains human health and life. Therefore, implementing ecological innovations in health units differs from other sectors.

The study presented in the article provides valuable information on the greening of Polish public hospitals. Thus, the study's results contribute to the development of knowledge about ecological innovation in healthcare units in Poland. Nevertheless, the survey has some limitations. The main limitation stems from the survey being conducted only among hospitals in Silesia, and it referred only to selected ecological innovations in the process. Expanding the survey to other regions of Poland and including a broader range of innovations would be worthwhile in the future. The determinants of ecological innovation are also worth exploring. The survey results may be used while creating instruments to support the implementation of sustainable development and legal regulations in this area.

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## KNOWLEDGE TRANSFER ACTIVITIES IN UNIVERSITY

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**Purpose:** The purpose of this article is to review the literature and the activities and resources of technology transfer offices at the European level. A comparison of the literature and the practical, applied by the KTOs, approach to knowledge transfer made it possible to formulate reflections that can be used in shaping improvements.

**Design/methodology/approach:** The literature review on knowledge transfer was conducted using the desk research method. Searches in the databases above complemented the literature collected for the following keywords: Knowledge transfer, knowledge transfer resources and activities, forms of knowledge transfer, knowledge transfer methods, knowledge commercialization. The article uses the ASTP 2021 Survey Report on Knowledge Transfer Activities in Europe, an industry report. The report is based on data from 519 knowledge transfer offices (KTOs) from 26 countries for fiscal year 2019.

**Findings:** The work indicates that there is great interest among researchers in knowledge transfer. This is related to the development of the knowledge economy. At the same time, a review of the activities and resources of technology transfer offices at the European level shows a wide variation in activities, resources and the results achieved. More accurate predictions of the motivations and decision-making approaches of academics involved in knowledge transfer and co-creation are needed.

**Originality/value:** The article shows the differences between the literature approach and the one used by KTO for knowledge transfer at the European level. The reflections can be used in shaping improvements in activities for increasing the commercialization of knowledge created at universities.

**Keywords:** Knowledge transfer, knowledge transfer resources and activities, or, forms of knowledge transfer, knowledge transfer methods, knowledge commercialization.

**Category of the paper:** General review.

## 1. Introduction

Building a competitive economy, a knowledge-based economy, requires that the process include efficient access to scientific achievements as a source of new knowledge (Kapetaniou, Lee, 2017). Knowledge transfer is a phenomenon that drives the development of innovation (Brzóska, Szmal, 2020), giving impetus to social and technological development. Knowledge transfer occurs largely through innovation systems, which consists of two main types of actors and interactions between them (Szmal, 2017). The first group includes companies that use innovations and ultimately create value. The second type of actors includes organizations that build the infrastructure necessary for innovation development. Despite, the introduction of innovation ecosystems, so-called innovation brokers, difficulties and limitations in the effective flow of knowledge are still observed.

There is a debate in the literature as to the competence (Klimkiewicz et al., 2022) scope of knowledge brokers in the innovation system, the experiences and challenges they face (Szmal, Janiszewski, 2018). Kauffeld-Monz and Fritsch (2013), studied brokers of the regional innovation system in terms of their tendency to focus on social benefits, (manifested in the desire to transfer knowledge to others) and private benefits (manifested in the desire to acquire knowledge from others). Intermediaries, functioning both within the organization and in the inter-organizational space, are tasked with the following functions: seeking relevant knowledge from external sources, translating complex knowledge so that it can be understood, and sharing accumulated knowledge using formal or informal mechanisms (Morrison, 2008, p. 820). It is crucial to properly frame the aspect of inter-organizational cooperation (Czakoń, 2018) in the optics of knowledge transfer actors' activities and resources. Many researchers around the world have studied knowledge transfer offices (KTOs) as intermediaries between providers of knowledge and inventions (i.e., university researchers) and entities that can commercialize these results (i.e., companies, entrepreneurs and venture capitalists). KTO can help sustain economic and technological growth by improving university-industry relations (Chau et al., 2017; Villani et al., 2017), as well as commercializing academic research toward possible market innovations by licensing university patents and/or creating spin-offs (Brescia et al., 2016; Zhou, Tang, 2020). Because the activities undertaken by KTO face many barriers, the article undertakes a discussion of selected aspects of technology transfer offices.

The purpose of this article is to review the literature and the activities and resources of technology transfer offices at the European level. A comparison of the literature and the practical, applied by the KTOs, approach to knowledge transfer made it possible to formulate reflections that can be used in shaping improvements.



## 2. Research model

The literature review on knowledge transfer was conducted using the desk research method. The bibliography includes 39 items, mainly from 2002-2023, including academic articles, books, monograph chapters, industry reports and electronic sources. The following databases were used to collect scientific literature: Google Scholar, ResearchGate, ScienceDirect, EBSCO. The following combination of words using Boolean operators (AND, OR) was used in the literature search in the databases above: ('Knowledge transfer' OR knowledge commercialization) AND (resources OR 'activities'). Searches in the databases above complemented the literature collected for the following keywords: Knowledge transfer, knowledge transfer resources and activities, forms of knowledge transfer, knowledge transfer methods, knowledge commercialization.

The paper uses industry report ASTP 2021 Survey Report on Knowledge Transfer Activities in Europe. ASTP is a pan-European association of knowledge transfer (KT) professionals whose main mission is to share best practices and enhance competence among KT professionals. The report is based on data from 519 Knowledge Transfer Offices (KTOs) across 26 countries for Financial Year (FY) 2019. This is the latest available report. The data was collected from two different sources: (1) data provided by individual Knowledge Transfer Offices who uploaded their replies directly through online survey (2) data from National Associations that conducted their own national surveys and provided ASTP with their data. Data collection started on January 2021 and closed initially on March 2021. A survey of 26 questions was used to gather information. In addition, the article uses information obtained from The Polish Association of Centers for Technology Transfer (PACTT.pl) is a voluntary association of representative units of Polish universities responsible for the protection, management and commercialization of university Intellectual Property (IP). The alliance is nationwide and currently has more than 80 members.

## 3. Knowledge transfer - selected problems

Knowledge transfer (KT) refers to the many ways in which knowledge from universities and public research institutions can be used by companies and other organizations to generate economic and social value and industry development (OECD, 2013). Their current role increasingly complements the traditional mission of teaching and research with interactions with industry and society (Kapetaniou, Lee, 2017). It encompasses a wide range of activities that support collaboration between universities, industry and the public sector, and includes a variety of purposes, modes and channels. Understanding the role of universities in this way

has attracted considerable attention from researchers and policymakers (Hsu et al., 2015; Trune, Goslin, 1998). While early research focused mainly on the goals of commercializing university-generated intellectual property rights (with a primary focus on patents and licensing activities), later research has emphasized additional missions, such as providing services to faculty, enhancing innovation and practical application of research results, supporting local economic development, complying with national and institutional policies, and promoting public value (Bozeman et al., 2015). Such an orientation is in line with the definition of KT activities, which by their very nature target a wide range of stakeholders with different goals and expectations (researchers, TTO managers, PRO administrators, industry, investors and decision-makers at regional, national and international levels).

Universities play a key role as independent knowledge institutions (Giuri et al., 2019). Their overarching goal is to ensure that their graduates develop the skills they need to prosper in their future work and to be open to collaboration with external stakeholders when it comes to KT (Meissner, Shmatko, 2017). Therefore, it is reasonable for universities to improve and adapt their management models to the changing landscape of the labor market and the processes of knowledge generation and diffusion. This is especially true with regard to KT activities. In fact, while universities typically serve all of KT's missions, management practices should be carefully considered, as they appear to serve different purposes (Benassi et al., 2017). In particular, several researchers and practitioners have stressed that universities should adopt a specific strategic approach to more clearly define a set of institutional goals and priorities, and then try to implement consistent actions to achieve such goals (Feldman et al., 2002; Sharer, Faley, 2008; Siegel et al., 2007). Siegel et al. (2007) argue that universities should make strategic choices about institutional goals and priorities at TCs to guide resource allocation decisions and choices about the mode of commercialization they want to emphasize.

Building on the insights of literature, Giuri et al. (2019) identify three strategic configurations of universities in the area of KT, depending on the emphasis that they devote to a specific set of KT priorities:

- Income-generation strategy - the major emphasis of the university and its TTO is on maximizing the stream of revenues that can be generated from the commercialization of ideas and inventions that are disclosed from research to industry (Axanova, 2012; Sharer, Faley, 2008). This approach is based on profit generation, whereby university KT experts collaborate with faculty to generate revenue from research, particularly from licensing agreements and research contracts. The implementation of this strategy demonstrates a strong orientation toward generating patented inventions owned by the university and using them commercially to reap financial benefits. Measures of success for this model focus primarily on revenue streams from licensing agreements or patent sales, as well as revenue derived from research contracts from industry.

- Service-to-faculty strategy - emphasizes the diffusion and practical application of knowledge outside of academia through dedicated support to faculty as a primary mission of KT activities (Sharer, Faley, 2008). In this approach, there is a focus on long-term capacity building at various levels, from the individual scientist to key actors in organizational entities. Emerging social, professional networks or technology communities generate opportunities for research collaboration and professional mobility and reveal possible applications of research results. A TTO that focuses on helping researchers to valorize their discoveries should therefore engage in scouting activities to attract top scientists with commercially focused research projects, respond quickly to faculty inquiries, offer business development assistance to research, and emphasize quick and efficient deal-making in collaboration with industry (Sharer, Faley, 2008). In this model, more emphasis is placed on the number of invention disclosures, the number of inventions that are patented, exposure to research funding, collaboration and network activity, and faculty recruitment and retention, rather than licensing revenue or start-up creation (Axanova, 2012; Batalia, 2006; Rasor, Heller, 2006).
- Local development strategy - emphasizes the attempt to contribute to the growth of the local economic systems where universities are embedded, by generating opportunities for knowledge exchange and new ventures creation (Axanova, 2012; Sharer, Faley, 2008). Universities focus on facilitating the development of technologies that form the basis for new ventures founded by researchers and/or students (start-up, spin-off), as well as the development of technologies that match the potential of local businesses. Universities and TTOs work closely to create partnerships with local public and private entities (establishing local incubators, proof-of-concept programs, accelerator programs, seed funds or industry-sponsored research labs) (Munari et al., 2016, 2018). Success is evidenced by the number of start-ups created by university lecturers or students, the creation of local jobs and the retention of graduates in these positions.

Knowledge transfer offices (KTOs) have become important agents of economic growth, innovation and technological progress (Zhou, 2020). As a result, researchers are paying increasing attention to the activities and performance of KTOs (Belitski et al., 2019). Work is emerging to better understand the motivational aspects of KTO employees - especially the antecedents of such motivation. Focusing on self-determination theory (SDT), we link the three basic needs (relatedness, competence and autonomy) that explain employees' intrinsic motivation with specific antecedents at the university and organizational levels (Pohle, Villani, Grimaldi, 2022). Academics are increasingly engaged in collaboration with companies, and the literature (De Silva et al., 2023) attempts to explain fundamental aspects of this phenomenon, i.e. to investigate the interplay between academic motivations and decision-making approaches and to unpack how resource- and engagement-based arguments could jointly offer a more accurate explanation regarding it. In addition to the creation of spin-offs (e.g. Kowal, Szmaj,

2022; Clarysse et al., 2011; Huyghe et al., 2016), knowledge transfer and co-creation have become two of the key and most common activities through which academics interact with companies (De Silva et al., 2021, Klofsten et al., 2019). Knowledge transfer involves the unidirectional transfer of knowledge from academics to enterprises, with the latter independently utilizing such knowledge (Siegel et al., 2007). Knowledge co-creation involves the integration of advanced and up-to-date knowledge held by academics with market and industry know-how held by enterprises to jointly overcome specific challenges and solve problems (De Silva, Rossi, 2018). The intrinsic differences between knowledge transfer and co-creation activities (table 1) mean that the interplay of motivations and decision-making approaches of academics involved in the respective activities may differ (McMullen et al., 2020). Also present in the discussion is work relating to cross-cultural knowledge transfer (Wang et al., 2023) raising awareness of how interdisciplinary this process is.

**Table 1.**

*The key characteristics of knowledge transfer and co-creation*

	<b>Knowledge transfer</b>	<b>Knowledge co-creation</b>
<b>Key objective</b>	Transferring academic knowledge to businesses, which then use or capitalize on it	Integrating academic and business knowledge to address a specific challenge or opportunity
<b>Role of the partners</b>	Academics produce knowledge, and businesses receive it	Academics and businesses produce knowledge together
<b>Nature of the knowledge</b>	Mainly codified and embedded in artifacts or documents, although some tacit knowledge may be needed for transfer effectiveness	Tacit knowledge is crucial for the co-creation, although the co-created knowledge can become partly codified
<b>Degree of interdependence</b>	Low interdependence	High interdependence
<b>Degree of complexity</b>	Typically low	Usually high
<b>Clarity of the outcomes</b>	The outcomes and their beneficiaries are clearly identified prior to the interaction	Both the outcomes and their beneficiaries are dependent upon a ‘ripple out’ process that is unlikely to be predictable
<b>Linearity of the interaction</b>	A linear model of knowledge transfer	A non-linear, bilateral model of open innovation
<b>Example</b>	Licensing/selling IP; publications	Joint research; joint research labs

Source: De Silva, Al-Tabbaa, Pinto, 2023.

#### **4. Findings - knowledge transfer resources and activities**

Based on the theoretical literature review conducted to introduce knowledge transfer activities, this section characterizes the practical resources and activities carried out by knowledge transfer offices (KTOs) in European countries. The report draws on the largest dataset ever available with 519 respondent KTOs from 26 countries. The countries of operation and the number of KTOs that participated in the survey are shown in Table 2.

**Table 2.**

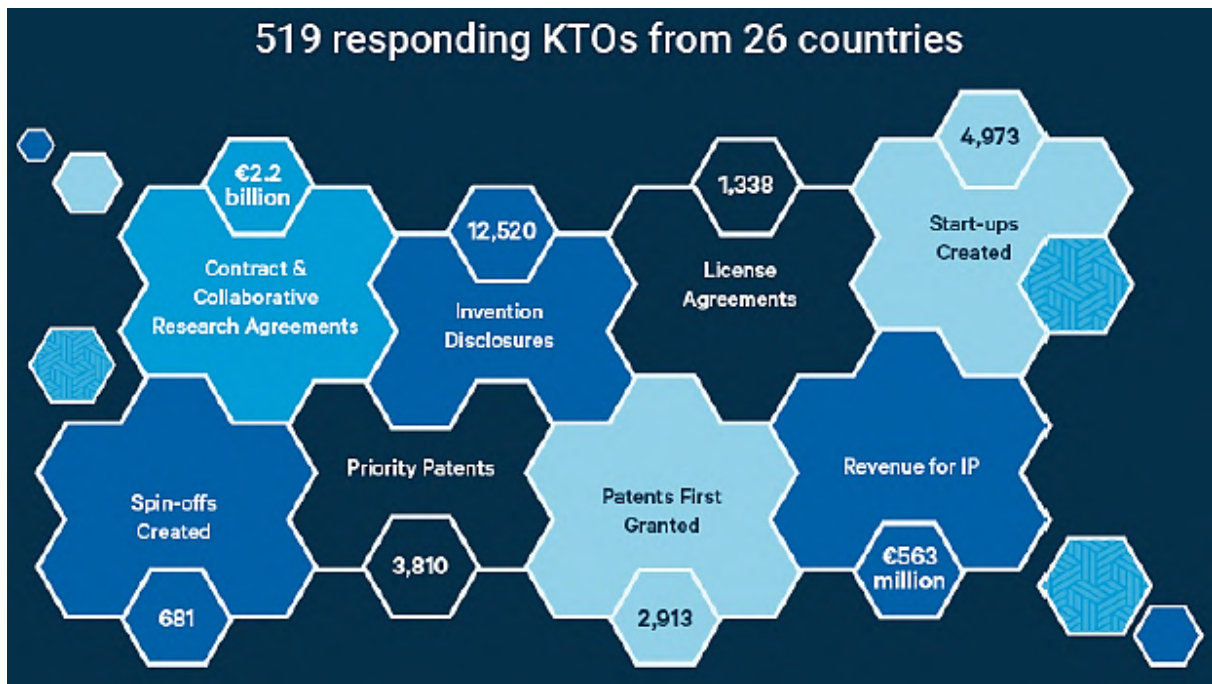
*Overview of ASTP Survey response rates FY2019,2018,2017 and 2016 kraje i liczebność KTO uczestniczących w badaniu*

Country	FY2019	FY2018	FY2017	FY2016
	2021 (n = 519)	2020 (n = 512)	2019 (n = 475)	2018(n=474)
United Kingdom	166	165	166	162
Italy	71	62	55	61
Spain	70	71	71	69
France	69	64	52	58
Germany	29	21	12	18
Ireland	25	25	27	24
Denmark	12	13	14	10
Poland	11	15	10	9
Czech Republic	10	10	5	8
Belgium	10	9	9	8
Netherlands	9	10	8	13
Norway	7	7	4	3
Portugal	7	1	2	1
Austria	4	4	2	3
Switzerland	3	12	13	2
Hungary*	3	6	5	4
Finland	3	2	6	5
Slovak Republic	2	1	1	1
Lithuania	1	2	3	4
Turkey	1	2	2	3
Croatia	1	2	1	0
Iceland	1	0	0	0
Luxembourg	1	1	1	1
Malta	1	1	0	1
Romania	1	0	0	0
Slovenia	1	0	0	0
Sweden	0	3	4	4
Serbia	0	1	0	1
Estonia	0	1	0	0
Greece	0	1	0	0
Russia Federation	0	0	2	0
Latvia	0	0	0	1

Source: ASTP 2021 Survey Report on Knowledge Transfer Activities in Europe.

The potential of the KTOs that participated in the survey is synthesized in Figure 1.

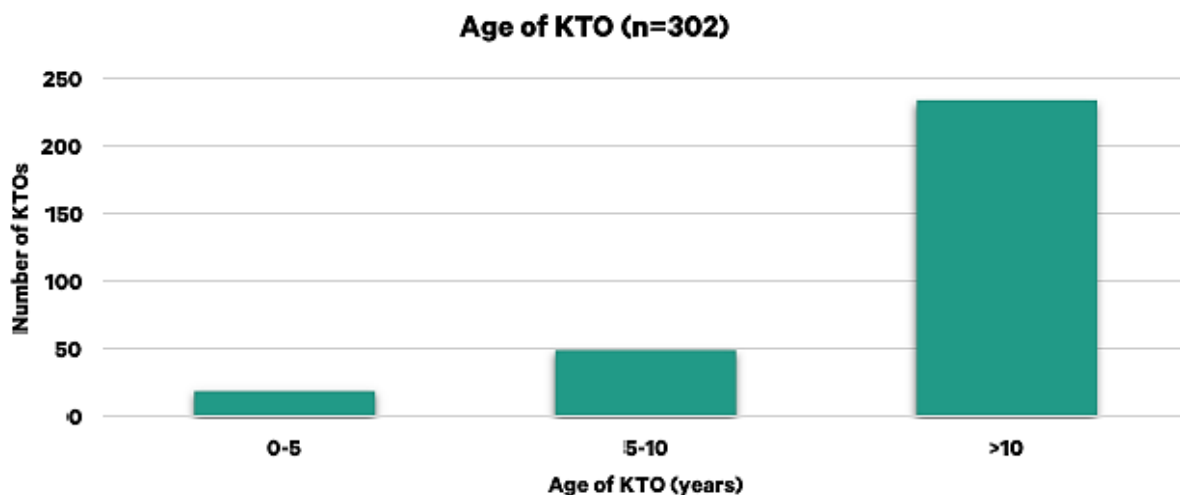
In the 519 datasets, not all respondents provided information for all questions in the survey. Therefore, the number of responses to each question is different. The actual number of respondents is shown in the size of the sample for a specific question, denoted by "n=" in each chart.



**Figure 1.** Overview of Survey Main Outputs and Findings.

Source: ASTP 2021 Survey Report on Knowledge Transfer Activities in Europe.

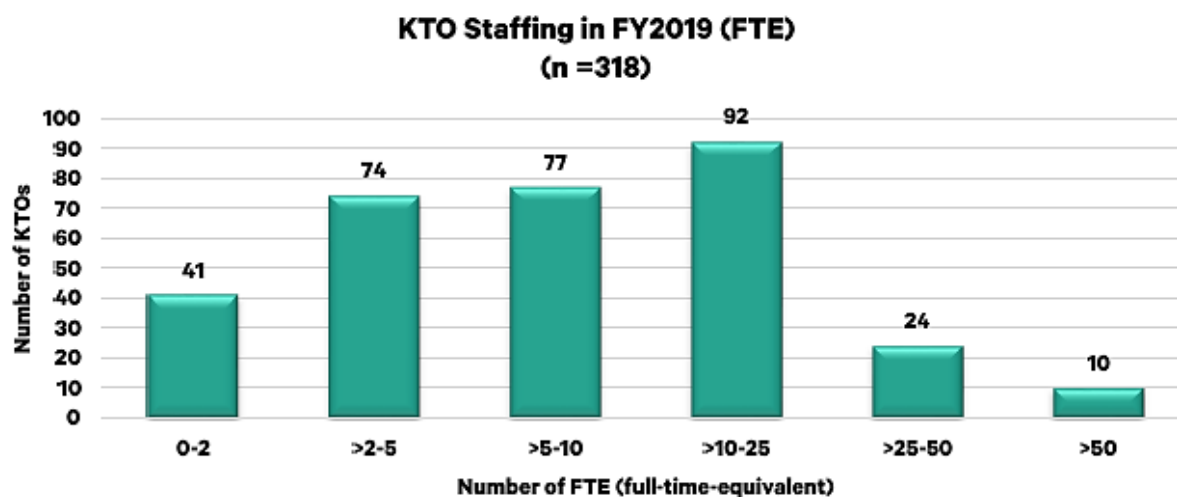
Figure 2 presents the distribution of the operating time of the KTOs in the sample. It is worth noting that the vast majority of KTOs have already gained considerable experience by conducting knowledge transfer for more than 10 years.



**Figure 2.** Distribution of KTO's age in number of years.

Source: ASTP 2021 Survey Report on Knowledge Transfer Activities in Europe.

An important dimension characterizing the capacity for viable KTO operations is the employment status of the required specialists. This aspect is shown in figure 3.



**Figure 3.** Distribution of KTO staffing levels in FTEs.

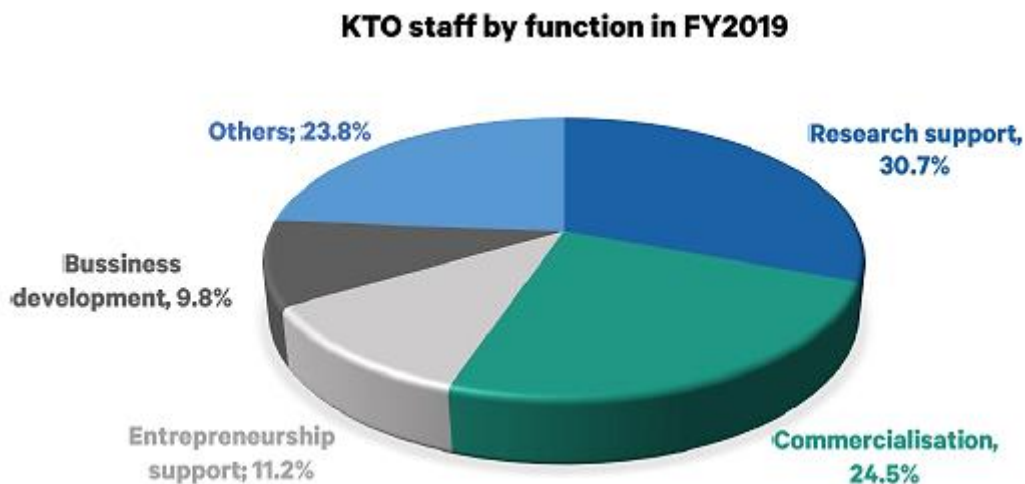
Source: ASTP 2021 Survey Report on Knowledge Transfer Activities in Europe.

Among the responding KTOs (n=318), the average number of FTEs ranges from 3 to 25. We can also note that 13% of KTOs are very small, with 2 or fewer FTEs, while 11% are very large, with more than 25 FTEs. 23% of KTOs employ 2 to 5 FTEs, 24% of KTOs employ 5 to 10 FTEs, and 29% employ 10 to 25 FTEs. Only a few KTOs are larger - 7.5% employ 25 to 50 FTEs, and another 3% are even larger.

In order to gain more insight into the activities of the KTO, respondents were asked to provide data on the proportion of all FTEs in the KTO who are involved in one of the following activities:

- Research support, including handling of MTAs, CDAs, Collaborative Research Agreements etc. Commercialisation activities, including IP protection and commercialisation, licensing, and consultancy agreements.
- Supporting entrepreneurship activities at PRO(s) including training, business planning and incubation.
- Business development including industry liaison.
- Other activities.

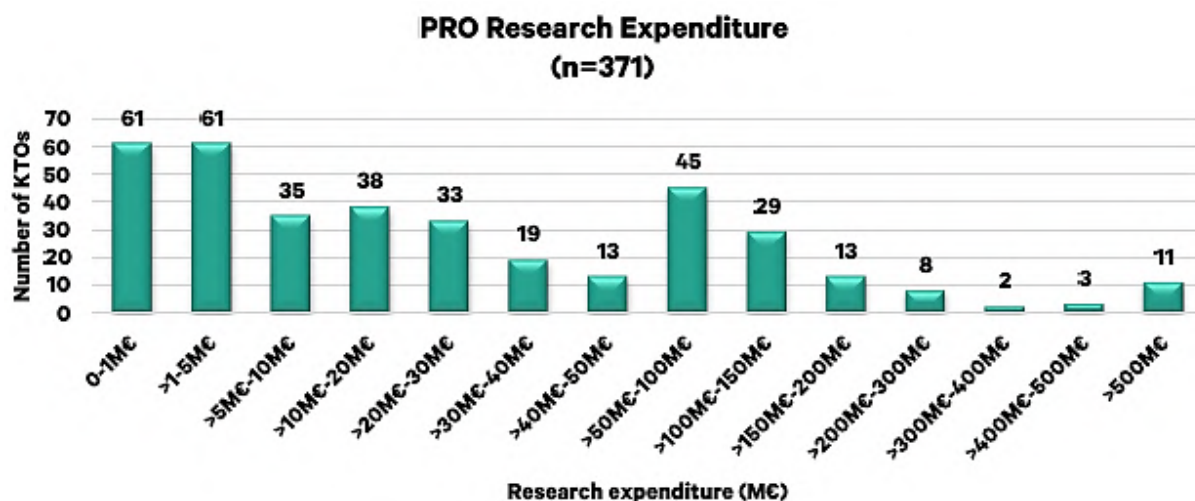
The breakdown of the KTO's involvement in each activity is presented in figure 4. The overall percentage of FTEs allocated to research support is the highest of the five different activity areas listed in the questionnaire, at 30.7%, and the percentage of FTEs allocated to commercialization activities is second (24.5%). A comparison of data from the various ECAs shows that, overall, a similar percentage of FTEs are allocated to business development and entrepreneurship support (about 10% each).



**Figure 4.** Distribution of KTO staff across major KTO functions.

Source: ASTP 2021 Survey Report on Knowledge Transfer Activities in Europe.

An important aspect of KTO activity is the fact for how many Public Research Organisation(s) (PRO(s)) work. Most KTOs serve a single PRO (94%) and some KTOs report data for multiple PROs, with 3% serving 2 different research institutions, and 2% serving between 4-7 PROs. Only a minority of 1% operates on behalf of 10 or more research institutions. This small group of KTOs operates in Germany and Norway only. To complete the picture of KTO activity, it is worth noting how large research budgets are allocated by supported PROs. This relationship is shown in figure 5.



**Figure 5.** Distribution of PRO research expenditure.

Source: ASTP 2021 Survey Report on Knowledge Transfer Activities in Europe.

The main activity of the KTOs has always been Intellectual Property (IP) management because it creates a base for commercialization of research results. The output of the IP management activity are quantitative indicators. Table 3 shows the total reported number of invention disclosures, priority patent applications and patents first granted to KTOs in FY2019.



**Table 3.***Total number of KTO's Intellectual Property Activities*

<b>KTO's IP Activities</b>	<b>No. of responding KTOs (n)</b>	<b>Total</b>
No. of invention disclosures	484	12,520
No. of priority patent applications	316	3,810
No. of patents first granted	272	2,913
No. of active patent families	307	38,056
No. of licensed or optioned Patent families	148	3,367

Source: ASTP 2021 Survey Report on Knowledge Transfer Activities in Europe.

177,784 conducted agreements with industry were reported by European KTOs in FY2019. A breakdown of these number across different industry agreement types are given in Table 4.

**Table 4.***Overview the number of contract research, collaborative research and consultancy agreements*

<b>New industry agreements</b>	<b>No. of responding KTOs (n)</b>	<b>Total</b>
Contract Research Agreements	352	35,363
Collaborative Research Agreements	186	10,286
Consultancy Agreements	334	131,133

Source: ASTP 2021 Survey Report on Knowledge Transfer Activities in Europe.

In terms of contract value shown in Table 5.

**Table 5.***Income generated from research, collaborative and consultancy agreements*

<b>Income from Industry agreements</b>	<b>No. of responding KTOs (n)</b>	<b>Total (€)</b>
Contract Research Agreements	332	1,384,447,767
Collaborative Research Agreements	145	825,292,501
Consultancy Agreements	303	506,807,932

Source: ASTP 2021 Survey Report on Knowledge Transfer Activities in Europe.

From the data collected in table 6, it is clear that, among Licenses, Options and Assignments, License agreements are by far the most common modus for commercialisation of technology/IP rights developed within academic centres across Europe.

Among the licence agreements, patent licences are the most common (47%) followed by software licences (20%) and materials licences (21%). By “other licences” (12%), we consider licences of IP from copyright, design, trademark, trade secret, plant breeder rights, and datasets.

**Table 6.***Overview of licenses, options and assignments signed*

<b>Commercial contract</b>	<b>Number of responding KTOs (n)</b>	<b>Total number of agreements signed</b>
Licenses	199	1.338
Options	165	155
Assignments	170	312
<b>License agreements</b>	<b>Number of responding KTOs (n)</b>	<b>Total number of agreements signed</b>
Patent licenses	199	626
Software licenses	131	272
Material licenses	154	286
Other licenses	107	154

Source: ASTP 2021 Survey Report on Knowledge Transfer Activities in Europe.

In FY2019, 432 respondents reported a total of €563 million in commercial revenues from intellectual property. This is one of the most frequently reported indicators, with more than 83% of KTOs responding. In addition, there was a steady increase in the total amount of IP revenue: €458 million (by 404 KTOs in fiscal 2017) to €522 million by 431 KTOs in fiscal 2018 to €563 million by 432 KTOs in fiscal 2019. Table 7.

**Table 7.**

*Total gross revenues from the commercialisation of IP*

IP Revenues	Number of responding KTOs (n)	Total (€)
Gross revenues from IP	432	563,183,505
Including Gross revenues from patent licenses	186	91,833,424
Including Cashed-in equity	291	76,832,280

Source: ASTP 2021 Survey Report on Knowledge Transfer Activities in Europe.

Analyzing the distribution of gross intellectual property revenues by KTO, 32% of KTOs (138/432) have no intellectual property commercialization revenues, and another 28% report revenues of €50,000 or less. Fifty-five KTOs (or about 13% of respondents) report revenues in fiscal year 2019 exceeding €1 million.

An equally important aspect of KTOs is the support provided in the process of creating new businesses. The main goal of many KTOs is to create new businesses, often supported or driven by government economic development policies. Its goal is to stimulate such activity in order to increase employment and expand the local industrial base. To contribute to the aforementioned economic development policies, governments focus on new companies regardless of where the business ideas come from, as long as they attract investment and create new jobs. The study distinguishes between (1) companies that have a formal agreement with the KTO or PRO to use intellectual property developed at the PRO to develop new products or services (spin-offs) and (2) companies that do not rely on such intellectual property or formal use agreements (start-ups), but were founded by PRO students or employees. This distinction is important because spin-offs refer to the results of research conducted by PROs, while start-ups do not, and therefore the former are more likely to be managed and supported by the KTO table 8. For the purpose of the aforementioned economic development policy, governments make such distinctions less often, given that new companies attract investment and create new jobs wherever business ideas may arise.

**Table 8.**

*Overview of the number of spin-offs and start-ups created*

	Number of responding KTOs (n)	Total number of companies created
Spin-offs created	468	681
Operating spin-offs	387	4,533
Staff in operating spin-offs (FTE)	199	37,178
Start-ups created	358	4,973

Source: ASTP 2021 Survey Report on Knowledge Transfer Activities in Europe.

The details show that almost 50% of the KTOs have not created any spin-offs nevertheless, the total number of spin-offs rose from 569 in FY2018 to 681 in FY2019 by reporting KTOs.

## 5. Conclusions

Universities are key agents of economic and social progress. Their current role increasingly complements the traditional mission of teaching and research with interactions with industry and society. The role of universities conceived in this way has attracted considerable attention from scholars and policymakers. KT is a complex and rapidly evolving phenomenon based on the interactions of several stakeholders. Universities can pursue a variety of goals through KT activities, such as providing services to faculty, enhancing innovation and practical application of research results, generating additional revenue streams, supporting local economic development, adhering to national and institutional policies, and promoting public value.

More accurate predictions of the motivations and decision-making approaches of academics involved in knowledge transfer and co-creation activities are needed. Resource-based and commitment-based arguments offer different predictions of the interplay between motivations and decision-making approaches adopted, the cognitive proximity between academics and business researchers reflecting whether the partners are from the same/different disciplines. Capturing these situational considerations that indicate how commitment- and resource-based arguments together offer a more comprehensive explanation of the interaction. We discuss the implications for how universities can offer tailored training, rewards and support structures based on the interaction between motivational and decision-making approaches. Motivations indicate intentions, decision approaches describe behavioral patterns; therefore, studying the interaction between these two key dimensions can provide an in-depth understanding of the psychology of academics engaging in business. Understanding this interplay is particularly important for better formulating the incentives and support structures that can yield effective interactions between academics and companies and the associated generation of business and social value.

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## AREAS OF PROGRAM SUCCESS: HOW TO SUCCESSFULLY CONDUCT TRANSFORMATION

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**Purpose:** The purpose of the article is to explore the areas of program management success and provide both theoretical and empirical insights into these areas and key factors in the context of successfully conducting a transformation.

**Design/methodology/approach:** The article presents the results of quantitative research conducted among 578 program management experts in 67 countries. Additionally, to achieve the assumed goal, a factor analysis was conducted, based on which the operationalization of success areas in program management in the context of transformation was carried out.

**Findings:** Thirteen success areas in program management in the context of transformation have been identified. Furthermore, they illustrate 73.08% of all significant variables that may occur and significantly impact its success.

**Research limitations/implications:** The perceived research limitations result from the chosen the methodological approach and the measurement tool, which, although was distributed in 7 languages, may not be able to reflect the subtleties of individual languages. Further research is recommended to test the defined success areas of the program through cross-sectional case studies.

**Originality/value:** The article identified 76 significant factors influencing the success of a program based on a literature review. Secondly, it defined 13 areas that determine the success of the program. Thirdly, the article responds to the call of Shao et al. (2012) and Wen et al. (2018) regarding the aggregation of success factors in program management.

**Keywords:** Transformation success, success areas, program context, program management.

**Category of the paper:** General review.

### 1. Introduction

In today's dynamic and constantly changing business environment, organizations face the challenge of continuously adapting to new conditions (Poi, Sorbarikor, 2022) to maintain their competitiveness and achieve long-term success (Saihi et al., 2023). As technologies, market

trends, regulations, and customer preferences evolve rapidly (Ibujés-Villacís, Franco-Crespo, 2022), companies must take strategic actions and implement transformations to stay ahead and meet the expectations of their stakeholders (Kafetzopoulos, Katou, 2023).

However, transformational processes within organizations can be complex, time-consuming, and highly risky. Implementing new strategies, technologies, or organizational culture requires profound changes at multiple levels (Park et al., 2021), which can encounter resistance, difficulties, and uncertainty (Cherian et al., 2021). Some transformation initiatives may fail or not deliver the expected benefits if not appropriately designed and managed (O'Hara, et al., 2022).

In this context, effective program management becomes of crucial importance. Program management allows for a cohesive approach to managing various projects and actions that constitute the entire transformation (Vuorinen and Martinsuo, 2018). By integrating these projects and coordinating their efforts, organizations avoid fragmentation and ensure consistency in achieving transformational goals (Gularso et al., 2023). Effective program management requires setting clear objectives (Miterev et al., 2020), proper planning, resource allocation (Martinsuo, Hoverfält, 2018), rigorous progress monitoring, and continuous adaptation of actions in response to changing circumstances (Trzeciak, Jonek-Kowalska, 2021).

Advances in program management research have led to a growing need to understand the conditions that contribute to program success. While research on project management success has been conducted for many years, covering critical success factors (Schopp et al., 2019), the role of the project manager (Mubarak et al., 2022), context (Trzeciak, 2022), and leadership competencies (Imam, Zaheer, 2021), these findings do not fully translate to the program level. Based on the suggestions of Shao (2018) and Rijke et al. (2014), the authors identified a knowledge gap and proposed defining and evaluating program success areas that would build awareness among program managers of stakeholder expectations and the value that results from meeting those expectations.

The theoretical contribution of this paper is the identification of universal program success areas, not specific to a particular program context. The findings serve as the basis for future research on program success measurement, the creation of a model, and outlining useful implications for managers to understand the importance of the identified success areas.

## **2. Theoretical background**

### **2.1. Organizational transformation process and program management**

In the field of program management, there is a rich literature focusing on theoretical models and practices aimed at conducting organizational transformations. Program management is

a strategy of a comprehensive approach to achieving set goals through the coordination of integrated projects and actions (Frederiksen et al., 2021). In the context of organizational transformations, effective program management becomes a key element in achieving desired outcomes (Martinsuo, Hoverfält, 2018). Taking this into consideration, the process of organizational transformation should be conducted as a program of strategic initiatives rather than as a single project.

Firstly, transformation processes are typically complex and encompass a wide range of changes within an organization (Hoback, 2018). They touch upon various areas such as organizational structure (Cherian et al., 2021), culture (Park et al., 2021), processes, technologies, and business strategy (O'Hara et al., 2022). Managing individual projects in isolation can lead to fragmentation and lack of coherence in achieving transformation goals. Managing them as a program allows for efficient coordination and harmonization of activities, ensuring that all projects collaborate towards a common goal.

Secondly, the process of transformation may involve multiple projects and initiatives managed by different teams (Kashan et al., 2021). Managing them as a program enables coherence and consolidation of actions, eliminating conflicts and duplications of efforts. Joint planning, monitoring, and reporting progress help ensure that all projects align with the defined objectives and organizational strategy (Trzeciak, 2023).

Thirdly, organizational transformations require significant resources, including human, financial, and technological (Martins et al., 2018). Managing them as a program allows for effective resource management and allocation to different projects, minimizing waste and ensuring efficient utilization (Vuorinen, Martinsuo, 2018).

Fourthly, organizational transformations impact various stakeholders, including employees, management, customers, suppliers, and investors (Lang et al., 2018). Managing them as a program facilitates engaging and involving these stakeholders at every stage of the transformation (Martins et al., 2018). Collaboration and communication with stakeholders contribute to their support and acceptance of changes, which are crucial for the success of the transformation (Liu et al., 2019).

In conclusion, conducting organizational transformation as a program of strategic initiatives allows for a holistic approach that considers various aspects of the organization. Managing it as a program provides a systematic and coordinated framework to tackle the complexities and challenges of transformations, increasing the likelihood of successful outcomes.

## **2.2. Research trends on the success of the program**

The analysis of the effectiveness of centralization and decentralization of programs became the subject of research presented by Yu and Kittler (2012). The authors pointed out that the decision on how to manage the program should result from the strategic needs of the organization itself. Ritson et al. (2012) presented a slightly different issue of the balance between defining and implementing the program strategy, which is necessary for the success of

the program, The authors stated that these elements are equally important. In addition, programs often result from incomplete, intricate strategic scenes, making it difficult to control and ensure the balance between vision and execution, which is essential for program success.

Another trend related to the issue of program success involves researching the relationship between the customer and value suppliers. For example, Liu et al., (2019) presented the behavior of program stakeholders in terms of obtaining and delivering the expected values of the program: commercial, intellectual and program cooperation. Moreover, it was emphasized that there is a need to involve the client and other program participants, which results in creating real value (Brownson, Fowler, 2020).

Similar conclusions were proposed by Laursen and Killen (2019) who revealed three sets of value creation (collaboration, coordination and perception). It is therefore essential for proper program management to balance the dilemmas of multiple stakeholders and maintain control while allowing ideas to emerge.

Another research trend draws attention to the importance of knowledge transfer and organizational culture, which positively modify educational behavior (Dutton et al., 2014; Pellegrinelli et al., 2015). It is emphasized that where the program is not only a coordinating mechanism, but an organizational mechanism for achieving a major strategic goal or for change, its component projects should be managed as well as possible to achieve efficiency in implementation and use of existing knowledge. However, beyond the importance of knowledge management, which should be seen as the ability to manage a program, there is a need for holistic management, economic rationale, leadership and sound management processes with the simultaneous role of vertical and horizontal communication in hierarchical structures (Duryan, Smyth, 2019).

Shehu and Akinotoye (2010), when examining people involved in the implementation of construction programmes in the United Kingdom, identified challenges and factors that organizations may face in practice of program management (i.e., program control, human and political aspects).

The aspect of program supervision was also highlighted by Eweje et al. (2012) who pointed out that decisions made by project managers influence the strategic value of the assets provided by the program. Moreover, the extent to which managers felt being under supervision has influenced the scope and quality of information they provided (Eweje, Turner, Müller, 2012).

Literature on the subject, proposing the mechanisms of integration (Turkulainen et al., 2015), also points to the coherence of the program and its projects. Program integrity management focuses on the processes and activities that align and coordinate processes and project management within the group of program management processes. Vuorinen and Martinsuo (2018) indicate that the effectiveness of a change program is generated through five integration tasks (i.e., creating and communicating a vision for change, monitoring program progress, exchanging information in the program-parent interface, coordinating work in a multi-project program, coordinating and supporting individual projects and project managers).

Moreover, a structured framework supporting the management of benefits in programs also requires the integration of actions to be performed with a clear set of controls, inputs, outputs and resources (Fernandes, O'Sullivan, 2021).

### 3. Methodology

The aim of this article is to explore the areas of program management success and provide both theoretical and empirical insights into these areas and key factors in the context of successfully conducting a transformation. Preliminary literature analysis led the research team to identify research gap and allowed to state the following research questions:

RQ1. What are the specific areas that contribute to the success of program management in the context of effectively conducting a transformation, based on empirical evidence?

RQ2. What implications do research findings provide for the theory and practice of program management?

For the purpose of achieving the assumed goal and answering the research questions, the authors developed research methodology consisting of the following steps:

1. Performing systematic analysis of the literature on program management in order to find out what factors influence its success.
2. Developing research survey to collect empirical assessment of those factors from the point of view of program management practitioners.
3. Performing statistical analysis (i.e., PCA) in order to aggregate possibly vast number of factors into fewer and wider categories allowing more flexible and context-oriented use in theory and practice of program management.

#### 3.1. Systematic Literature Review

The study comprises a systematic literature review that examines published research on program management practices. Unlike conventional reviews, the systematic review method involves meticulously documenting and adhering to well-defined standards throughout the process of acquiring, evaluating, and combining literature (Tranfield et al., 2003).

To begin the study, the research team compiled a list of well-known scientific journals in the area of project management. Then, they searched journals databases using the keyword "program" in the title, abstract, or keywords of the articles. It was important that the articles were published after 2010. This initial step enabled the team to collect preliminary literature for further analysis, and the detailed information about the publications analysed is presented in Table 1.

**Table 1.**  
*Systematic Literature Review process employed in the study*

Step	Actions taken in the research process	The result of the actions performed
1	Searching databases of journals in accordance with the adopted criteria	The number of matches found during journals inquiry: ( $n=261$ ) Built Environment Project and Asset Management ( $n = 21$ ) Impact Assessment and Project Appraisal ( $n = 30$ ) International Journal of Managing Projects in Business ( $n = 49$ ) International Journal of Project Management ( $n = 118$ ) Project Management Journal ( $n = 43$ )
2	Verification of titles and abstracts in terms of eligibility (do they meet the inclusion criteria)	Number of articles qualified based on title and abstract analysis ( $n = 56$ )
3	Evaluation of full texts for eligibility (do they meet the inclusion criteria). First iteration.	Number of articles accepted for further analysis after the first iteration: ( $n = 32$ ) Number of articles rejected (did not meet inclusion criteria) ( $n = 24$ ): Review of the literature ( $n = 12$ ) The term of the program only mentioned ( $n = 7$ ) Government project, mega project, etc. ( $n = 5$ )
4	Supplementing the preliminary database with additional articles identified in the full-text review in step 3.	The number of matches found during subsidiary journals inquiry: ( $n'=39$ ) International Journal of Information Systems and Project Management ( $n = 8$ ) International Journal of Information Technology Project Management ( $n = 4$ ) International Journal of Project Organisation and Management ( $n = 10$ ) Journal of Modern Project Management ( $n = 17$ )
5	Pre-screening of additional articles for eligibility (do they meet the inclusion criteria)	Number of additional articles qualified based on title and abstract analysis ( $n'=7$ )
6	Evaluation of full texts for eligibility (do they meet the inclusion criteria). Second iteration	Number of articles accepted for further analysis after the second iteration: ( $n'=7$ ) Number of articles rejected (did not meet inclusion criteria) ( $n'=0$ )
7	Analysis of the collected literature in terms of important factors affecting the success of the program	Number of articles analyzed: $n = 39$ ( $32+7$ )

Source: Own work.

After an initial search, 261 papers relevant to the team's interests were identified and subjected to further evaluation based on their titles and abstracts. Papers that did not specify the program type or methodology were subjected to a full text analysis, and those that did not relate to program management were excluded. The research team intentionally excluded papers that focused on IT software programming, a specific program such as development, training, government, or research programs, or those that only referred to program management in general terms. Following the standard practices of systematic literature reviews (Booth et al., 2012), the research team took additional steps to ensure a comprehensive list of program management research papers. In addition to searching for papers that directly addressed program management, they also examined other project management publications that discussed the use of program management. This approach resulted in the identification of seven additional papers that met the selection criteria.

As a result of the selection process (full-text analysis), the final set of papers for literature analysis consisted of a total of number of 39 publications on context, processes, organization, competencies, life cycle and program values and integration. In addition, through a systematic review of the literature, the team identified 76 important factors influencing the success of the program, which are presented in Appendix 1.

### **3.2. Research survey**

After completing the systematic literature review, the researchers were able to move on to the next phase of the study, which involved constructing a survey questionnaire. A total of 76 program factors were identified through the literature analysis and were included in the questionnaire. The survey questionnaire was divided into three sections: the first section focused on the characteristics of the respondents, while the second and third sections assessed the degree of use and influence of the identified factors on program management success. To ensure a higher response rate, the questionnaire was created in electronic form and made available in seven languages, namely English, French, Spanish, Japanese, German, Polish and Russian.

The quantitative research was conducted with a specific group of professionals involved in program implementation, who are members of international organizations for project management such as the International Project Management Association (IPMA) and the Project Management Institute (PMI). To ensure the representativeness of the study, the researchers determined the required sample size based on specific assumptions. They assumed a p fraction index of 50%, an error size of 5%, and a statistical significance of  $\alpha = 0.05$ . After performing the necessary calculations, they determined that a minimum sample size of 385 was needed. The researchers received 578 correctly completed questionnaires from 67 countries, thanks to the collaboration established with IPMA and PMI, exceeding the minimum required sample size.

## **4. Results**

In accordance with methodological recommendations, factor analysis is performed according to a specific procedure (Field, 2005). First, the collinearity of the questions being analysed (Gress et al., 2018) was tested using the correlation matrix and variance inflation factor (VIF). As a result of the 15 iterations conducted, 15 questions with a high collinearity coefficient (above 10) were removed from further analysis. In addition, it was also noted that the excluded questions with collinearity were related to similar issues, which confirms the high reliability of the research carried out.

According to the methodological assumptions concerning the fulfilment of the basic requirements for factor analysis, the following verifications should be made:

- The number of respondents relative to the analysed variables should be at least five times larger (Mishra et al., 2017). The number of variables included in the analysis is 61. However, the number of respondents is 578, which exceeds the required value.
- Verification of the Kaiser-Meyer-Olkin (KMO) value (Field, 2005). The Kaiser-Meyer-Olkin (KMO) value is 0.838 (with a significance of  $p < 0.001$ ), which is well above the minimum of 0.60 for exploratory factor analysis.
- Conducting the Bartlett's test of sphericity (Field, 2005). In the analysed example, the empirical Chi2 value is 31639.552. Based on the obtained result regarding degrees of freedom (1830), the theoretical Chi2 value was also calculated assuming  $p = 0.95$ ;  $df = 1830$ . The obtained value was 1930.634. Furthermore, the ratio of empirical to theoretical Chi2 value is more than sixteen times higher. Considering the above, it can be stated that the probability of obtaining the result assuming that the correlation matrix is an identity matrix is close to zero.

Factor analysis was performed using Statistica 13.1 software under the following assumptions:

- The number of extracted factors was chosen using the Kaiser criterion (eigenvalue of the factor is greater than 1.0).
- Varimax factor rotation was performed, as it facilitates factor interpretation by minimizing the number of variables with high loadings on each factor (Gress et al., 2018). The results of the analysis are presented in Table 2.

**Table 2.**

*Percentage of variance explained by individual factors after rotation*

Component	Eigenvalues			
	Eigenvalues	% of Variance	Cumulative Eigenvalue	Cumulative % of Variance
<b>1</b>	18,89623	30,97743	18,89623	30,97743
<b>2</b>	4,25170	6,97001	23,14793	37,94743
<b>3</b>	3,95909	6,49031	27,10702	44,43774
<b>4</b>	2,91503	4,77874	30,02206	49,21649
<b>5</b>	2,43712	3,99528	32,45918	53,21177
<b>6</b>	2,06882	3,39150	34,52799	56,60327
<b>7</b>	1,87881	3,08002	36,40681	59,68329
<b>8</b>	1,61219	2,64294	38,01900	62,32623
<b>9</b>	1,51202	2,47873	39,53102	64,80495
<b>10</b>	1,46802	2,40660	40,99904	67,21155
<b>11</b>	1,24863	2,04693	42,24767	69,25848
<b>12</b>	1,22348	2,00570	43,47115	71,26419
<b>13</b>	1,10905	1,81812	44,58021	<b>73,08231</b>

Source: Own work.

- Factor loadings of  $> 0.40$  were considered, assuming statistical significance for the sample above 500.



The results obtained indicate that the selected factors explain 73.08% of all variables. Furthermore, the aim of the factor analysis was to identify areas of success by evaluating the impact of the identified factors on the program's success. Based on the results, it can be concluded that the success areas isolated through factor analysis comprise 73.08% of all critical factors that can have a significant impact on program success during implementation. Furthermore, the impact of each area on program success is equivalent to the percentage of total variance explained by the 13 selected factors in the analysis (Table 3).

**Table 3.**  
*Areas of program success*

Factors	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13
Development and execution of a strategic program management plan	0,59												
Economic justification for the program				0,41				0,60					
Supervision over the program					0,44								
Resource allocation								0,47					
Procedures for granting legal approvals								0,56					
Risk management related to the relationship with stakeholders									0,60				
Recognition of stakeholder attributes					0,43								
Supplier relationship management			0,60										
Stakeholder management					0,52								
Support from top management													
Satisfaction of key stakeholders					0,50								
Focus on the customer		0,43						0,44					
Staff of the office technically/ substantively competent with regard to the program								0,48					
Involvement of the program management team							0,40			0,52			
Teamwork			0,45				0,42						
Stable, qualified program staff							0,62						
Qualified and charismatic program manager	0,45					0,57							
Organization support for the program	0,47						0,47						
Program manager leadership	0,73												
Clearly defined and coherent vision of the program		0,75											
Clearly defined and stable program requirements		0,47											0,54
Clear and realistic program objectives		0,52				0,48							
Program planning		0,67											
Planning the program definition phase		0,58											
Transparency of the program scope				0,70									
Approval of the program plan and its evaluation									0,71				
Understandable purpose of the benefits of the program		0,61			0,47								
Incremental delivery of program benefits					0,70								
Passing on business benefits	0,48		0,61										
Project maturity of the organization			0,67										
Holistic view of the program organization			0,56										
Program management infrastructure (e.g., resources, processes)			0,71										
Organization of program management before its implementation					0,47					0,47			
Simplicity of program management			0,63										
Delegation of powers and responsibilities			0,81										
Internal corporate mechanisms						0,56							
User involvement										0,83			
Ensuring continuity of financing												0,46	
Appropriate program risk allocation						0,73							
Budgeting the program													
Vertical and horizontal communication							0,60						
Appropriateness of the selection of methods, techniques, and tools to the level of complexity of the program							0,65						



The area of preparing an organization for program management (C3) includes factors at formal (Miterev et al., 2020), descriptive (Breese, 2012), and operational levels (Pellegrinelli et al., 2015). These elements can be summed up in the phrase "program and organizational order," which refers to the awareness, ordering, and adoption of coherent principles to facilitate effective program implementation (Frederiksen et al., 2021). High-level activities are supported by operational-level activities (Turkulainen et al., 2015).

Program governance (C4) requires a structured and strategic approach, informed by adopted principles and supported by appropriate resources (Ritson et al., 2012), to ensure the acquisition of necessary information for informed decision-making (Miterev et al., 2016). Just as organizations developing a project management system require the application of standard program management (Liu et al., 2019), regardless of whether it is an independent or existing solution. Implementation of a system demands proper information-gathering from the program's construction phase through to closure, along with the necessary supervision and monitoring processes (Görög, 2011).

The involvement of stakeholders in program implementation (C5) is a complex activity. Managing stakeholders in a program does not require different tools from managing stakeholders in projects (Trzeciak, Jonek-Kowalska 2021), but managing a larger number of stakeholders with varying attitudes (Fortune et al., 2015) can be challenging. Therefore, stakeholder management should be integrated into the program management system (Dingsøyr et al., 2018), allowing for effective identification of stakeholder expectations (Angus, Kittler, 2012) and enabling the delivery of business benefits while minimizing risks.

Business change management (C6) guides stakeholders, teams, and organizations through changes (Martinsuo, Hoverfält, 2018). User involvement, program budgeting, and resource allocation are critical components (Fortune et al., 2015), showing the strategic role of decisions in the program (Miterev et al. 2016). The user's involvement is crucial in identifying where and why resources should be allocated to bring expected benefits (Fernandes, O'Sullivan, 2021), and the effective management of business change is essential for achieving these goals.

The program manager's competencies (C7) are crucial to the program's success. The manager must possess the required qualifications (Pollack, 2012), charisma, and issue management skills (Shi et al., 2014), select appropriate methods and tools (Dingsøyr et al., 2018), and demonstrate both hard and soft skills (Shao, 2018). While soft skills such as teamwork and collaboration are important, the team's work quality and stability are more significant (Jia et al., 2011). Regular monitoring and control of program implementation (Trzeciak, Jonek-Kowalska, 2021) is also essential.

To better meet the needs of large-scale programs, which can affect many stakeholders and generate vast amounts of information, it is essential to establish a program office (C8) as the primary control and information centre for the program. The most critical factors in achieving the expected results of the program with regards to the program office are the implementation of legal approval procedures (Aritua et al., 2011) and the active involvement of the program

management team (Vuorinen, Martinsuo, 2018). This highlights the importance of supporting the program management process through the formalization of management activities.

To ensure effective compliance and benefit management (C9), it is crucial to describe them in a clear and coherent manner (Fernandes, O'Sullivan, 2021), while considering the needs and expectations of individual program stakeholders (Dutton et al., 2014) and the associated risk (Angus, Kittler, 2012). Furthermore, it is important to consider the factors that contribute to successful benefits realization (van Buuren et al., 2010), as well as awareness and compliance with laws and regulations (Miterev et al., 2020). These aspects are essential for establishing a strong relationship between the organization and the program.

Program sustainability and financial management (C10) involves structured planning and control to achieve business benefits (Rijke et al., 2014). Its impact on program success is related to financing, ensuring financial liquidity and optimal allocation of resources (Smits, van Marrewijk, 2012). Some programs do not have a budget and each project must find its own funding source, which is supported by the program's complexity and specificity (Laine et al., 2016). Programs can be financed through budgeting within consortia with financial support from government or research funds.

The significance of knowledge and innovation management (C11) has been highlighted by several authors (Rijke et al., 2014; Laursen, Killen, 2019). Pellegrinelli et al. (2015) observed that when a program is not only a coordinating tool for independent projects, but also an organizational mechanism for achieving the main strategic goal or change, its component projects should be managed with utmost care to ensure efficient implementation and utilization of existing knowledge.

The goal of risk management (C12) is to enhance effective decision-making by comprehending risk factors and their impact on program delivery. According to Aritua et al. (2011), the skills required to structure risk in a way that informs decision-making must differ from the skills required to deal with the risk of a single project. Breese (2012) further emphasizes that the more uncertain and ambiguous the benefits, the more crucial it is to focus attention on them and confront the risk factors that may influence their delivery.

The final area is the purposefulness of the program (C13). Programs are conducted to achieve business benefits (Fernandes, O'Sullivan, 2021), which are realized through the results of individual projects (Vuorinen, Martinsuo, 2018). Therefore, at the program level, it is crucial to prioritize projects based on their contribution to achieving the intended benefits (Fernandes, O'Sullivan, 2021). Consequently, the program's desirability must be evaluated by assessing whether the activities align with the specified goals, if the optimal methods and resources were employed to achieve the goals, and most importantly, if the goals were achieved.

*RQ2. What implications do research findings provide for the theory and practice of program management?*

The research has two main theoretical implications. Firstly, it addresses the knowledge gap identified by Shao et al. (2012) and Wen et al. (2018) by defining the areas of program success. It highlights the insufficiency of quantitative research on international samples in this area. Secondly, the identified areas of program success can serve as a foundation for the development of a model and measurable success.

The practical implications focus on the operationalization of the results of the statistical analysis. More specifically, the attention is drawn to measurable aspects that can be used to evaluate the success of the program within the dimensioned areas of success. This is addressed to program managers.

## 6. Conclusion

The aim of this article is to explore the areas of program management success and provide both theoretical and empirical insights into these areas and key factors in the context of successfully conducting a transformation. To achieve the research objective, we employed principal component analysis (PCA) using data gathered from 578 questionnaires assessing the impact of 76 key factors in program management, which were identified based on a review of the literature on program success.

The conducted research has enabled us to answer the research questions posed. In connection with the above, it should be stated that the following areas have the main influence on the program success level: program strategy and vision, controlled delivery of results, the preparation of an organization for the program management, program governance, the involvement of stakeholders in the implementation of the program, business change management, competencies of the program manager, program management office, compliance and benefit management, program sustainability and financial management, knowledge and innovation management, program risk management, purposefulness of the program.

Additionally, there is a statistical basis for defining the main areas of program success. The literature review also found that program context positively impacts the identified areas of program success, shaping and adapting them to the organization's evolving needs while protecting the program's projects from the turbulent and uncertain external environment.

The research results confirm the importance of the areas of success that were studied individually by many authors, as presented in more detail in the literature review section. Additionally, it should be noted that successful program management entails ensuring that the program is implemented in the most appropriate and effective manner to fulfil its purpose and objectives.

The reliability of the research builds on the use of well-established concepts and measurement structures to obtain credible results. In addition, the results are in line with other related studies that were used as a theoretical support in the research design process. The perceived research limitations result from the chosen the methodological approach and the measurement tool, which, although was distributed in 7 languages, may not be able to reflect the subtleties of individual languages. Further research is recommended to test the defined success areas of the program through cross-sectional case studies.

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## WELDING OF SUPER DUPLEX S32750 WITH DOCOL 1100 FOR THE TRANSPORT PURPOSES

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**Purpose:** The main novelty and the goal of the paper is to present the dissimilar SDSS with AHSS welding for automotive application. The welding automotive structure is connected with two different grades of steel with various structure (martensite with mixture of austenite and delta ferrite).

**Design/methodology/approach:** Two dissimilar grades of steel were welded in order to get a proper joint for automotive industry. The properties of the joint was carefully tested (NDT and DT).

**Findings:** Relations between various welding parameters and the properties of weld.

**Research limitations/implications:** In the future, it can be suggested to investigate the effect of modified shielding gas mixtures for the MAG welding.

**Practical implications:** The proposed process innovation will result in savings.

**Social implications:** Modifying the shielding gas mixtures will not affect the environment and production management methods. Producing dissimilar welds translates into savings.

**Originality/value:** It is to propose a new solution in automotive industry. The article is especially addressed to manufacturers of dissimilar material for means of transport.

**Keywords:** automotive, dissimilar, welding, SDSS, AHSS, transport, shielding gas mixture, production savings.

**Category of the paper:** Research paper.

## 1. Introduction

The paper presents the results of various MAG (metal active gas) welding tests for complicated dissimilar welds. Two various metals were welded with absolutely dissimilar structure. Delta ferrite-austenite steel (EN 1.4410, X2CrNiMoN25-7-4) with martensitic steel DOCOL 1100 M were joined by MAG process with various parameters. These dissimilar welding was dedicated mainly into automotive industry. The dissimilar welds are recommended for transport industry because it corresponds with serious savings (Jaewson et al., 2011; Darabi et al., 2016; Hadryś, 2015). Welding in this case is rather difficult because of completely different structures of base metal: delta ferrite plus austenite (Super Duplex Stainless Steel) with martensitic steel (Golański et al., 2018, pp. 53-63; Skowrońska et al., 2017, pp. 104-111). The popular S32750 steel was selected as an example of super duplex steel, while the advanced high-strength DOCOL 1100 M steel was selected as a martensitic steel. In dissimilar welds, there are observed welding incompatibilities and defects, mainly cracks in the WMD (weld metal deposit) and HAZ (heat affected zone). The quality of welds depends mainly on correctly established parameters (Silva et al., 2019; Krupicz et al., 2020). The deciding MAG welding parameters are:

- type of electrode wires,
- composition of gas mixtures in MAG welding,
- pre-heating temperature.

Dissimilar welding of super duplex steel with martensitic steel is complicated because of different physical properties (Fydrych, Łabanowski et al., 2013; Shwachko et al., 2000). Preheating is mainly recommended for delta ferrite steels and duplex steels, and also for some dissimilar welds (Szymczak, 2020). In the article, it was mainly decided to check the influence of various amount of nitrogen added to the shielding gas mixture, because super duplex steels have a high nitrogen content, and in martensitic steels the increased nitrogen content could be treated as beneficial. An important second welding parameter is determining the appropriate preheating temperature, because for both dissimilar steel grades preheating is recommended, but there is no agreement on a common preheating temperature (Szymczak, 2020). Austenitic 309 LSi wire with an elevated chromium content was selected for welding process.

## 2. Materials

For dissimilar MAG welding of super duplex steel S32750 steel with martensitic DOCOL 1100 M steel the austenitic electrode wire 309LSi was selected. Attempts were also made with low-alloy steel electrode wires (Union X90 and Union X 96) but these tests did not give good

results, because there were observed various types of welding defects. The main direction of research was the modification of gas mixtures in the MAG process containing Ar and CO<sub>2</sub>, to which it was decided to introduce elevated nitrogen content.

Before the welding process, it was proposed the pre-heating at three different temperatures of 120°C, 150°C and 200°C. A thickness of weld was 2 mm. Table 1 presents the mechanical properties of welded dissimilar materials.

**Table 1.**  
*Tensile strength of tested materials*

Steel grade	YS, MPa	UTS, MPa
S32750	520	830
DOCOL 1100 M	910	1070

The data from tab. 1 indicates that both grade of steel do not have completely different properties. Martensitic DOCOL 1100 M steel has much higher strength (UTS) and elevated yield strength (YS) than super duplex S32750 steel. Although the mechanical properties of both materials are rather similar. Super duplex steel has much lower coefficient of thermal expansion than martensitic steel, but simultaneously super duplex steel has a higher thermal conductivity than martensitic steel, which makes welding both materials together difficult. These physical properties of both materials result from their various chemical composition (Table 2).

**Table 2.**  
*Chemical composition of tested grades of steel*

Steel	C	Si	Mn	P	S	Al	Cr	Mo	N	Ni	Ti
S32750	0.01	0.9	1.1	0.01	0.01	0.01	25	3.8	0.27	6.8	-
DOCOL 1100 M	0.1	0.12	0.22	0.01	0.002	0.03	0.02	0.04	0.01	0.02	0.21

The table shows that the chemical composition of both materials is different. Both steels do not have good plastic properties, so it was decided to weld them with austenitic wire (Tab. 3).

**Table 3.**  
*Electrode wire–composition*

wire	C%	Si%	Mn%	P%	Cr%	Mo%	Ni%	Ti%	P	S
309LSi	0.02	0.85	1.8		24	0.2	14	0.001	0.02	0.02

It was decided to realize welding process of 2 mm thickness without chamfering. The electrode wire diameter in both cases was 1 mm. The weld was formed as single-pass. At the beginning of welding process, the current and the voltage parameters were suggested:

- welding current: 116 A,
- arc voltage: 22 V.

Other important welding parameters were determined as follow:

- welding speed: 310 mm/min,
- • shielding gas flow: 14.2 dm<sup>3</sup>/min.

The joints were made with a several combinations. The most important element of investigation included checking the preheating temperature and selecting of proper shielding gas mixture for MAG welding process containing:

- Ar-18%-CO<sub>2</sub>-2% N<sub>2</sub>,
- Ar-18%-CO<sub>2</sub>-3% N<sub>2</sub>,
- Ar-18%-CO<sub>2</sub>-4% N<sub>2</sub>.

Also a very important element of the research was to determine the most appropriate preheating temperature:

- pre-heating to the temperature of 120°C,
- pre-heating to the temperature of 150°C,
- pre-heating to the temperature of 200°C.

### 3. Methods

After the welding process with various parameters, some non-destructive tests (NDT) and also some destructive tests (DT) were carried out to assess the best quality of the joints.

Initially some NDT were carried out:

- VT - visual test corresponded with → PN-EN ISO-17638) standard,
- MT - magnetic particle test corresponded with → PN-EN ISO-17638 standard.

Then, some DT testing were carried out:

- nitrogen amount in weld metal deposit (measured on the LECO ONH836 analyzer),
- tensile strength → PN-EN ISO 527-1 standard,
- bending test → PN-EN ISO 7438 standard.

### 4. Results and discussion

The dissimilar joints were made using one austenitic electrode wires, three different of shielding gas mixtures and with three different pre-heating temperature. In total, 12 different welds were made, marked with samples from E1 to E-9 (tab. 4).

**Table 4.**  
*Samples designations*

Sample	Shielding gas mixture	Pre-heating temperature, °C
E1	Ar-18%-CO <sub>2</sub> -2% N <sub>2</sub> .	120
E2	Ar-18%-CO <sub>2</sub> -3% N <sub>2</sub> .	120
E3	Ar-18%-CO <sub>2</sub> -4% N <sub>2</sub> .	120
E4	Ar-18%-CO <sub>2</sub> -2% N <sub>2</sub> .	150
E5	Ar-18%-CO <sub>2</sub> -3% N <sub>2</sub> .	150
E6	Ar-18%-CO <sub>2</sub> -4% N <sub>2</sub> .	150
E7	Ar-18%-CO <sub>2</sub> -2% N <sub>2</sub> .	200
E8	Ar-18%-CO <sub>2</sub> -3% N <sub>2</sub> .	200
E9	Ar-18%-CO <sub>2</sub> -4% N <sub>2</sub> .	200

NDT tests were performed for all samples (E1-E9) after welding process. Most of the samples (E2, E4, E5, E6, E8) were defect-free (column rows marked in green colour), but there were also samples (E1, E3, E7, E9) made incorrectly (column rows marked in orange colour). The NDT results with comments on the observations during inspection are presented in Table 5.

**Table 5.**  
*NDT results for tested dissimilar welds*

Sample	Observation
E1	Small cracking in HAZ from the S32750 steel side
E2	Correct weld, defect free, correct dimension of HAZ
E3	Small cracking in HAZ from the DOCOL 1100 M steel side
E4	Correct weld, defect free, correct form and dimension of HAZ
E5	Correct weld, defect free, correct form and dimension of HAZ
E6	Correct weld, defect free, correct form and dimension of HAZ
E7	Small cracking in HAZ from the DOCOL 1100M steel side
E8	Correct weld, defect free, but too expanded HAZ on the side of DOCOL 1100 M steel
E9	Small cracking in HAZ from both sides, too expanded HAZ on the side of DOCOL 1100 M steel

It was found that the preheating temperature has the greatest impact on the possibility of defects occurring. Preheating is recommended differently for the two dissimilar materials tested. AHSS steels, represented by DOCOL 1100 M steel, tend to expand the heat affected zone (HAZ) when the preheating temperature is too high. This is unfavorable because it affects various types of phase transformations, including the growth of nitrides and carbonitrides. In turn, duplex and super duplex steels require preheating due to the brittleness of delta ferrite. Therefore, you need to find a "compromise" temperature, which is not an easy challenge.

The selection of shielding gas mixture was less important. The next part of the research focused on the nitrogen content in the shielding gas mixture, which directly translates into the nitrogen content in the weld. It was decided to carefully check the relationship between the nitrogen content in the gas mixture and the nitrogen content in the weld metal. For this purpose, tests were performed on the Leco-ONH-836 device. In that part of the investigation it was decided to check only joints that did not have defects (marked row with green colour in the Tab. 5). The nitrogen amount in the dissimilar weld S32750/DOCOL 1100 M is presented in Table 6.

**Table 6.***Nitrogen amount in the weld metal*

Sample	Nitrogen in weld metal, ppm
E2	65
E4	55
E5	65
E6	70
E8	65

The assumptions were confirmed that the increase in nitrogen in the shielding mixture Ar-CO<sub>2</sub> would significantly translate into the nitrogen content in the weld. Only in one of the examined cases a high nitrogen content of 70 ppm was obtained. This corresponded to the supply of 4% N<sub>2</sub> to the shielding mixture (sample E6, table row marked in blue colour). An increased nitrogen content in the weld was also observed to the level of 65 ppm N, which corresponded to the addition of 3% N<sub>2</sub> to the shielding gas (E2, E5, E8 samples). Then it was decided to check the mechanical properties of the samples, assuming that the nitrogen content in the weld should significantly increase the strength. The tests were performed at room temp. (20°C). Table 7 shows the tensile strength (UTS) of the joints.

**Table 7.***Tensile strength of joints*

Sample	UTS [MPa]
E2	501
E4	488
E5	515
E6	533
E8	512

The data from the tab. 7 indicate that it is possible to achieve high tensile strength (of the dissimilar super duplex stainless steel with martensite steel) joint over the 530 MPa (table row marked in green colour). It has been proven that nitrogen should be added to the protective Ar-CO<sub>2</sub> mixture in an elevated amount (of 3% N<sub>2</sub> or 4% N<sub>2</sub>), because the low nitrogen content in the mixture (of 2% N<sub>2</sub>) does not allow for achieving a joint strength of even 500 MPa (table row marked in orange colour).

The best results were achieved when simultaneously:

- pre-heating temperature is 150°C,
- amount of 4% N<sub>2</sub> is added to the Ar-18% CO<sub>2</sub> shielding gas mixture.

As the last part of the article a bending tests was carried out. Measurements were done from the face and from the root sides of the joint. A bending test was performed at ambient temperature. The observation and results of bending test are presented in Table 8.



**Table 8.***Bending test of dissimilar weld*

Sample	Face side	Root side
E2	No cracks	small cracks
E4	No cracks	No cracks
E5	No cracks	No cracks
E6	No cracks	No cracks
E8	No cracks	No cracks

The bending tests were very positive, as no cracks were observed in almost all samples. This proves very good properties of the thin-walled dissimilar joint. In dissimilar joints, it is easier to obtain good strength properties than plastic ones, which is why the result of the bending test is very valuable and satisfactory for the authors of this publication.

## 5. Summary

The paper is intended for the automotive industry, where there is an increasing demand for various types of dissimilar welds. In the last 3 publications for this magazine, the authors focused on presenting the possibilities of welding AHSS steel (advanced high strength steel) with other types of steel. The possibility of welding AHSS steels with HSS steels with worse plastic properties was demonstrated. Then, research was carried out on the possibility of welding AHSS steel with austenitic steels and AHSS steel with ferritic steels (delta ferrite). All these publications emphasized the precision of selecting the appropriate process parameters in order to obtain a product of excellent quality. Similarly, for the purposes of this article, a lot of research (9 variants) was carried out to demonstrate what the preheating temperature should be and what the size of the shielding gas mixture should be. For this purpose, the composition of the shielding gas mixtures was simultaneously changed (based on the Ar-CO<sub>2</sub> mixture, adding 2% N<sub>2</sub>, 3% N<sub>2</sub>, 4% N<sub>2</sub>, respectively) and the preheating temperature was changed (120°C, 150°C, 200°C). Nine combinations of results were created, from which subsequent tests eliminated the joints with the worst properties. After NDT tests, it was noticed that the most appropriate preheating temperature is 150°C. Only destructive tests (tensile strength, bending) allowed the determination of the most appropriate process parameters.

Based on the research study, the following conclusions were given:

1. Dissimilar joints allows for process savings, but are not easy to produce.
2. Dissimilar steel joints dominated by austenite and delta ferrite in first material and martensite in the second material are possible to produce.
3. All welding parameters should be selected very precisely.
4. The most important parameters of the dissimilar welding are the pre-heating temperature and the chemical composition of the shielding gas mixture.

5. The best welding results were obtained when simultaneously:
  - the preheating temperature was 150°C,
  - the shielding gas mixture should contain Ar-18% CO<sub>2</sub>-4%N<sub>2</sub>,
  - an electrode wire should have austenite structure.

## Acknowledgments

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## DEVELOPMENT OF DELIVERY AND COLLECTION BOXES IN THE CONTEXT OF CITY LOGISTICS USING THE EXAMPLE OF INPOST COMPANY

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**Purpose:** The aim of this article was to examine the development of the use of delivery and collection boxes in the context of urban logistics, using the example of the company InPost.

**Design/methodology/approach:** The research on the development of sending/receiving points was divided into stages. First, a review of theoretical materials on the issue under study was conducted and the development of the InPost compartment was analyzed. Then a survey was created and posted on various social media. The survey targeted urban residents using online shopping. In the final stage, the results were collected and analyzed in the context of the development of sending and receiving points from the perspective of residents.

**Findings:** Undoubtedly, in recent years we can observe an increase in consumer interest in online shopping. Research confirms that the development of online shopping is closely linked to the development of various forms of delivery. Undoubtedly, in recent years, shipping and receiving boxes have been increasingly used, as the residents surveyed also noted.

**Originality/value:** The article presents the author's survey on the development of shipping/receiving boxes from the point of view of residents conducted in 2023.

**Keywords:** Development of vending/receiving machines, development of e-commerce, transportation of goods in town.

**Category of the paper:** Research paper.

### Introduction

In recent years, except the traditional form of direct to customer delivery, the development of alternative methods such as the use of pick-up points or delivery and collection boxes has been observed. The crucial moment was the COVID-19 pandemic, which undoubtedly forced delivery companies to look for solutions for contactless delivery to the customer. Despite a number of global economic issues, online sales is still growing, which in result influences the higher demand for courier services. For online shoppers, buying a product can be as simple as

clicking a few buttons on a website and waiting for delivery. Thus for cities, dealing with traffic problems caused by e-commerce deliveries has become a complex problem requiring innovative solutions. Transport, which affects economic strength, product availability and the quality of life and attractiveness of urban areas, is an inherent element of online shopping (Wierzbicka, 2023). The delivery vehicles park and block pedestrian crosses. Grocery e-shops such as Walmart and Kroger, and food delivery services such as DoorDash, Uber Eats and Postmates, are increasing their online revenues by offering city centre home deliveries via vans, bikes and scooters in increasingly shorter time windows. As a result, demand for last-mile delivery is growing rapidly and is expected to increase by 78% globally by 2030. The World Economic Forum reports that by 2030 there will be 36% more delivery vehicles in city centres compared to 2020, increasing the external costs of road transport (World Economic Forum, 2020).

The aim of this article was to examine the development of the use of delivery and collection boxes in the context of urban logistics, using the example of the company InPost. An extensive literature review and a questionnaire survey targeting urban residents was carried out to identify changes in the area.

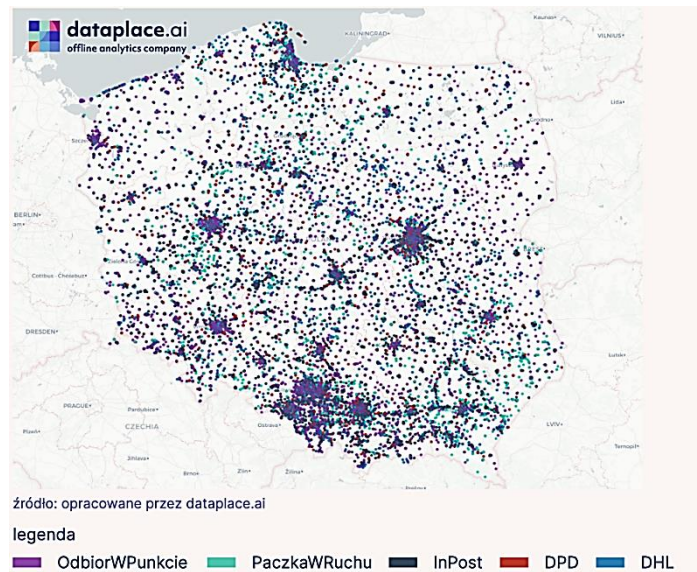
## **Literature review**

The rapid development of the internet and an increase in the number of people with Internet access has made it possible to manage many economic, logistical and social processes remotely (Tarasiuk, Dłużniewska, 2021). The attractiveness of the use of the Internet has generated more and more new ways of using it. Nowadays, every company knows the huge importance of e-commerce in the market. Many people wonder whether we will still be using stationary shopping in the future, when we already have the possibility to see a product in a 3D view, try it on at home and send it back if necessary. Logistics is an important element in e-commerce, as it is used to deliver goods ordered by customers of online stores online (Kwiatkowski, Winnicka, 2018). According to Philip Kotler's definition, e-commerce is a general term used to describe buying and selling processes supported by electronic devices (Kotler, 2002). Another definition, provided by the Organisation for Economic Cooperation and Development (OECD) writes that it is a business conducted over computer networks, such as the Internet, including related infrastructure. E-commerce should be understood as a way of doing business using telecommunications and computer technology for the exchange of data between independent computer information systems for business transactions (Wawszczyk, 2003). With the development of the internet accessible on mobile devices, the concept of 'm-commerce' has also emerged, understood as purchases made using mobile devices. According to a report by ExpertSender, in 2020, more than 79% of Poles with internet access

(representing approximately 85% of the population) will have made an online purchase. One of the most important problems of online shopping in the context of city logistics has become the delivery of many small parcels to highly dispersed delivery points. This problem has been referred to in the literature as the 'last mile problem'. Direct deliveries in particular became an obstacle, as they could not be delivered due to a lack of collection. In result, this led to reduced customer satisfaction, which is why many companies started to use other solutions to enable customers to pick up their parcels at a time and place convenient to them. Such solutions include:

- Pickup at a selected point.
- A parcel in „Ruch” collection points.
- Inpost vending machines.
- DPD vending machines.
- DHL vending machines.

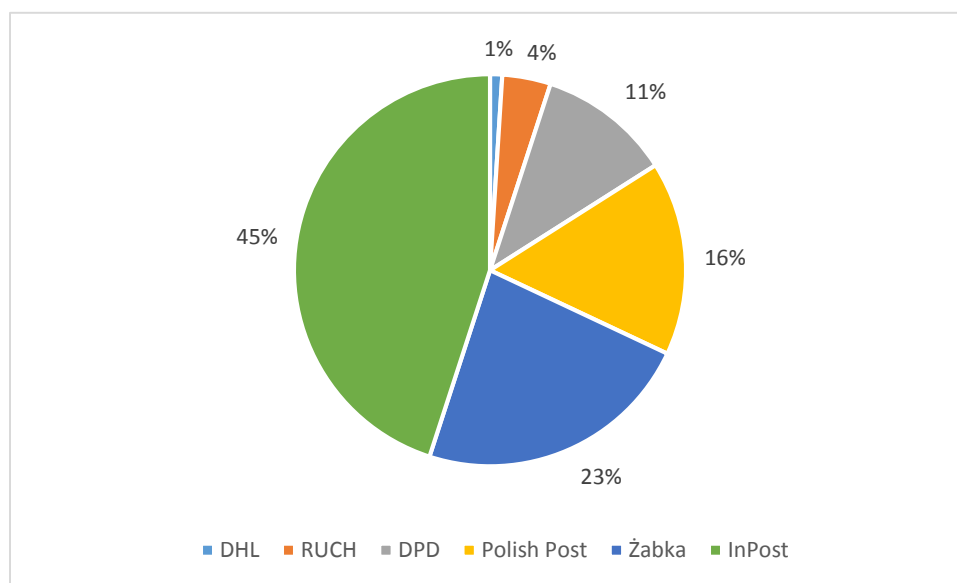
A parcel machine is a system of automatic post office boxes (or postal terminals) for sending and receiving parcels. The machines are distributed in public places, often close to supermarkets, petrol stations or university campuses. Most machines are available 24 hours a day. The report "Parcel vending machines and collection points in Poland - the new reality of the delivery world." presents a map, with parcel vending machines and pick-up points of the largest chains in Poland marked (Figure 1).



**Figure 1:** A Pickup in collection point.

Source: *Automaty paczkowe i punkty odbioru w Polsce- nowa rzeczywistość świata dostaw*. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.telepolis.pl/images/2021/08/raport-punkty-odbioru.pdf, s. 6. Access 17.09.2023r.

Looking at Figure 1, one can get the impression that there is practically ace left in Poland for new entrants into the parcel collection business. It should also be noted that the distribution of most points from different networks overlap, and are located near large cities. This is due, among other things, to the density of the population per 1m2. In addition, it is worth noting that the highest density of outlets, with the exception of the Warsaw area, is in southern Poland. Parcel vending machines are devices participating in e-commerce or mail-order sales, enabling self-pick-up of parcels at a time and place convenient for the customer. The promoter and pioneer of the idea of collection banks in the form of parcel vending machines is InPost, which is a company belonging to the Integer.pl S.A. capital group. In June 2021, according to the report 'Parcel vending machines and collection points in Poland - the new reality of the delivery world', Inpost's parcel machines occupied 45% of the country's area in relation to the analysed providers (Figure 2). The same report highlights that a total of 21,367,171 people in Poland have convenient access to pick-up points. The strategy of creating dense networks has both advantages and disadvantages. The advantage is undoubtedly accessibility, while the disadvantage is that the higher the percentage of shared traffic shared between points in the same network, the greater the chance that the point will not earn its own money.



**Figure 2:** Percentage share of parcel collection points of the analyzed suppliers, in Poland.

Source: *Automaty paczkowe i punkty odbioru w Polsce- nowa rzeczywistość świata dostaw*. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.telepolis.pl/images/2021/08/raport-punkty-odbioru.pdf, s. 9. Access 17.09.2023r.

Analysing the above literature considerations, the question should be asked: is an even greater development of vending machines possible in Poland and how do city dwellers perceive this development?



## Methodology of the study

The research on the development of sending and receiving points was carried out in three stages. The research process began with a literature search to determine the current state of development of the e-commerce industry and its impact on the development of delivery and collection points and parcel machines. Secondly, information made available by the currently most popular parcel delivery company InPost was examined. In the third stage, a questionnaire was constructed on the basis of the literature research, which was then administered to city residents in order to assess the development of sending and receiving points from their perspective. The survey questionnaire was created by using Google Forms and shared on social media and sent out via email. The traditional paper-based form of the questionnaire was abandoned due to the selection of the research group. The questionnaire was primarily intended to reach people who use a computer on a daily basis and are part of the e-commerce industry. The preparation of the questionnaire survey developed for residents included the determination of a minimum sample size for the research. In the end, 135 responses were obtained, which can serve as the residents' opinion on the development of the sending and receiving point. The questionnaire addressed issues relating to:

- Preferred delivery methods when shopping online.
- The main criteria for choosing delivery.
- Observing the development of sending and receiving points and parcel machines from a resident's perspective.

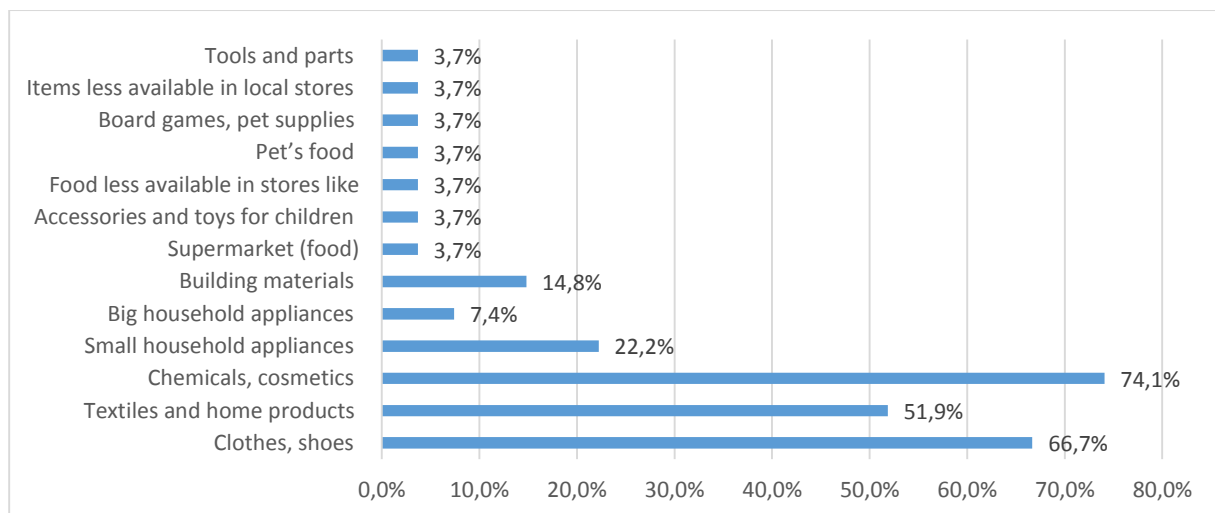
An important aspect of the survey was to determine the nuisance of indirect supply development from the public's perspective. The results of the survey are presented below.

## Results

InPost is a Polish private logistics operator based in Kraków. The company belongs to the capital group Integer.pl S.A. In September 2009, the first InPost parcel machine was placed in Kraków. By the end of 2022, InPost already offered its customers around 22,000 parcel machines throughout Poland. InPost parcel machines also operate abroad. In addition to Poland, the company operates under its banner in the UK and Italy. InPost declares to support pro-ecological attitudes, especially in the context of reducing CO<sub>2</sub> emissions. According to a press release made available in March 2023. InPost, with its network of Paczkomat® devices, is steadily strengthening its position as the leader in logistics services for e-commerce in Poland. According to a survey conducted by Kantar in 2022. 92% of respondents chose Paczkomat as their preferred form of delivery when shopping online, while a year later this form of delivery

is already indicated by 94% of respondents. In addition, according to the survey, as many as 85% of Internet users consider Paczkomat® to be the most environmentally friendly form of delivery. In recent years, the InPost Group has become the leader among e-commerce delivery platforms in Europe, delivering 744.9m parcels, 40% more than the year before.

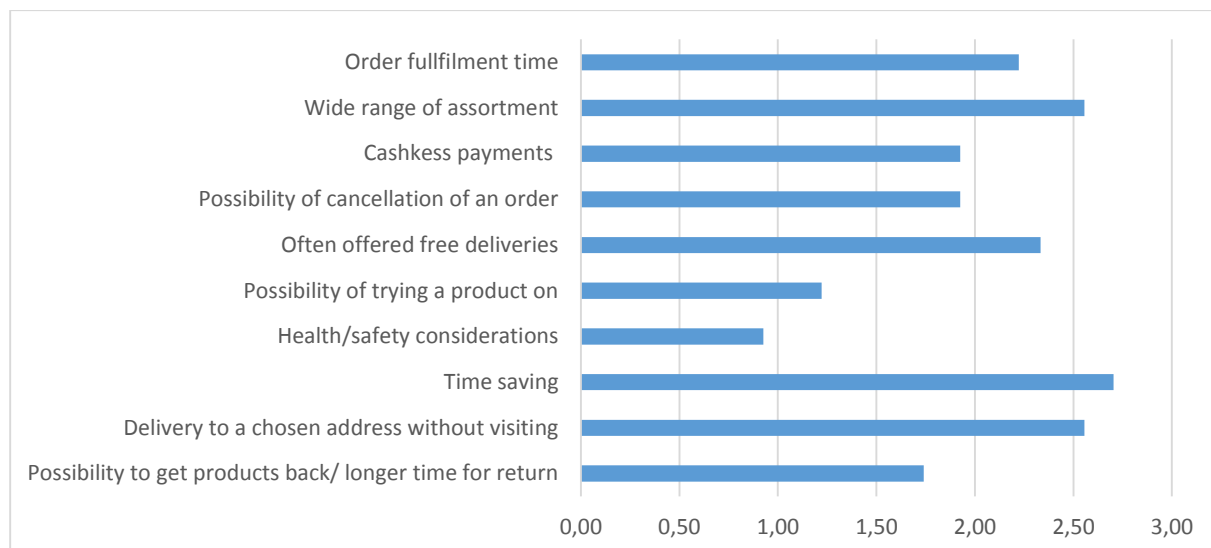
The results of a survey were analysed to determine residents' opinions on the development of delivery and collection points. The first question concerned the frequency of online shopping. It turns out that 63% of respondents use this form of shopping several times a month. The remaining respondents indicated that they shop online several times a week (18.5%) and about once a month (18.5%). The next question concerned the object of shopping. In this question, respondents could mark more than one answer. Chemicals and cosmetics (74.1%) and shoes and clothing (66.7%) were the most popular as the most frequently purchased item when shopping online. The results of the remaining responses are shown in Figure 3.



**Figure 3.** Products most frequently purchased online.

Source: own elaboration based on surveys conducted.

Respondents were then asked about the influence of individual criteria, selected on the basis of the literature review and their own experiences, on their choice of online shopping. Respondents were asked to rate each criterion on a scale of 0-3, where 3 meant that they were mainly guided by the criterion and 0- that it was unimportant. A weighted average was calculated for each criterion for an accurate analysis. The results are shown in Figure 4.



**Figure 4.** Criteria that influence the choice of online shopping.

As can be seen from Figure 4, the most important criterion according to respondents is time saving, followed by a wide assortment choice. The least important to respondents appeared to be security matters. The next questions concerned the choice of delivery method. Respondents were asked to rate on a scale of 0-3 the methods of delivery of products, where 0 meant "I do not use this type of delivery" and 3 meant "I use it practically always". As in the previous question, a weighted average was calculated for each form of delivery for accurate analysis. The results are shown in Figure 5.

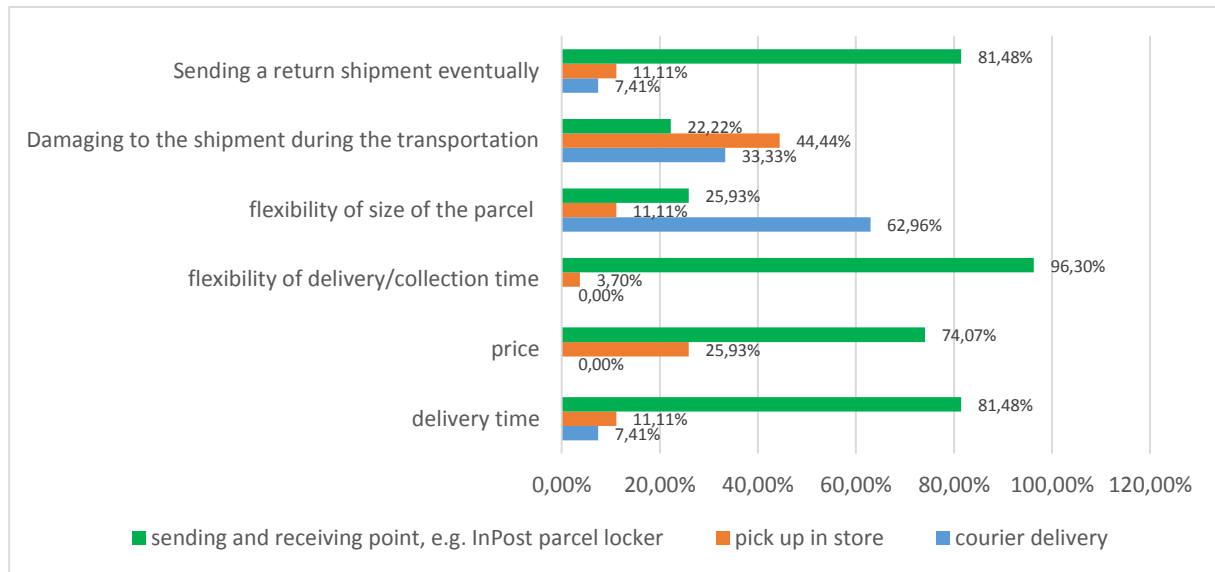


**Figure 5.** The most popular forms of delivery.

Source: own elaboration based on surveys conducted.

In Figure 5, it can be seen that delivery to InPost-type delivery and collection points has become the most popular among respondents. Only in second place was the once very popular courier delivery directly to the home. An explanation for this phenomenon can be found in the next question on the main motivation for choosing a delivery method. It turns out that for

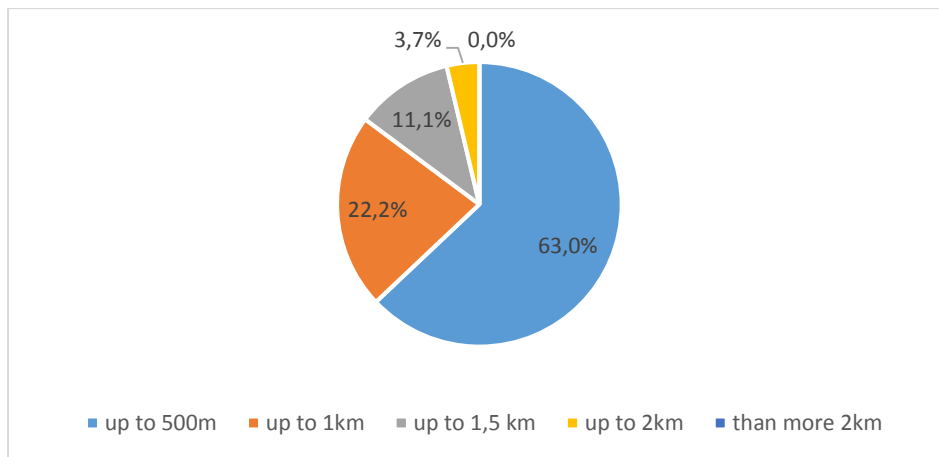
63% of respondents, the most important factor is the ability to adjust the pick-up time to their own needs, only followed by the cost of delivery (22.2%). A further question asked which delivery method respondents felt was the most advantageous in terms of a particular determinant. The criteria used were delivery time, price, flexibility of delivery time, flexibility in terms of shipment size, damage to the shipment during transport and the posting of a possible return shipment. It turns out that in four out of the six determinants given, delivery to parcel machines was selected as the most favourable delivery method. The exact results are shown in Figure 6.



**Figure 6.** The most favourable forms of delivery according to different determinants.

Source: own elaboration based on surveys conducted.

As can be seen from Figure 6, respondents found the drop-off/pick-up points, e.g. InPost parcel machines, to be convenient in terms of delivery time, flexibility of pick-up time, price and sending a possible return shipment. Courier deliveries, on the other hand, proved to be the most advantageous for customers in terms of parcel security. In-store collection, on the other hand, offers the greatest flexibility in terms of the size of the goods ordered. The survey also shows that the most inconvenient for residents are courier home delivery (48.1%) and personal collection in a shop (44.4%). It appears that only parcel post and pick-up points are inconvenient for a small group of respondents (7.4%). In order to investigate the extent to which the network of sending and receiving points was expanded, two further questions were asked of respondents. The first asked: at what distance from the place of residence is the nearest sending and receiving point. As many as 63% of respondents indicated that the distance was no more than 500 m. The results of the remaining responses are shown in Figure 7.



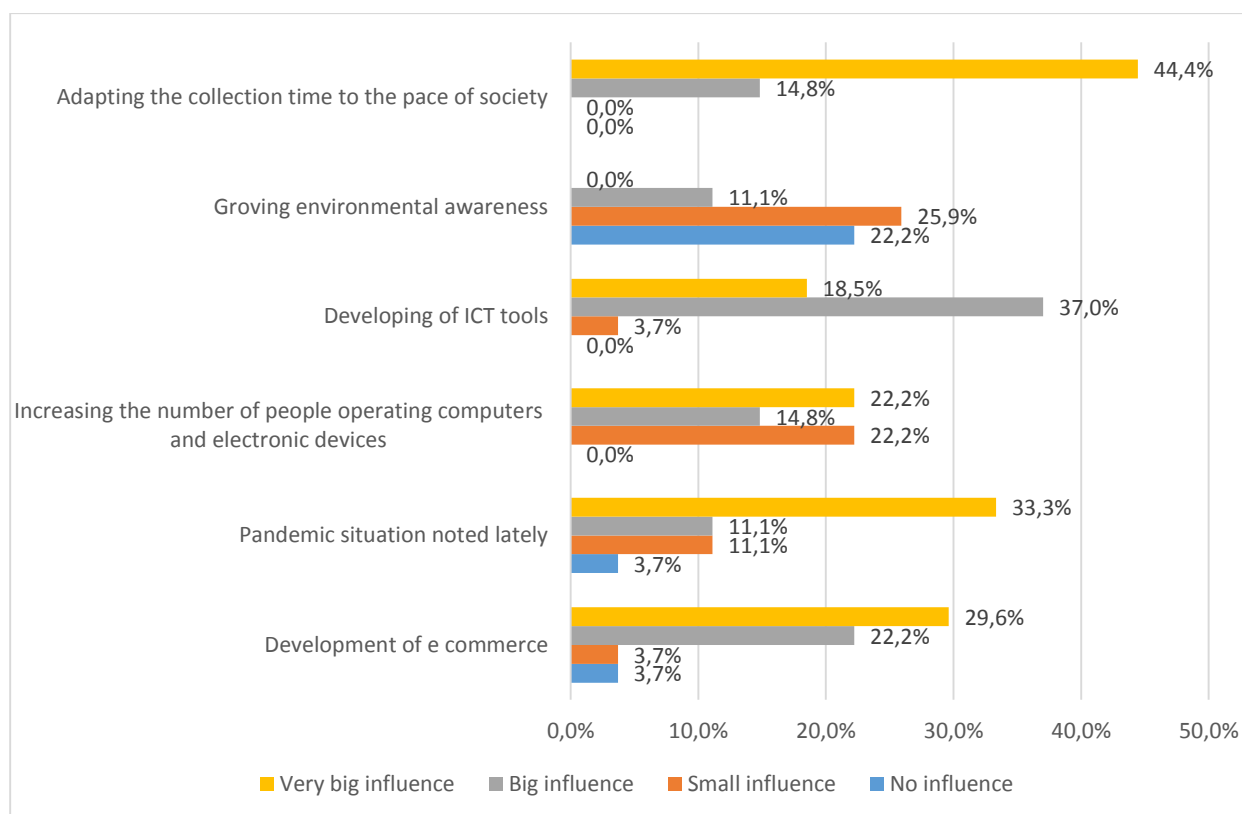
**Figure 7.** Distance from the nearest delivery point.

Source: own elaboration based on surveys conducted.

The second question, on the other hand, asked respondents whether any new transmission and reception boxes had been set up recently in the vicinity of their place of residence. This was answered in the affirmative by 77.8% of respondents, of whom at the same time 95.2% indicated that the new boxes did not cause any inconvenience and therefore did not have a negative impact on their quality of life.

Respondents were also able to rate the benefit of the new drop-off points on a scale of 1-5, where 1- a small benefit and 5- a huge benefit. Taking into account the weighted average of the answers obtained (4.41), it can be concluded that residents consider the creation of new points to be a great benefit, which only confirms the previous survey results.

Next, the respondents assessed the influence of the individual factors, determined from the literature review, on the development of transmission and reception boxes. The results of the study are shown in Figure 8. 44.4% of the respondents rated the alignment of reception times with the pace of society as a very strong influence on this development.



**Figure 8.** Influence of individual factors on the choice of vending machines.

Source: own elaboration based on surveys conducted

In order to analyse the results of the study in detail, a weighted average was calculated for each factor, assigning weights according to the degree of influence. The results of the calculations are presented in Table 1. The values obtained were then compared, identifying the factors that residents believe have the greatest impact on the development of the transmission and reception boxes.

**Table 1.**

*Influence of individual factors on the choice of vending machines*

	no impact	low impact	high impact	very high impact	Weighted average
Weight →	0	1	2	3	
Factor ↓	Number of responses received				
Developments in the e-commerce industry	5	5	30	40	2,31
Pandemic situation noted in recent times	5	15	15	45	2,25
Increase in the number of people using computers and mobile devices	0	30	20	30	2
Development of ICT tools	0	5	50	25	2,25
Increasing environmental awareness of society	30	35	15	0	0,81
Adaptation of reception times to the pace of society	0	0	20	60	2,75

Source: own elaboration based on surveys conducted.

The study using a weighted average only confirms that the greatest influence on the development of sending and receiving points is the alignment of collection times with the pace of society. In second place with a score of 2.31 was the development of the e-commerce industry. According to the respondents, the escalation of parcel points was not influenced by the increasing environmental awareness of society. However, at the same time, 81.5 per cent of respondents said that delivery to a pick-up point was more environmentally friendly than direct delivery to the home, which was considered in the next question. Then, in another open-ended question, respondents were able to comment on why they thought delivery to a collection point was greener. Responses varied, but most focused on three key benefits:

- reducing the number of destination pick-up points, which minimises fuel consumption and kilometres travelled,
- reducing the length of routes for delivered goods while minimising external transport costs,
- saving time.

The survey was concluded with a question on the possible risks posed by delivery and collection boxes. 66.7 per cent of respondents indicated that, in their opinion, existing and newly established points do not pose a threat to the environment.

## Discussion

Undoubtedly, in recent years we can observe an increase in consumer interest in online shopping. As transport, and in particular the transport of goods, is strongly linked to the e-commerce industry, companies are looking every day for new delivery solutions to attract new customers. The first questions of the survey confirm that online shopping is becoming more and more popular, due to the variety of assortments and time savings. The research presented in this article confirms several important points. First, delivery using parcel vending machines has recently become the most popular form of delivery, which is due to its convenience in terms of delivery time, flexibility of pickup times, pricing, and simple posting of a possible return shipment. This is also confirmed by research conducted by Kantar, according to which 92% of those surveyed in 2022 (Kantar, 2023) chose Parcel Post as their preferred form of delivery when shopping online. Secondly, the biggest influence on the development of sending and receiving points is the alignment of pickup times with the pace of society and the development of e-commerce. Similar research results were obtained by Szewczyk and Trajder in 2017. According to their research, the two most frequently chosen determinants of parcel vending machine selection turned out to be flexible pickup times and parcel convenience. The questionnaire surveys conducted in this article also have their limitations. They can only serve as an opinion of residents with regard to the development of

transmission and reception boxes. This is evidenced by the incomplete survey sample, which was only 135 people, while, with an estimated fraction size of 0.5, and an acceptable error of 0.05 (5%), and  $\alpha = 5\%$ , the survey sample size should be a minimum of 384 people. In addition, the research was limited to the opinions of local residents, and the development of parcel vending machines has also been influenced by businesses that have quickly adapted to the new delivery strategy. The author intends to expand the research with questionnaires to additional stakeholders in the future. It should also be noted that the number of people of all ages using computers is increasing year on year, which I believe is also not insignificant for the development of both e-commerce and various forms of delivery. In 2009, the idea of Paczkomats was born in Poland, so modern devices resembling post office boxes, which make it possible to independently collect and send parcels 24 hours a day, 7 days a week. Initially, few people believed in the success of the idea. It seemed abstract to leave ordered products in a place other than the customer's home. The surveys conducted show that according to residents, parcel vending machines are a very good solution, making it easier to receive parcels and thus improving their quality of life. The research carried out brings another argument to management science, showing that appropriate logistics solutions combined with the use of modern technology have a positive impact on the lives of residents and smooth the flow of goods in cities. So why have drop boxes been so successful over the years? According to Szewczyk and Trajer, parcel machines are an innovative tool in the courier industry developed by the independent logistics operator InPost (Szewczyk, Trajer, 2017). Ciepaj E., on the other hand, describes parcel machines as a revolutionary system "tailor-made" for the customer (Ciepaj, 2012). According to the author, they perfectly meet the needs of customers while keeping up with the dynamic development of the e-commerce industry. Recipients do not have to wait for a courier or stand in lines to pick up a package at specific times. In addition, the costs of deliveries using outboxes are comparable to, and often lower than, those to be incurred by choosing a courier. Shipper-receiver boxes are, in the author's opinion, a good solution in the context of urban logistics. Placing multiple parcels in one place reduces the number of courier transport routes, which in turn reduces the external cost of transporting goods, and also reduces the number of delivery trucks traveling through cities.

## Conclusions

There is no doubt that in recent years there has been an upsurge in the development of broadcast boxes. This is due to a number of factors, including the growth of the e-commerce industry, the COVID-19 pandemic and the increasing use of computers and mobile devices by increasingly older people. The pioneer among companies currently offering parcel machine delivery is InPost. It is InPost that initiated this form of delivery in Poland by implementing the



so-called Paczkomaty. The use of parcel boxes in the context of urban logistics has many advantages. Firstly, it reduces the number of delivery points, which undoubtedly affects car traffic in the city. Secondly, it reduces the external costs of transport by reducing emissions, urban congestion and noise. A disadvantage of vending machines is considered by some to be the appearance of metal boxes in the city landscape, which are not always in the right places and are currently not regulated in any way. The survey carried out showed that the development of vending boxes is not only noticeable in number, but also by the public. Many people use this form of delivery because of the time savings as many of these machines are open 24 hours a day and the cost, which is usually lower than home delivery by courier. Parcel vending machines are a modern solution that adapts the timing of delivery to the pace of society. In the future, it could be a delivery method used not only by individual customers but also by small businesses.

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## GOVERNING BODIES OF ORDINARY ASSOCIATIONS IN THE CITY OF GLIWICE

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**Purpose:** The purpose of this paper is to define the model of formation (creation), structure, tasks, competences, relations with other entities and responsibilities of governing bodies of ordinary associations and to identify these associations and their governing bodies in the city of Gliwice. Ordinary associations are entered in the register of ordinary associations kept by district and city district offices, which is the city of Gliwice. On the basis of the analysis of data on these associations, the author attempts to answer the research questions: What is the correct model for the process of establishing governing bodies of ordinary associations, what internal structure should they have, what sentences should they have, what types of responsibility do they bear and what are their relations with other entities and what impact do these issues have on the subsequent functioning of the association?

**Design/methodology/approach:** The realisation of the above-mentioned objectives is made possible through the application of two research methods: the legal analysis method (dogmatic method), which is appropriate for the analysis of a phenomenon determined by legal regulations, and the empirical research of the register of ordinary associations kept by the City of Gliwice. The author used various techniques and tools to collect and analyse data, i.e. legal analysis, analysis of entries in the register of ordinary associations in Gliwice, analysis of court rulings and internet sources.

**Findings:** The author identified ordinary associations based in Gliwice, their governing bodies and the types of these bodies, determined the models for the formation and structure of governing bodies of ordinary associations, their tasks, responsibilities and relationship with other entities.

**Practical implications:** Models for the creation of governing bodies of ordinary associations can be used in practice by those intending to create ordinary associations.

**Social implications:** Ordinary associations are one of the organisational forms in which a person can actively interact with society. This organisation allows him or her to be creative and thus realise his or her own and the collective needs of others. The choice of the type of governing body will have further consequences in terms of the relationship of the ordinary association with external actors and association members. Familiarising with the paper will allow to consciously create an ordinary association and join it with an awareness of the consequences and responsibility for the obligations of the ordinary association.

**Originality/value:** This paper is the first scientific, analytical study identifying ordinary associations and the types of their governing bodies in the city of Gliwice.

**Keywords:** association management, associations, organisation of an ordinary association, formation of an association.

**Category of the paper:** research paper.

## 1. Introduction

Man is a social being. From his nature comes the need to be a member of a community and the need to influence the functioning of that community. The community passes on to the individual its past achievements and in the community the individual develops his/her talents, which then enrich social development. It is a kind of relay race towards the future. Examples of communities are the family, a group of people in a workplace, in a school, in a parish, in a locality, in a territorial unit, in a state. In the modern world, the functioning of these communities is regulated by law.

An individual can influence social life either individually or through collective organised action, e.g. through associations, political parties. One such organisational and legal form is the ordinary association. Ordinary associations are only one of the possible forms of associations. The Act of 7 April 1989 - Law on Associations (hereinafter: PrStow) provides for two organisational and legal forms of associations. The basic form is the association, which is registered by the registration court in the National Court Register. The second organisational and legal form of an association is an ordinary association, which is not registered in the National Court Register but is entered in the register of ordinary associations (Miemiec, 2019), kept by administrative bodies - mayors or presidents of cities in cities with district rights. The city of Gliwice is a city with district rights, i.e. it is an urban municipality that, in addition to its municipal tasks, additionally performs district tasks, and the bodies in such a city are the city council and the city president. Gliwice is a large city located in the Silesian Voivodship with a population of over 166,000 (<https://gliwice.eu>). It is a city where the Silesian University of Technology is based, where this paper was written as part of the research.

The President of the City of Gliwice keeps a register of ordinary associations. This register is public, open and available in electronic form within the Public Information Bulletin of the Municipal Office in Gliwice. This bulletin aims to make public information available in electronic form in a universal manner. It consists of websites where public authorities and other entities performing public tasks make public information required by Polish law available. Using access to this register, I obtained data and information on specific ordinary associations and their governing bodies registered in Gliwice.

## **2. Organisational and legal models of governing bodies of ordinary associations**

### **2.1. Types of bodies of the ordinary association**

The basic legal act according to which an ordinary association can be established and according to which it will function is the Law on Associations. The Act defines the legal nature of the association and its rules of operation. It stipulates that an association is a voluntary, self-governing, permanent association with non-profit purposes (art. 2 PrStow). The legislator does not impose objectives, programmes of action or organisational structure. It leaves these issues to be decided by persons wishing to establish an ordinary association. Unlike an association registered in the National Court Register an ordinary association, which is only registered in the register of ordinary associations kept by mayors (presidents of cities with county rights), ordinary associations do not have legal personality, they are a simplified form of association (art. 40 PrStow) but they have legal capacity and judicial capacity. However, only all members of the association have legal standing and therefore the capacity to take legal action (judgment of the Supreme Administrative Court of 12 February 2018, II OSK 1157/17, *Legalis*). An ordinary association may be established by as few as three persons. In order to do so, they must adopt two resolutions: on the establishment of an ordinary association and on the adoption of its rules of procedure.

In defining the organs of an ordinary association, the law is very liberal. The necessary body is only the governing body, which can be either the representative or the board of directors (Suski, 2018). An optional body, which may or may not be, is the internal control body. The legislator has not established the body of the association as the general meeting of members. This is a consequence of the fact that the members of an ordinary association are liable for the obligations of the ordinary association without limitation with all their assets jointly and severally with the other members and with the association (Article 40(1b) PrStow). The consent of all members of the ordinary association is required in order for the governing body to take an action exceeding the scope of ordinary management. For this reason, the legislator did not consider it necessary to create such a body. However, since an ordinary association is a self-governing association, there is no contraindication for the bylaws to provide for the existence of such a body, but it cannot then have the competence to substitute the consent of all members of the ordinary association to perform legal acts exceeding the scope of ordinary management.

### **2.2. The process of creation and functioning of governing bodies**

Since the Law on Associations does not impose one type of governing body of an ordinary association, but gives the possibility to choose between two forms of body, the founding members have to make this choice in the process of forming an ordinary association. As already

mentioned, one of the resolutions that the founding members must adopt is the resolution on the adoption of the rules of procedure of the ordinary association. This is an act of internal law of the association. It defines not only the name of the ordinary association and the type of governing body, but also the purpose or objectives, the area of action, the means of action, the seat and many other issues. Every organisation should have a normative act that defines the shape of the intra-organisational bond, the system of goals, values (Kožuch, 2004, 2020). In an ordinary association, this act is the rules of procedure.

The choice of the type of governing body in a particular ordinary association depends on a number of issues. An important aspect is that the representative is a one-person, monocratic body, while the management board, as a rule, is a collegial, multi-member body (Michalska-Badziak, 2009; Ochendowski, 2009). However, there is no contraindication for the board to be a single-member board, as occurs in one case in Gliwice. It certainly matters whether the founding members prioritise collective action, taking account of different points of view, or whether they consider efficient one-person management to be of greater value, assuming that the person acting as a representative is sufficiently competent, operative, well-organised and able to make decisions accurately and efficiently (Knosala, 2006). The representative is also single-mindedly accountable to the members of the association, rather than, as in the case of the board of directors, this accountability is diluted, the sense of responsibility is then diminished.

When the founding members decide on a board of directors as the governing body of an ordinary association, then the Law on Associations requires that the association's bylaws specify in particular the procedure for the election of the board of directors, the procedure for the completion of its composition, its competences, the conditions for the validity of resolutions, the manner of the association's representation (in particular the contracting of property obligations (art. 40, para. 3 PrStow)).

The board of directors should be made up of people who together represent a kind of added value, they are the most important resource of the association as an organisation (Kožuch, 2020). For the smooth functioning of the board of directors, an important issue is the number of board members and the functions that the individual board members will perform in carrying out their duties. The PrStow Act does not impose these functions, they should be determined by the association's bylaws. Usually, the functions of the members of the board are: chairman of the board, vice-chairman, secretary, treasurer, member of the board. There is no contraindication for the bylaws to provide for other functions. There is also no statutory requirement to elect a person to a specific function at once when electing the board of directors. Such an election procedure is the most common in practice, but there is no contraindication if the bylaws of the association provide for the election of the board of directors without specifying the functions of individual persons and only later the members of the board of directors elect persons from among themselves for specific functions.

In the process of forming an association, the election of the first board of directors should ideally take place at the founding assembly. However, the PrStow Act does not impose such a requirement. Therefore, resolutions on the establishment of the association and the adoption of its rules of procedure may be taken at the founding meeting and only at the next meeting the management board may be elected. The PrStow Act, while not requiring an ordinary association to have such a body as a general meeting of members, has allowed for the possibility of decision-making by the founding members by circulation. Which procedure will be applied in a particular ordinary association will depend on the provisions contained in the association's bylaws. In principle, an analogous situation exists with regard to the completion of the board of directors.

With regard to the completion of the board of directors, the question of both the election procedure and the initiative for completion needs to be regulated. Completion of the board of directors can be done either at the members' meeting or by circulation. Irrespective of the election procedure, the bylaws of the association must specify the conditions for the validity of the resolutions, in particular with regard to the election of the board of directors and the completion of its composition. The solution to this issue, which is most oriented towards efficient decision-making and at the same time guarantees a course of action in line with the majority of the association's members, will be the norm according to which a simple majority of the association's members will suffice for the validity of the resolution concerning the election of the board of directors and the supplementation of its composition.

The will of the board will be expressed in the form of a resolution (unless the board is a one-person board). A board of directors will be a better choice than a one-person representative if the founding members value discussion more before decisions are made and want more people to examine the issue. An important circumstance will also be when the founding members represent different views but decide nevertheless to set up an association together. Then, for example, each fraction may have one board member representing its interests, views, positions.

A weakness of the board as the association's governing body may be that the decision-making process takes too long. In order to counteract such a phenomenon, the following should be provided for in the rules of procedure: the number of board members, the type of majority required for a resolution to be valid. For example, that resolutions are passed by a simple majority, and in the event of a tie, the vote of the chairman chairing the board meeting or the vote of the chairman of the board is casting. Then, even an equal number of votes "for" and "against" does not result in a state of non-adoption of the resolution. Provision should also be made for the problem of the proper *quorum* and the procedure for convening board meetings. The first issue of the validity of the decisions taken is the correct notification of the members of the board of directors of the convened board meeting. In this respect, provision may be made for a rule stipulating that the board of directors shall adopt resolutions either when fully constituted or, if the board of directors has been duly notified of a meeting of the board of

directors, a simple majority shall be sufficient for a resolution to be valid, and in the event of a tie the chairman of the board of directors shall have the casting vote. The rules of procedure for this purpose should specify who is the chairman of the board meeting. For example: a meeting of the board of directors is chaired by the chairman of the board of directors, in the event of absence by the vice-chairman, followed, for example, by the oldest member of the board of directors. Regulating these issues in this way will make it possible in future to smoothly overcome crisis situations arising from problems of a personal nature. There should be clear rules on who should convene the board, when, where and how. A simple majority rather than an absolute or qualified majority is conducive to the smooth adoption of resolutions. If an absolute or qualified majority were to be set for the validity of resolutions, consideration should be given to providing that, in the absence of an absolute or qualified majority, a simple majority of the board members present at the next board meeting convened on the issue would suffice to pass a resolution.

Like almost every organisational unit, an ordinary association also acts through its bodies. The rules of procedure of this association must define the way in which the association is represented. If the governing body is a representative, then he or she, single handedly, represents the ordinary association towards external parties. On the other hand, if the governing body is a (multi-member) board of directors, then the bylaws of the association must specify the manner of representation of the ordinary association. By stating in the bylaws that the association is represented by a board of directors, the effect will be that the board of directors has to represent the association in its full composition. A more practical solution would be a norm stating that the ordinary association is represented by the chairman of the board of directors together with the other member of the board of directors or by two members of the board of directors together.

A particularly important issue in the field of representation is the representation of an ordinary association with regard to the incurring of property obligations. This issue is so momentous due to the fact that an ordinary association does not have a legal personality and that not only the association but each member of the association is liable for the obligations of the ordinary association with all its assets (Hadrowicz, 2019). Therefore, a member of an ordinary association should choose such a governing body in which he or she will have full confidence. I will address the issue of the scope of tasks, competences and responsibilities of the governing body of an ordinary association in the next subsection of the paper.

### **2.3. Tasks and powers of the governing bodies**

The governing body of an ordinary association, once its creation is completed, should carry out its tasks in accordance with its competences as defined in the Law on Associations and in the rules of procedure. The first task, even before an ordinary association can start its activity, is to submit in writing an application for entry in the register of ordinary associations. If the application for entry is submitted by the management board, regardless of the principles



of representation specified in the rules of activity, it must be signed by all members of the management board (art. 40, para. 6 PrStow). Such an application, together with the minutes of the founding meeting and the attachments, should be submitted to the competent supervisory body of ordinary associations, which is the mayor or the city presidents in cities with district rights. The application for entry in the register of ordinary associations should be accompanied by:

1. operating regulations,
2. a list of the founders of the ordinary association, including their names, surnames, date and place of birth, place of residence and the founders' handwritten signatures,
3. the name, residential address and personal ID number of the representative of the ordinary association or the members of the management board,
4. the name, residential address and personal ID number of the members of the internal control body, if the rules of procedure provide for such a body,
5. the address of the registered office of the ordinary association (Article 40(5) PrStow).

Only after an entry in the register of ordinary associations is made, the association is formed and may start its activities. The authority keeping the register shall notify the governing body of the ordinary association of the entry immediately after the entry in the register. If the administrative body keeping the register fails to make an entry of the association in the register, the managing body is entitled to legal remedies (art. 40a par. 5 and 6 PrStow) of both administrative (urging) and judicial (complaint to the administrative court) nature. The managing body should, after receiving a notice of the registration of the association in the register of ordinary associations, apply for the REGON (*statistical number*) and TIN to be assigned to the association by the authorities competent for the place of the association's registered office. In order to obtain a REGON, it is necessary to submit an identification declaration to a branch of the statistical office, while the identification declaration in order to obtain a NIP should be submitted to the tax office. The latter two activities can also be carried out through electronic communication.

The tasks of the governing body of an ordinary association will depend on the purpose and objectives of the association, as set out in the rules of procedure. These bylaws should define "in particular" the tasks of the association's representative/management body. The Law on Associations, in Article 41a, defines two types of activities: activities of ordinary management and activities exceeding the scope of ordinary management. There is no statutory definition of acts of ordinary management. In the doctrine and jurisprudence of the courts, the view has become firmly established that these are both legal and factual actions, related to the day-to-day matters of the management of the organisation, things, with the use of things, collection of benefits, actions aimed at maintaining things in their current state (Malicki, 2023; Kidyba, 2010; Rudnicki, S., Rudnicki, G., 2008; Winiarz, 1989). Whether an activity is an activity of ordinary management or an activity exceeding ordinary management is determined by the totality of relations, circumstances related to the thing or the legal situation in which a particular

activity has to be performed (Deneka, 2021). The representative/manager has the competence to independently undertake all activities of ordinary management, unless the rules of operations classify them as activities exceeding ordinary management.

Typical tasks to be included in the ordinary management activities are: representing the ordinary association to the outside world, dealing with current affairs, realising the objectives set out in the activity regulations, convening the members' meeting, drawing up and executing the activity plans, day-to-day management of the association's property, collecting membership fees and performing emergency activities, e.g. those which, if omitted, would expose the association to a loss, adopting resolutions on the admission of members and on the exclusion of members.

With regard to actions exceeding ordinary management, the governing body will have the competence to undertake such actions only if previously all members of the ordinary association consent to the action and grant the representative/manager a power of attorney to carry it out (Article 41(2) PrStow). The consent and the power of attorney for documentary purposes should be made in writing, unless the provisions of the law require a special form for the performance of a specific action, e.g. for the transfer of ownership of real estate or for the establishment of a limited right in rem, the form of a notarial deed is required. In such a case, the consent (analogously to the consent of a third party) and the power of attorney should be in such a form as is required for the given legal action. The PrStow Act, in Article 41a(3), lists 'in particular' the types of acts that are acts exceeding the scope of ordinary management. These include:

1. acquisition and disposal of real estate or the right of perpetual usufruct,
2. establishment of a limited right in rem,
3. conclusion of a credit or loan agreement,
4. assumption of debt, acknowledgement of debt, discharge of debt, accession to debt, conclusion of a suretyship agreement or conclusion of any other similar agreement,
5. incurring other liabilities exceeding the value of PLN 10,000.

From the above exemplary, but statutorily determined catalogue of acts exceeding the scope of ordinary management, it may be concluded that contracting liabilities other than those specified above of a value lower than PLN 10,000 shall be acts of ordinary management. The catalogue of activities exceeding the scope of ordinary management may be additionally specified in the regulations of activity and may determine, for example, that the activities exceeding the scope of ordinary management shall be the activities resulting in contracting property obligations of lower value than specified by the act, e.g. the activities exceeding the value of PLN 3000, change of the association's regulations. The association's by-laws may also stipulate that specific actions require the prior consent of a specified majority of the association's members, e.g. a resolution on the loss of membership by a member of the association. Actions taken by the governing body without the required consent are invalid.

The precise definition of the activities that the representative/management board may not undertake without the consent of all members of the ordinary association or a certain majority of them is particularly important in view of the statutorily defined rules of liability for the association's obligations. Each member of an ordinary association shall be liable for the obligations of that association without limitation and with all its assets (Article 40(1b) PrStow; Hadrowicz, 2019). This is joint and several liability with the other members of the association and with the association (Judgment of the Regional Administrative Court in Lublin of 24 November 2017, I SA/Lu 671/17, Legalis). Pursuant to Article 366 of the Civil Code, a creditor may demand all or part of a performance from all debtors jointly, from several of them or from each of them separately, and satisfaction of the creditor by any of the debtors releases the others. The debtors remain joint and several until the creditor is fully satisfied.

A separate issue is the civil (property) liability of board members (Hadrowicz, 2019) in internal relations. If there was no specific contract with a member of the management board, his/her liability will be towards the association and the members of the association under the general rules set out in the Civil Code (Article 415 of the Civil Code - "whoever caused damage through his/her fault"). On the other hand, if there was a management contract, the basis for the liability of the members of the management board will be Article (art. 471 et seq. KC - "The debtor is obliged to compensate for damage resulting from non-performance or improper performance of an obligation, unless the non-performance or improper performance is a consequence of circumstances for which the debtor is not responsible").

It is also important to bear in mind criminal law liability, e.g. for abuse of powers granted or failure to fulfil a duty (Article 296 of the Criminal Code) and tax law liability, e.g. that members of governing bodies are jointly and severally liable for tax arrears with all their assets (Article 116a of the Tax Ordinance).

For these reasons, the prudence and competence of the governing body of an ordinary association and the trust that the members of the ordinary association have in the members of the governing body are of paramount importance.

### **3. Background research on the type and structure of governing bodies of ordinary associations in Gliwice**

All the considerations so far refer to the bodies of ordinary associations, regardless of the place of their seat in Poland. As this scientific paper was written within the framework of the scientific activity of the author employed at the Silesian University of Technology, which has its seat in Gliwice, ordinary associations registered in the register of ordinary associations kept by the President of the City of Gliwice as an authority of the city with the rights of a district were selected for analytical and statistical research. The tabular study covers all registered

ordinary associations, showing the names of the ordinary associations and the established type of governing body - whether it is a representative or a board of directors. If the governing body is the board of directors, the determination additionally includes the functions that occur on the boards of the associations. The last column of the table specifies whether the ordinary association has an internal control body.

**Table 1.**

*List of associations entered in the register of ordinary associations in the City of Gliwice specifying the name of the ordinary association, type of governing body, functions on the board of directors and internal control body*

Item	Name of the ordinary association	Type of the Board entity: representative/ the Board	Board functions	Internal control body
1.	Stowarzyszenie Gier Planszowych Gambit	representative	—————	not applicable
2.	Ośrodek Studiów o Mieście Gliwice	the Board	Board of three members	not applicable
3.	Res Economica	the Board	President and Coordinator	not applicable
4.	Polskie Stowarzyszenie Inżynierów Chłodnictwa i Klimatyzacji PSICHIK	representative	—————	not applicable
5.	Stowarzyszenie "KOCHAM GLIWICE"	representative	—————	not applicable
6.	Stowarzyszenie Nowoczesne Gliwice	representative	—————	not applicable
7.	Stowarzyszenie Mieszkańców Gliwice WSPÓLNIE DLA GLIWIC	representative	—————	not applicable
8.	"Bractwo Stare Gliwice" Klub Sportowy (dissolved)	representative	—————	not applicable
9.	Stowarzyszenie "Uwolij się"	representative	—————	not applicable
10.	Brzezinka Razem	the Board	President, Vice-President, Secretary	Audit Committee: Chairman and two members
11.	Gliwicki Ruch Obrony Terytorialnej	the Board	President and two board members	not applicable
12.	Stowarzyszenie "KAROLINA"	representative	—————	not applicable
13.	"Alter Alrerum Docent"	representative	—————	not applicable
14.	Stowarzyszenie Czyste Gliwice w Likwidacji skrót nazwy Czyste Gliwice (deleted from the register)	no data available	no data available	no data available
15.	Amatorskie Stowarzyszenie Internautów	no data available	no data available	no data available
16.	Ogólnopolskie Stowarzyszenie Strzelecko Kolekcjonerskie ARTEFAKT	representative	—————	not applicable
17.	FRONT REX	representative	—————	not applicable
18.	Polski Instytut Biograficzny	representative	—————	not applicable
19.	Stowarzyszenie "Szachowa"	the Board	Board of three members	not applicable
20.	Stowarzyszenie "Do Ziemi Obiecanej" im. księdza Andrzeja Szpaka	the Board	President, two Vice-Presidents	not applicable
21.	Stop Dla Masztu Telekomunikacyjnego Przy Ul. Kurpiowskiej	representative	—————	not applicable
22.	Stowarzyszenie św. Rity - Patronki w sprawach trudnych i beznadziejnych	representative	—————	not applicable

Cont. table 1.

23.	Lambretta Club Polska w skrócie LCP	representative	—————	not applicable
24.	Instytut Świadomości Społecznej Alert	representative	—————	not applicable
25.	Stowarzyszenie Edukacji Quarta Ratio	representative	—————	not applicable
26.	Stowarzyszenie na rzecz Porozumienia "Polubić konflikt"	representative	—————	not applicable
27.	Miasto Ogród Gliwice	representative	—————	not applicable
28.	"DLA ARTYSTÓW" - under liquidation	no data available	—————	no data available
29.	Ogólnopolskie Stowarzyszenie Przeciwdziałania Niezgodnym z Prawem Praktykom Organów Administracji Publicznej	representative	—————	not applicable
30.	Stowarzyszenie Kupców Na Lipowej	the Board	president vice-president, treasurer	not applicable
31.	Rzecznik Sprawiedliwości i Dialogu	representative	—————	not applicable
32.	ANIMATORZY (dissolved)	representative	—————	not applicable
33.	Stowarzyszenie Chrześcijańskie "Samarytanin" (dissolved)	representative	—————	not applicable
34.	Uczniowie Drogi Mesjasza	the Board	Chairman (President), Vice-Chairman, Secretary, Treasurer, Deputy Treasurer, Board Member (6)	not applicable
35.	Ruch Narodowo - Radykalny	representative	—————	not applicable
36.	Stowarzyszenie na Rzecz Kultury i Tradycji im. ks. dr. Piotra Semenkenko	representative	—————	not applicable
37.	Młodzi Aktywni	the Board	Chairman, deputy chairman, member of the management board	not applicable
38.	Zdrowe Miasto	the Board	three-member board	not applicable
39.	Ogólnopolskie Stowarzyszenie Ruch Ludzi Prawa Zwierząt	representative	—————	not applicable
40.	"SEMPER FIDELIS RP"	representative	—————	not applicable
41.	Wolni Ludzie GZ	the Board	Chairman, Vice Chairman, Treasurer	not applicable
42.	Klub Motocyklowy MILITARY RIDERS CLUB POLSKA	representative	—————	not applicable
43.	Stowarzyszenie Pokochaj Fotografię	the Board	President, Vice-President	not applicable
44.	"Lex Urbi" Stowarzyszenie Poszanowania Ładu Przestrzennego w Gliwicach	the Board	President Deputy President Secretary	not applicable
45.	Spółdzielcy SM Stare Gliwice	representative	—————	not applicable
46.	Plan dla Gliwic	the Board	President, 1st Vice President, Second VicePresident, Treasurer	not applicable
47.	SLAVA Pomoc Ukrainie	the Board	three board members	not applicable
48.	Wrak-Race Silesia	representative	—————	not applicable
49.	Gliwickie Stowarzyszenie Kolekcjonerów Broni	representative	—————	not applicable
50.	Stowarzyszenie Osada Tajty	the Board	Chairman of the Management Board (1)	not applicable
51.	Plejada Syriusza	representative	—————	not applicable
52.	Przyszłość Ziemi Gliwickiej	representative	—————	not applicable

Cont. table 1.

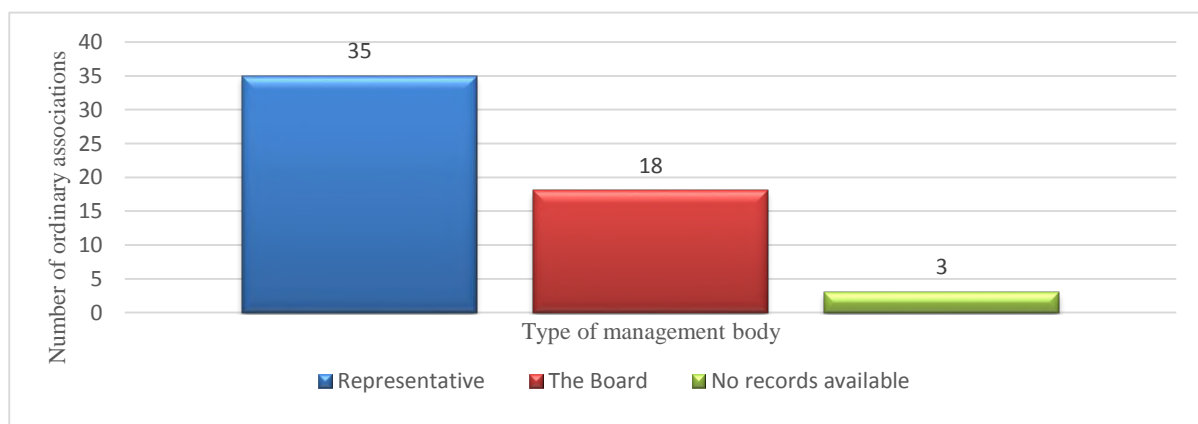
53.	Wspólne Gliwice	the Board	President Vice President.	not applicable
54.	Gliwickie Stowarzyszenie Strzeleckie "Para Bellum"	the Board	President Vice President Treasurer	not applicable
55.	Strefa Rozwoju Relacji Społecznych	representative	—————	not applicable

Source: Own work based on data from the Register of ordinary associations, kept by the City of Gliwice, <https://bip.gliwice.eu/rejesty/rejestr/10989>, 31.08.2023.

The list of associations was arranged according to the chronology of entries in the register of ordinary associations. Under the first item, an ordinary association named Stowarzyszenie Gier Planszowych Gambit was entered on 28.07.2016. The means of action of this association aimed at realising the objectives of the association include the organisation and support of: conventions, meetings popularising board games, educational activities, social campaigns, submitting motions, opinions and initiatives to enterprises, institutions of government administration, local self-government, social and professional organisations, the judiciary in the scope of statutory activities.

The last entry in the register was made on 06.07.2023 under entry number 55 and concerned an association called Strefa Rozwoju Relacji Społecznych. Its objectives include the social development of children, young people and adults. The means of action of this association to achieve its objectives are: preparation and implementation of projects thematically related to the objectives of the association in cooperation with state and local administration, creation of preventive, educational, sports, health and tourism programmes, organisation of leisure and free time for children and young people, etc.

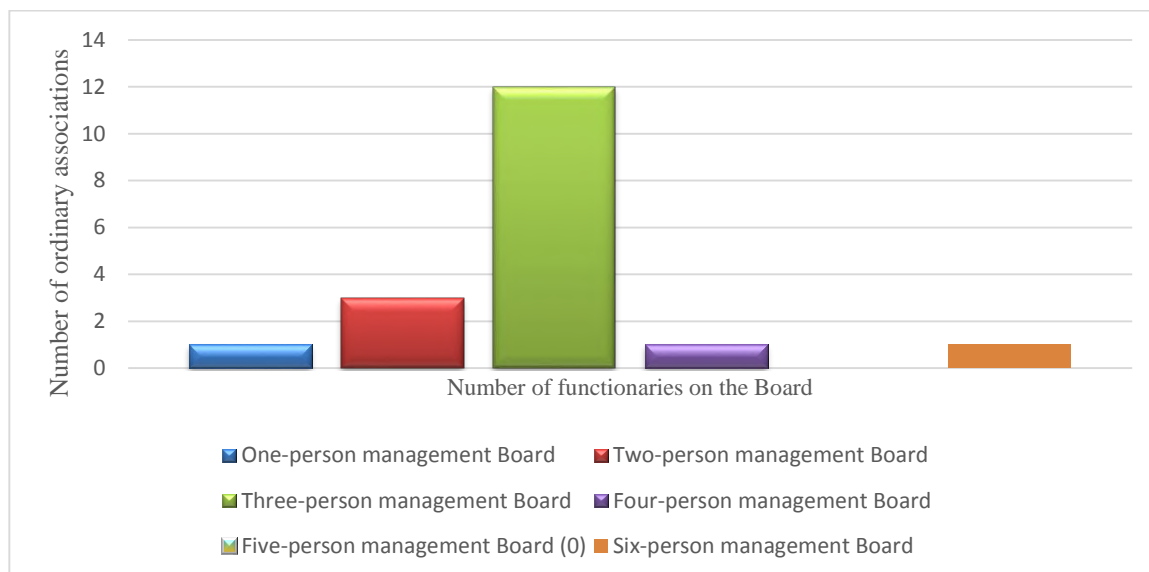
There are 55 such associations in the register of associations kept by the President of the City of Gliwice. 34 of them, i.e. approx. 61.8%, have a representative as a governing body, 18, i.e. approx. 32.7%, have a board of directors, in three cases (approx. 5.5%) there was no data in the register about the legal form of the governing body. The status is shown in the chart below.



**Figure 1.** Number and type of governing body of ordinary associations in the City of Gliwice.

Source: Own work based on data from the Register of ordinary associations, kept by the City of Gliwice, <https://bip.gliwice.eu/rejesty/rejestr/10989>, 31.08.2023.

With regard to the composition of the board: in one case the board is one person (President), in three cases the board is two persons, in 12 cases the board is three persons, in one case four persons and in one case six persons.



**Figure 2.** Number of functionaries on the board of ordinary associations in the City of Gliwice.

Source: Own work based on data from the Register of ordinary associations, kept by the City of Gliwice, <https://bip.gliwice.eu/rejesty/rejestr/10989>, 31.08.2023.

The above data shows that approximately 66.6% of the ordinary associations in Gliwice whose governing body is a board have a three-member board. Two-person boards occur in about 16.7% and one-person, four-person and six-person boards occur in about 5.5% of cases each.

#### 4. Conclusions and recommendations

An ordinary association has no legal personality, but it has legal capacity and judicial capacity (however, only all members of the association have legal standing and therefore the capacity to sue), which means that it can be a subject of rights and obligations, it can acquire rights and incur obligations; it can sue and be sued. It is a so called "person without corporate status", just like commercial partnerships and housing communities.

The consequence of the lack of legal personality of an ordinary association is the liability of the members of this type of association for the obligations of the association. The legislator has specified that it is a joint and several liability with the other members of this association and the ordinary association with all its assets and without limitations. The liability of the members of an ordinary association thus defined should sensitise the members of this association to the problem of selecting a competent and prudent person or persons to manage the ordinary association, as their actions may have negative consequences for the personal

assets of the members of the ordinary association (the liability for the obligations of an association registered in the National Court Register is regulated differently, where the members of the association are not liable with their assets for the obligations of the association).

The empirical research carried out is the first study of the structure of the governing bodies of ordinary associations in the city of Gliwice and, in this respect, adds to our knowledge of the governance of these associations. According to a survey of the register of ordinary associations in Gliwice, in about 62% of ordinary associations a single person was trusted as the governing body - the representative - and in about 32% of cases a multi-member board was entrusted with the management. Whatever the rationale of the founding members of an ordinary association in determining the type of governing body, when forming this association they should choose a person in whom they will have at least as much confidence as in themselves, as this choice will have consequences for their personal assets.

*De lege ferenda* it should be postulated that the legislator should amend the Law on Associations in such a way that the liability for the obligations of an ordinary association should first be borne by both: the association and the members of the governing bodies of the association, and only if the assets of the association and the persons who are representatives or members of the governing bodies are insufficient, only then would the liability for the obligations of the ordinary association be borne by the members of the association. In the current state of the law, the liability of the members of the association arises immediately when the enforcement of the assets of the ordinary association proves to be ineffective.

Irrespective of the type of governing body, the persons elected to these bodies should have the right competence, aptitude, such that the members of the ordinary association, who are liable with their assets for the association's obligations, can trust them as themselves.

For the smooth functioning of the board of directors, the number of board members and the functions that the individual board members will perform is an important issue. The members of the association may determine these issues in the bylaws of the association at their own discretion. As a positive issue for the deformation of the association's activity, the possibility to obtain approval and proxies for actions exceeding the ordinary management and to complete the board by circulation should be considered.

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## COMMUNITY ENGAGEMENT IN SMART CITY – SMARTPHONE APPLICATIONS ASPECTS

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**Purpose:** The purpose of this publication is to present the usage of smartphone application in Smart Cities in community engagement.

**Design/methodology/approach:** Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.

**Findings:** The integration of smartphone applications in community engagement within smart cities signifies a transformative paradigm shift, offering a myriad of advantages that redefine residents' interactions and contributions to community development. These applications act as dynamic platforms, utilizing technology to amplify communication, collaboration, and participation, fostering a more connected and empowered citizenry. The benefits encompass immediate access to real-time information, heightened civic participation, participatory decision-making, efficient public services, sustainability promotion, community building, emergency response, education, cultural and recreational engagement, and inclusive accessibility. Nevertheless, the implementation of smartphone applications in community engagement encounters challenges, including digital inequality, privacy concerns, technological literacy limitations, language and cultural barriers, security risks, exclusion of vulnerable groups, and issues related to data accuracy and reliability. To ensure inclusivity, effectiveness, and equity, it is imperative to actively address these challenges, emphasizing social equity considerations and balancing technological innovation with the diverse needs of the entire community. Bridging digital divides, providing education and support, addressing privacy issues, and promoting a balanced approach to technology use are vital steps toward creating truly inclusive and effective community engagement strategies in smart cities. Through thoughtful consideration and proactive measures, smart cities can fully harness the potential of smartphone applications to create vibrant, connected, and resilient urban communities.

**Originality/value:** Detailed analysis of usage smartphone applications in the case of community engagement.

**Keywords:** Smart City, energy efficiency, energy efficiency management, smartphone applications, community engagement.

**Category of the paper:** literature review.

## 1. Introduction

Community engagement in the context of smart cities has become increasingly crucial in fostering sustainable development and enhancing the quality of life for urban residents. One pivotal aspect of community engagement in smart cities revolves around the utilization of smartphone applications. These applications serve as powerful tools that not only connect individuals with the urban environment but also empower them to actively participate in shaping the future of their communities.

Smartphone applications designed for community engagement in smart cities offer a multifaceted approach to address the diverse needs and preferences of urban residents. These applications provide a platform for citizens to access real-time information about various aspects of city life, ranging from public transportation schedules and traffic conditions to local events and community initiatives. By harnessing the capabilities of smartphones, these applications ensure that residents are well-informed and can make timely decisions that contribute to the efficient functioning of the city (Rahman, Dura, 2022).

The purpose of this publication is to present the usage of smartphone application in Smart Cities in the case of community engagement.

## 2. The usage of smartphone applications in community engagement

Smartphone applications play a pivotal role in promoting civic participation and collaboration among community members. Through features such as forums, discussion boards, and interactive maps, these applications facilitate communication and information-sharing among residents. This fosters a sense of belonging and collective responsibility, as citizens can engage in open dialogue, voice their opinions, and collaborate on projects that positively impact their neighborhoods.

In the realm of urban planning, smartphone applications contribute significantly to participatory decision-making processes. City planners and policymakers can leverage these applications to gather valuable insights from residents regarding their preferences and priorities. By incorporating citizen input into the decision-making process, smart cities can ensure that urban development initiatives align with the actual needs and aspirations of the community, promoting a more inclusive and responsive approach to governance (Jonek-Kowalska, Wolniak, 2021, 2022; Gajdzik et al., 2023). Furthermore, smartphone applications enhance the efficiency of public services by providing a streamlined interface for residents to report issues and request services. From reporting potholes and streetlight outages to submitting requests for waste management services, these applications empower citizens to actively contribute to the

maintenance and improvement of their urban environment. This real-time feedback mechanism not only expedites the resolution of issues but also strengthens the bond between the city administration and its residents (Herdiansayah, 2023; Rose et al., 2021).

In the context of sustainability, smartphone applications can be instrumental in promoting eco-friendly practices and fostering a culture of environmental consciousness. Users can access information about recycling programs, green spaces, and sustainable transportation options, encouraging them to make more environmentally responsible choices in their daily lives. This aligns with the broader goals of smart cities to create a sustainable and resilient urban environment.

Smartphone applications have emerged as powerful tools in transforming the landscape of community engagement, fostering a dynamic and interactive relationship between residents and their urban environments. These applications serve as catalysts for bridging the gap between citizens and local authorities, providing a myriad of functionalities that enhance communication, collaboration, and participation in shaping the future of communities. One primary facet of smartphone applications in community engagement revolves around the delivery of real-time information. Residents can seamlessly access up-to-date details on public transportation schedules, traffic conditions, local events, and ongoing community initiatives. This immediacy empowers citizens to stay informed and make well-informed decisions, contributing to the efficient functioning of the city.

Civic participation and collaboration are also significantly augmented through these applications. Interactive features such as forums, discussion boards, and interactive maps create virtual spaces for residents to engage in open dialogues, express their opinions, and collaborate on projects. This virtual exchange cultivates a sense of belonging and collective responsibility, strengthening the social fabric of communities. Participatory decision-making is another critical aspect facilitated by smartphone applications. City planners and policymakers leverage these platforms to involve citizens in crucial decisions related to urban planning. Through feedback mechanisms and surveys, residents can actively contribute insights, ensuring that development initiatives align with the actual needs and aspirations of the community (Rachmawati et al., 2021; Dutta et al., 2021; Ivanyi, Biro-Szigeti, 2019).

Efficient public services are enhanced by smartphone applications, as residents can easily report issues and request services through streamlined interfaces. This seamless communication between citizens and city administrations expedites issue resolution, creating a responsive and citizen-centric approach to public service delivery. Smartphone applications play a pivotal role in promoting sustainability by providing information on recycling programs, green spaces, and sustainable transportation options. These applications contribute to building a culture of environmental consciousness, encouraging residents to make eco-friendly choices in their daily lives.

Beyond functionality, these applications act as virtual hubs for community building. By connecting residents and facilitating social interactions, they contribute to the organization of local events, meet-ups, and community initiatives. This virtual engagement strengthens the bonds among community members, fostering a vibrant and closely-knit social fabric. In times of emergencies, smartphone applications contribute to community safety by offering features such as emergency alerts, real-time incident reporting, and location-based services. This aids in effective emergency response coordination and ensures the well-being of residents (Simonofski et al., 2023; Chmielarz et al., 2021).

Smartphone applications also serve as educational tools, promoting awareness about local issues, civic responsibilities, and opportunities for community involvement. By providing valuable information, these applications contribute to an informed and engaged citizenry, fostering a sense of civic duty and responsibility within the community. In showcasing cultural and recreational opportunities, smartphone applications enrich residents' awareness of local offerings, from museums and parks to cultural events. This contributes to a vibrant and culturally enriched community life, enhancing the overall quality of life for residents (Dutta et al., 2019).

Crucially, smartphone applications prioritize inclusive design to ensure accessibility for diverse populations. Features such as voice commands and intuitive interfaces enable broad community engagement, ensuring that everyone, regardless of ability, can actively participate in the benefits of smart city initiatives (Chmielarz et al., 2021).

Table 1 contains descriptions of how smartphone applications are used in community engagement.

**Table 1.**

*How smartphone applications are used in community engagement*

<b>Aspect of Environmental Monitoring</b>	<b>Use of Smartphone Applications</b>
<b>Real-time Information Access</b>	Smartphone applications serve as dynamic platforms for delivering real-time information to residents. Users can access up-to-date details on public transportation schedules, current traffic conditions, local events, and ongoing community initiatives. This ensures that citizens stay informed and can make timely decisions based on the latest data.
<b>Civic Participation and Collaboration</b>	These applications feature interactive components such as forums, discussion boards, and interactive maps to facilitate communication and collaboration among community members. Residents can actively engage in open dialogues, express their opinions, and collaborate on various projects that contribute to the betterment of their neighborhoods. This promotes a sense of belonging and collective responsibility within the community.
<b>Participatory Decision-Making</b>	City planners and policymakers leverage smartphone applications to engage citizens in the decision-making processes related to urban planning. These applications often include features that allow residents to provide feedback, share insights, and participate in surveys, ensuring that the development initiatives align with the actual needs and aspirations of the community.
<b>Efficient Public Services</b>	Residents can use smartphone applications to report issues, such as potholes or streetlight outages, and request services like waste management. The streamlined interface provided by these applications enhances communication between citizens and city administrations, leading to faster issue resolution and improved public service delivery.

Cont. table 1.

<b>Sustainability Promotion</b>	Smartphone applications play a crucial role in promoting sustainable practices. They provide information about recycling programs, green spaces, and sustainable transportation options. By raising awareness and encouraging eco-friendly choices, these applications contribute to building a culture of environmental consciousness among users, fostering a more sustainable urban environment.
<b>Community Building and Engagement</b>	These applications act as virtual hubs for community building by connecting residents and fostering social interactions. They often include features that facilitate the organization of local events, meet-ups, and community initiatives. By providing a space for residents to connect and engage, these applications contribute to the creation of vibrant and closely-knit communities.
<b>Emergency Response and Safety</b>	Smartphone applications enhance community safety by incorporating features for emergency alerts, real-time incident reporting, and location-based services. In times of crisis, these applications play a critical role in disseminating information, coordinating emergency responses, and ensuring the safety of residents.
<b>Education and Awareness</b>	Residents can access educational content through these applications, promoting awareness about local issues, civic responsibilities, and opportunities for community involvement. By providing valuable information, these applications contribute to an informed and engaged citizenry, fostering a sense of civic duty and responsibility within the community.
<b>Cultural and Recreational Engagement</b>	Smartphone applications showcase cultural and recreational opportunities within the community, such as museums, parks, and cultural events. By highlighting these aspects, the applications contribute to residents' awareness and participation in the local cultural scene, fostering a vibrant and culturally enriched community life.
<b>Inclusive Accessibility</b>	Smartphone applications prioritize inclusive design to ensure accessibility for diverse populations, including people with disabilities. By incorporating features such as voice commands, screen readers, and intuitive interfaces, these applications enable broad community engagement and participation, ensuring that everyone has equal access to the benefits of smart city initiatives.

Source: (Kalasova et al., 2021; Chmielarz et al., 2021; Rose et al., 2021; Dutta et al., 2019; Ivani, Biro-Szigeti, 2019; Leal et al., 2023; Chowdhury et al., 2023; Sanchez et al., 2018; Aguilera, Boutueil, 2018).

The integration of smartphone applications in community engagement has ushered in a transformative era, offering a multitude of advantages that redefine how residents interact with and contribute to the development of their communities. These applications serve as dynamic platforms that leverage technology to enhance communication, collaboration, and participation, thereby fostering a more connected and empowered citizenry. One notable advantage is the immediate access to real-time information. Smartphone applications provide residents with instant updates on public transportation schedules, traffic conditions, local events, and community initiatives. This ensures that individuals stay well-informed, enabling timely decision-making and contributing to a more efficient and responsive urban environment.

Enhanced civic participation is another significant benefit. These applications create interactive spaces, such as forums and discussion boards, where residents can actively engage in open dialogues, express their opinions, and collaborate on community projects. The result is a strengthened sense of belonging and shared responsibility, as citizens become more involved in shaping the future of their neighborhoods. Participatory decision-making is facilitated through smartphone applications, allowing city planners and policymakers to involve citizens in crucial processes related to urban planning. Through feedback mechanisms, surveys, and interactive features, residents can contribute valuable insights, ensuring that development initiatives align with the actual needs and aspirations of the community (Boichuk, 2020).

Efficient public services are achieved as residents can easily report issues and request services through streamlined interfaces. This seamless communication between citizens and city administrations expedites issue resolution, creating a more responsive and citizen-centric approach to public service delivery. Smartphone applications also play a pivotal role in promoting sustainability. By providing information on recycling programs, green spaces, and sustainable transportation options, these applications encourage residents to make eco-friendly choices in their daily lives, contributing to a culture of environmental consciousness within the community (Kalasova et al., 2021).

Community building and engagement are significantly enriched through smartphone applications, acting as virtual hubs that connect residents and facilitate social interactions. Features promoting local events and initiatives contribute to the creation of vibrant and closely-knit communities, fostering a sense of unity among residents. In times of emergencies, these applications contribute to community safety. With features for emergency alerts, real-time incident reporting, and location-based services, they play a crucial role in disseminating information and coordinating effective emergency responses, ensuring the well-being of residents.

Educationally, residents can access valuable content through these applications, promoting awareness about local issues, civic responsibilities, and opportunities for community involvement. This contributes to an informed and engaged citizenry, fostering a sense of civic duty and responsibility within the community. Moreover, smartphone applications showcase cultural and recreational opportunities within the community, enhancing residents' awareness of local offerings such as museums and events. This contributes to a more vibrant and culturally enriched community life, enhancing the overall quality of life for residents.

Crucially, these applications prioritize inclusive design, ensuring accessibility for diverse populations. Features such as voice commands and intuitive interfaces enable broad community engagement, allowing everyone, regardless of ability, to actively participate in the benefits of smart city initiatives.

Table 2 highlighting the advantages of using smartphone applications in community engagement within smart cities. Using smartphone applications in community engagement provides a multifaceted array of advantages, ranging from immediate access to information and enhanced civic participation to inclusive accessibility and the promotion of sustainable practices. These applications play a pivotal role in shaping modern urban living by fostering connectivity, collaboration, and informed decision-making within communities.



**Table 2.***Advantages of using smartphone applications in community engagement*

<b>Advantage</b>	<b>Description</b>
<b>Real-time Information Access</b>	Smartphone applications provide residents with instant access to real-time information, including public transportation schedules, traffic conditions, local events, and community initiatives, ensuring timely decision-making and enhanced urban navigation.
<b>Enhanced Civic Participation</b>	These applications create interactive spaces such as forums and discussion boards, fostering increased civic participation. Residents can engage in open dialogues, express opinions, and collaborate on community projects, promoting a sense of belonging and shared responsibility.
<b>Participatory Decision-Making</b>	Smartphone applications facilitate citizen involvement in decision-making processes related to urban planning. City planners and policymakers can gather insights through feedback mechanisms, surveys, and interactive features, ensuring development aligns with community needs.
<b>Efficient Public Services</b>	Residents can report issues and request services through streamlined interfaces, improving communication between citizens and city administrations. This expedites issue resolution and enhances the overall efficiency of public service delivery.
<b>Promotion of Sustainability</b>	These applications contribute to the promotion of sustainable practices by providing information on recycling programs, green spaces, and sustainable transportation options. Residents are encouraged to make eco-friendly choices, fostering a culture of environmental consciousness.
<b>Community Building and Engagement</b>	Smartphone applications serve as virtual hubs for community building, connecting residents and facilitating social interactions. Through features promoting local events and initiatives, these applications contribute to the creation of vibrant and closely-knit communities.
<b>Emergency Response and Safety</b>	Applications with features for emergency alerts, real-time incident reporting, and location-based services enhance community safety. In times of crisis, these tools play a crucial role in disseminating information and coordinating effective emergency responses.
<b>Education and Awareness</b>	Residents can access educational content, promoting awareness about local issues, civic responsibilities, and opportunities for community involvement. These applications contribute to an informed and engaged citizenry, fostering civic duty within the community.
<b>Cultural and Recreational Engagement</b>	Smartphone applications showcase cultural and recreational opportunities, such as museums and events, enhancing residents' awareness and participation in the local cultural scene. This contributes to a more vibrant and culturally enriched community life.
<b>Inclusive Accessibility</b>	Applications prioritize inclusive design, ensuring accessibility for diverse populations. Features such as voice commands and intuitive interfaces enable broad community engagement, allowing everyone, regardless of ability, to participate in smart city initiatives.

Source: (Kalasova et al., 2021; Chmielarz et al., 2021; Rose et al., 2021; Dutta et al., 2019; Ivani, Biro-Szigeti, 2019; Leal et al., 2023; Chowdhury et al., 2023; Sanchez et al., 2018; Aguilera, Boutueil, 2018).

While smartphone applications have become integral to community engagement strategies in smart cities, their implementation is not without challenges. These problems, if not effectively addressed, can hinder the effectiveness and inclusivity of community initiatives, potentially leaving certain segments of the population marginalized. The prevalence of smartphone applications assumes universal access to smartphones and reliable internet connectivity. However, digital inequality persists, leaving some residents without the necessary tools to participate in community engagement efforts. This divide can disproportionately affect marginalized communities, contributing to disparities in civic participation.

The collection and utilization of personal data through community engagement applications raise significant privacy concerns. Residents may be wary of sharing personal information, fearing potential misuse or unauthorized access. Balancing the need for data-driven insights with robust privacy measures is crucial to foster trust. Not all residents possess the same level of technological literacy, and some individuals, particularly older demographics, may face challenges in navigating and utilizing smartphone applications effectively. Designing interfaces with user-friendly features and providing educational support can help address this issue.

Language diversity and cultural differences can pose barriers to effective communication through smartphone applications. If these applications do not cater to multiple languages and cultural nuances, certain groups may feel excluded, hindering the goal of inclusive community engagement. Language diversity and cultural differences can pose barriers to effective communication through smartphone applications. If these applications do not cater to multiple languages and cultural nuances, certain groups may feel excluded, hindering the goal of inclusive community engagement.

Vulnerable populations, such as those experiencing homelessness or individuals with limited access to technology, may find themselves excluded from community engagement efforts that rely heavily on smartphone applications. Ensuring alternative methods of participation is essential for inclusivity. The accuracy and reliability of data presented through smartphone applications are critical for informed decision-making. Inaccurate or outdated information may lead to misguided community initiatives, emphasizing the need for continuous monitoring and verification of data sources.

An overreliance on smartphone applications may inadvertently exclude residents who prefer traditional communication methods or are not comfortable with extensive technology use. Striking a balance between digital and analog engagement methods is essential to reach diverse segments of the population. Inadequate accessibility features within smartphone applications can create barriers for individuals with disabilities. Ensuring that these applications adhere to accessibility standards is crucial to accommodate users with varying abilities (Benevolo et al., 2016; Kalasova et al., 2021).

Socioeconomic disparities, including disparities in access to smartphones and internet services, can perpetuate inequalities in community engagement. Bridging these gaps requires targeted efforts to provide access and support to underserved communities. Some residents may resist the transition to digital community engagement, preferring traditional methods. Overcoming resistance involves effective communication about the benefits of smartphone applications and addressing concerns regarding the shift towards technology-driven engagement (Boichuk, 2020).

Recognizing and actively mitigating these challenges is essential for creating truly inclusive and effective community engagement strategies within the context of smart cities. Balancing technological innovation with social equity considerations ensures that the benefits of smartphone applications are accessible to all residents (Dutta et al., 2019).

Table 3 highlighting some of the common problems and challenges associated with the usage of smartphone applications in community engagement within smart cities. While smartphone applications offer numerous benefits for community engagement in smart cities, it's crucial to acknowledge and address these challenges to ensure that such initiatives are inclusive, secure, and effectively cater to the diverse needs of the entire community.

**Table 3.**

*Problems of using smartphone applications in community engagement within smart cities*

<b>Problem</b>	<b>Description</b>
<b>Digital Inequality</b>	Not all residents may have access to smartphones or the internet, leading to digital inequality. This can exclude certain demographics from participating in community engagement activities through smartphone applications.
<b>Privacy Concerns</b>	The collection of personal data by smartphone applications raises privacy concerns among users. Residents may be hesitant to engage with these applications due to uncertainties about the handling and security of their information.
<b>Limited Technological Literacy</b>	Some residents, particularly older or less tech-savvy individuals, may face challenges in using smartphone applications effectively. Limited technological literacy can hinder widespread adoption and engagement with these tools.
<b>Language and Cultural Barriers</b>	Language and cultural differences can pose barriers to effective community engagement through smartphone applications. Applications may not cater to diverse linguistic or cultural needs, limiting accessibility for certain segments of the population.
<b>Security Risks and Cyber Threats</b>	Smartphone applications can be vulnerable to security risks and cyber threats, potentially exposing users' personal information. Concerns about data breaches or malicious activities may discourage residents from actively participating in community engagement through these platforms.
<b>Exclusion of Vulnerable Groups</b>	Vulnerable or marginalized groups, such as those experiencing homelessness or individuals with limited access to technology, may be excluded from community engagement initiatives reliant on smartphone applications. Ensuring inclusivity becomes a significant challenge.
<b>Data Accuracy and Reliability</b>	The accuracy and reliability of data presented through smartphone applications can be a concern. Inaccurate information may lead to misinformed decision-making and erode trust in the effectiveness of these applications for community engagement.
<b>Overreliance on Technology</b>	A heavy reliance on smartphone applications for community engagement may exclude residents who prefer traditional methods of communication or lack the inclination to use technology extensively. Striking a balance between digital and non-digital engagement is crucial.
<b>Limited Accessibility Features</b>	Insufficient accessibility features can hinder the use of smartphone applications by individuals with disabilities. Inadequate accommodations for varying abilities may limit the inclusivity of community engagement efforts through these platforms.
<b>Socioeconomic Disparities</b>	Socioeconomic disparities may impact the availability and quality of smartphones and internet access within certain communities. This can exacerbate existing inequalities, hindering equitable participation in community engagement initiatives relying on smartphone applications.
<b>Resistance to Change</b>	Some residents may resist the shift towards digital community engagement, preferring traditional methods. Resistance to change poses a challenge in encouraging widespread adoption of smartphone applications as primary tools for community interaction and participation.

Source: (Kalasova et al., 2021; Chmielarz et al., 2021; Rose et al., 2021; Dutta et al., 2019; Ivani, Biro-Szigeti, 2019; Leal et al., 2023; Chowdhury et al., 2023; Sanchez et al., 2018; Aguilera, Boutueil, 2018).

### 3. Conclusion

The integration of smartphone applications in community engagement within smart cities represents a transformative shift, offering a multitude of advantages that redefine how residents interact with and contribute to the development of their communities. These applications serve as dynamic platforms, leveraging technology to enhance communication, collaboration, and participation, thereby fostering a more connected and empowered citizenry. Immediate access to real-time information, enhanced civic participation, participatory decision-making, efficient public services, sustainability promotion, community building, emergency response and safety, education and awareness, cultural and recreational engagement, and inclusive accessibility are among the key benefits highlighted in this discourse. However, the implementation of smartphone applications in community engagement is not without challenges. Digital inequality, privacy concerns, limited technological literacy, language and cultural barriers, security risks, exclusion of vulnerable groups, data accuracy and reliability, overreliance on technology, limited accessibility features, socioeconomic disparities, and resistance to change are significant hurdles that, if not effectively addressed, can hinder the inclusivity, effectiveness, and equity of community initiatives. It is crucial to recognize and actively mitigate these challenges to ensure that the advantages of smartphone applications are accessible to all residents.

The evolution of community engagement strategies within smart cities must prioritize social equity considerations, balancing technological innovation with the diverse needs of the entire community. Bridging digital divides, addressing privacy issues, providing technological education and support, catering to linguistic and cultural diversity, enhancing security measures, ensuring inclusivity for vulnerable populations, verifying data accuracy, promoting a balanced approach to technology use, prioritizing accessibility features, addressing socioeconomic disparities, and effectively communicating the benefits of digital engagement are key steps toward creating truly inclusive and effective community engagement strategies within the context of smart cities. Through thoughtful consideration and proactive measures, smart cities can harness the full potential of smartphone applications to create vibrant, connected, and resilient urban communities.

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## THE USAGE OF 5 WHY IN INDUSTRY 4.0 CONDITIONS

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**Purpose:** The purpose of this publication is to present the usage of 5 Why approach in Industry 4.0 conditions.

**Design/methodology/approach:** Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.

**Findings:** The integration of the 5 Whys method with Industry 4.0 presents a strategic and synergistic solution to the escalating challenges faced by industries in the era of smart manufacturing. With rapid technological advancements such as automation, artificial intelligence, and the Internet of Things reshaping the industrial landscape, there is a growing need for effective methodologies for root cause analysis and resolution. The 5 Whys method seamlessly aligns with the core principles of Industry 4.0, emphasizing interconnected systems and data-driven decision-making. By iteratively asking the question "Why?" organizations can delve beyond surface-level symptoms, uncovering fundamental root causes of disruptions in smart manufacturing processes. This publication underscores the method's simplicity, power, and collaborative nature, offering a systematic and insightful approach to problem-solving within the complexities of Industry 4.0. Through its application, organizations can navigate challenges, ensuring adaptability and resilience in the face of technological evolution, and fostering a culture of continuous improvement and collaborative problem-solving in the dynamic landscape of smart manufacturing.

**Originality/Value:** Detailed analysis of all subjects related to the problems connected with the usage of 5 why in Industry 4.0 conditions.

**Keywords:** Industry 4.0; Quality 4.0; quality management; quality methods; 5 Why.

**Category of the paper:** literature review.

### 1. Introduction

In the context of Industry 4.0, the 5 Whys method serves as a strategic tool for identifying and addressing challenges within the rapidly evolving landscape of smart manufacturing. As industries embrace advanced technologies like automation, artificial intelligence,

and the Internet of Things (IoT), the complexity of operational issues has increased, making it imperative to have effective problem-solving methodologies in place.

The 5 Whys method aligns seamlessly with the principles of Industry 4.0, where interconnected systems and data-driven decision-making play a central role. When confronted with disruptions, inefficiencies, or malfunctions in smart manufacturing processes, employing the 5 Whys method allows organizations to move beyond superficial symptoms and dissect the root causes (Jokovic et al., 2023).

The purpose of this publication is to present the usage of 5 Why approach in Industry 4.0 condition.

## 2. The basics of 5 Why approach

The 5 Whys method is a problem-solving technique that aims to identify the root cause of an issue by repeatedly asking the question "Why?" This method, originally developed by Sakichi Toyoda and used within the Toyota Motor Corporation, is a simple yet powerful tool for uncovering the deeper reasons behind problems. Instead of addressing only the symptoms of a problem, the 5 Whys method encourages individuals or teams to delve into the underlying causes. By asking "Why?" five times in succession, one can peel away the layers of a problem to reveal its core. The process is iterative, with each "Why?" leading to a more profound understanding of the issue (Barsalou, 2023; Maganga, Taifa, 2023).

This method is effective because it promotes critical thinking and helps prevent the tendency to jump to conclusions or implement quick fixes. It fosters a systematic and methodical approach to problem-solving. As each "Why?" is posed, it encourages participants to explore different facets of the problem and consider various perspectives. Moreover, the 5 Whys method is not limited to manufacturing or specific industries; it can be applied in various contexts, from business and healthcare to personal development. It encourages open communication and collaboration among team members, as they work together to uncover the root causes of a problem.

While the 5 Whys method is a valuable tool, it's essential to use it judiciously. Some problems may require more or fewer than five iterations to reach the root cause. Additionally, it's crucial to remain open-minded and receptive to unexpected answers that may emerge during the process. The 5 Whys method is a structured and iterative approach to problem-solving, encouraging a deeper exploration of the root causes of issues. By repeatedly asking "Why?" and peeling away layers of a problem, individuals and teams can gain valuable insights and develop effective (Gajdzik et al., 2023).



By repeatedly asking "Why?" in the Industry 4.0 context, organizations can navigate the intricate web of interconnected technologies and systems to unearth the underlying issues affecting performance. This method encourages a holistic approach, prompting stakeholders to consider not only the immediate problems but also the broader implications within the digital ecosystem (Alrabadi et al., 2023).

In a smart manufacturing environment, where real-time data and analytics are pivotal, the 5 Whys method aids in the interpretation of complex data sets. It facilitates a structured inquiry into anomalies or deviations from expected outcomes, ensuring that decision-makers delve into the intricacies of Industry 4.0 challenges rather than resorting to surface-level solutions.

Moreover, the collaborative nature of the 5 Whys method aligns with the interdisciplinary requirements of Industry 4.0 initiatives. Cross-functional teams can leverage their diverse expertise to collaboratively investigate issues, fostering a culture of continuous improvement and innovation in the dynamic Industry 4.0 landscape (Singh et al., 2023).

The 5 Whys method emerges as a valuable asset in Industry 4.0 conditions, providing a systematic and insightful approach to problem-solving amid the complexities of smart manufacturing. By embracing this methodology, organizations can navigate the challenges posed by advanced technologies, ensuring resilience and adaptability in the era of Industry 4.0.

Table 1 contains description of 5 Why key principles. This table provides a concise overview of the key principles that guide the implementation and effectiveness of the Balanced Scorecard methodology.

**Table 1.**  
*Key principles of 5 Why*

Key principle	Description
<b>Root Cause Analysis</b>	The primary objective of the 5 Whys is to go beyond surface-level symptoms and identify the fundamental, underlying causes of a problem. This principle ensures a focus on addressing the core issues.
<b>Iterative Inquiry</b>	The 5 Whys method is iterative in nature, involving the sequential asking of "Why?" to explore multiple layers of causation. This iterative process helps uncover deeper insights into the problem at hand.
<b>Systematic Approach</b>	The method encourages a structured and systematic approach to problem-solving. By asking a series of "Why?" questions, individuals or teams can methodically analyze and understand the interconnected causes.
<b>Preventing Recurrence</b>	Beyond solving the immediate problem, the 5 Whys seeks to develop effective and sustainable solutions by addressing root causes. This principle aims to prevent the recurrence of similar issues in the future.
<b>Collaborative Engagement</b>	The 5 Whys method promotes collaboration among team members or stakeholders. By involving diverse perspectives, it leverages collective knowledge to gain a comprehensive understanding of the problem.
<b>Open-Minded Inquiry</b>	Practitioners of the 5 Whys approach problems with an open mind, avoiding premature assumptions. This principle encourages a non-biased exploration of causes, allowing for unexpected insights to emerge.
<b>Adaptability to Context</b>	The method is versatile and adaptable to various contexts, industries, and scenarios. Its application can be tailored to suit the specific needs and complexities of different problem-solving situations.

Cont. table 1.

<b>Continuous Improvement</b>	Embedded in the philosophy of the 5 Whys is the concept of continuous improvement. By consistently probing deeper into problems, organizations foster a culture of ongoing learning and refinement.
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Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

### 3. How 5 Why method can be integrated with Industry 4.0 and Quality 4.0 concept

The integration of the 5 Whys method with Industry 4.0 and the Quality 4.0 concept represents a synergistic approach to problem-solving and quality management in the modern industrial landscape. Industry 4.0, characterized by the convergence of digital technologies, automation, and data exchange, has ushered in a new era of smart manufacturing. Quality 4.0, an extension of Industry 4.0, emphasizes the integration of digital technologies to enhance quality management processes (Bousdekis et al., 2023).

The 5 Whys method seamlessly aligns with the principles of Industry 4.0 by providing a structured and iterative approach to root cause analysis. In the digitalized environment of Industry 4.0, where interconnected systems generate vast amounts of data, the 5 Whys method serves as a valuable tool to navigate through this complexity. It enables organizations to move beyond surface-level issues and explore the deeper layers of causation, facilitating a more comprehensive understanding of problems within the context of advanced technologies.

Quality 4.0, with its focus on leveraging digital tools and data analytics for quality improvement, finds a natural ally in the 5 Whys method. The iterative nature of 5 Whys aligns with the continuous improvement ethos of Quality 4.0. By repeatedly asking "Why?" and delving into root causes, organizations can not only address immediate quality issues but also establish a framework for ongoing enhancement and optimization (Maganga, Taifa, 2023).

The collaborative engagement encouraged by the 5 Whys method resonates with the interdisciplinary nature of Industry 4.0 initiatives. Cross-functional teams, comprising experts from various domains, can leverage their collective knowledge to investigate and solve complex problems. This collaborative approach is particularly valuable in the interconnected and multifaceted landscape of Industry 4.0 and Quality 4.0 (Jonek-Kowalska, Wolniak, 2021, 2022).

Furthermore, the adaptability of the 5 Whys method makes it well-suited for the dynamic and evolving nature of Industry 4.0 and Quality 4.0 environments. Organizations can tailor the application of the method to suit the specific challenges and intricacies of their digitalized operations, ensuring a customized and effective problem-solving strategy.

The integration of the 5 Whys method with Industry 4.0 and Quality 4.0 signifies a strategic alignment of traditional problem-solving approaches with the demands of modern, technology-driven manufacturing. This integration fosters a culture of continuous improvement, collaborative problem-solving, and optimized quality management within the evolving industrial landscape (Antony et al., 2023; Escobar et al., 2023; Antony et al., 2023; Salimbeni, Redchuk, 2023).

Table 2 is listing examples of integration of 5 Why method with Industry 4.0.

**Table 2.**  
*5 Why integration with industry 4.0*

Aspect	Description
<b>Root Cause Analysis in Digital Ecosystems</b>	The 5 Whys method, when integrated with Industry 4.0, enhances root cause analysis in the digital landscape. It enables organizations to dissect complex issues within interconnected systems, moving beyond surface-level symptoms to identify the fundamental causes impacting digitalized processes.
<b>Iterative Problem-Solving in a Data-Driven Environment</b>	In the data-driven context of Industry 4.0, the iterative nature of the 5 Whys method becomes especially valuable. The sequential questioning of "Why?" facilitates a step-by-step exploration of issues, allowing organizations to navigate through vast datasets and uncover deeper insights into the root causes of problems.
<b>Structured Approach to Addressing Technological Challenges</b>	The 5 Whys method promotes a systematic and structured approach to problem-solving, aligning well with the technological complexities of Industry 4.0. By asking a series of "Why?" questions, organizations can methodically analyze issues related to automation, IoT, and advanced technologies, ensuring a comprehensive understanding of challenges.
<b>Adaptability to Industry 4.0 Dynamics</b>	One of the strengths of the 5 Whys method is its adaptability. When integrated with Industry 4.0, it can be flexibly applied to suit the dynamic and evolving nature of digitalized operations. This adaptability ensures that the method remains effective in addressing the specific challenges posed by advancements in smart manufacturing.
<b>Collaborative Exploration in Cross-Functional Teams</b>	In the interdisciplinary landscape of Industry 4.0, the 5 Whys method encourages collaborative problem-solving. Cross-functional teams, comprising experts from different domains, can collectively engage in the analysis of complex issues. This collaborative approach leverages diverse perspectives to gain a holistic understanding of challenges.
<b>Continuous Improvement within Digital Transformation</b>	Integrated with Industry 4.0 principles, the 5 Whys method aligns with the ethos of continuous improvement. By probing deeper into issues, organizations not only address immediate challenges but also establish a framework for ongoing optimization and enhancement within the context of digital transformation.
<b>Real-Time Analysis</b>	In the real-time data environment of Industry 4.0, the 5 Whys method can be applied promptly to analyze issues as they occur. This real-time analysis ensures timely identification of root causes and facilitates quick corrective actions in the fast-paced digital landscape.
<b>Data-Driven Decision Making</b>	Leveraging the abundance of data in Industry 4.0, the 5 Whys method supports data-driven decision-making. The analysis of data at each "Why?" stage allows organizations to make informed decisions based on concrete insights, enhancing the overall decision-making process.
<b>Integration with Digital Twins</b>	The 5 Whys method can be seamlessly integrated with digital twin technology, enabling a virtual representation of the manufacturing process. This integration enhances the visualization of problems and their root causes, facilitating a more comprehensive analysis and solution development.
<b>Predictive Maintenance Optimization</b>	By using the 5 Whys method in conjunction with predictive maintenance analytics, organizations can identify and address root causes leading to equipment failures. This proactive approach optimizes maintenance strategies, minimizing downtime and enhancing the efficiency of Industry 4.0 operations.

Cont. table 2.

<b>Cybersecurity Incident Analysis</b>	In the era of Industry 4.0, where cybersecurity is paramount, the 5 Whys method can be applied to analyze incidents. Understanding the root causes of security breaches enables organizations to strengthen their cybersecurity measures and develop robust strategies for protecting digital assets.
<b>Machine Learning Integration</b>	The 5 Whys method can be enhanced by integrating machine learning algorithms to analyze historical data. This integration allows for a more sophisticated analysis of patterns and trends, aiding in the identification of root causes and contributing to the continuous improvement goals of Industry 4.0.
<b>Supply Chain Resilience</b>	Integrating the 5 Whys with Industry 4.0 principles extends to supply chain resilience. By applying the method to supply chain disruptions, organizations can uncover root causes, implement proactive solutions, and enhance the resilience of their supply networks in the face of digital disruptions.
<b>Augmented Reality for Problem Visualization</b>	Utilizing augmented reality, the 5 Whys method can provide enhanced problem visualization. This integration allows teams to visually explore the manufacturing environment, overlaying digital data onto the physical space and facilitating a more immersive and insightful analysis of root causes.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khoureshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

Table 3 is describe the advantages 5 Why approach usage in industry 4.0. This table underscores the multifaceted advantages of integrating the 5 Whys method with the technological advancements and complexities of Industry 4.0.

**Table 3.**

*The advantages of 5 Why integration with industry 4.0*

<b>Advantage</b>	<b>Description</b>
<b>Enhanced Root Cause Analysis</b>	Integration with Industry 4.0 amplifies the effectiveness of the 5 Whys method in dissecting complex issues within interconnected systems. This enhancement allows organizations to identify and address root causes with greater precision, leading to more robust solutions in the digitalized manufacturing environment.
<b>Timely Problem Resolution</b>	In the real-time data environment of Industry 4.0, the 5 Whys method enables organizations to promptly analyze issues as they occur. This timely problem resolution ensures that corrective actions can be implemented swiftly, minimizing downtime and optimizing operational efficiency in the fast-paced digital landscape.
<b>Data-Driven Decision Making</b>	Leveraging the abundance of data in Industry 4.0, the 5 Whys method supports data-driven decision-making. The systematic analysis of data at each "Why?" stage provides concrete insights, empowering organizations to make informed decisions that align with the overarching goals of digital transformation.
<b>Optimized Predictive Maintenance</b>	Integration with predictive maintenance analytics allows organizations to identify root causes leading to equipment failures. This proactive approach to maintenance optimization, guided by the 5 Whys method, minimizes downtime, extends equipment lifespan, and enhances the overall efficiency of Industry 4.0 operations.
<b>Improved Cybersecurity Measures</b>	In the context of heightened cybersecurity concerns in Industry 4.0, the 5 Whys method aids in analyzing incidents. Understanding the root causes of security breaches enables organizations to strengthen their cybersecurity measures, fostering a secure digital environment and safeguarding critical assets and data.
<b>Machine Learning-Driven Insights</b>	Integration with machine learning algorithms enhances the analytical capabilities of the 5 Whys method. By leveraging historical data and advanced analytics, organizations can gain deeper insights into patterns and trends, facilitating a more sophisticated analysis of root causes and contributing to continuous improvement goals.

Cont. table 3.

<b>Enhanced Supply Chain Resilience</b>	Applying the 5 Whys method to supply chain disruptions improves resilience. Organizations can uncover root causes, implement proactive solutions, and enhance the overall resilience of their supply networks. This integration supports adaptive strategies in navigating uncertainties and disruptions within the Industry 4.0 supply chain.
<b>Augmented Reality for Visual Analysis</b>	Utilizing augmented reality, the 5 Whys method provides enhanced problem visualization. This integration allows teams to visually explore the manufacturing environment, overlaying digital data onto the physical space. It facilitates a more immersive and insightful analysis of root causes, fostering quicker and more informed decision-making.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

Table 4 is describe the problems of 5 Why approach usage in Industry 4.0 and methods to overcome them. This table highlights potential problems associated with integrating the Balanced Scorecard with Industry 4.0 and suggests methods to overcome these challenges, focusing on data management, integration complexity, cybersecurity, workforce readiness, financial considerations, and standardization efforts.

**Table 4.**

*The problems of 5 Why integration with Industry 4.0*

<b>Problems</b>	<b>Description of Problem</b>	<b>Overcoming Strategies</b>
<b>Data Overload and Complexity</b>	In the data-rich environment of Industry 4.0, there may be an overwhelming amount of information to analyze. The complexity of interconnected systems can make it challenging to identify relevant data points, potentially leading to information overload and difficulties in determining the true root causes of problems.	<b>Data Prioritization:</b> Implement strategies for prioritizing relevant data based on its significance to the problem at hand. Focus on extracting key insights that directly contribute to understanding and resolving the issue.
<b>Interconnected System Dependencies</b>	Industry 4.0 relies on highly interconnected systems, and problems in one area can have ripple effects across the entire network. Understanding the dependencies between various components and accurately isolating the primary cause can be complicated, especially when issues manifest as a result of interactions between different technological elements.	<b>System Mapping:</b> Develop comprehensive system maps to visualize interdependencies. Clearly define and document the relationships between different components, aiding in the identification of potential points of failure. Collaborate with domain experts to gain insights into complex system interactions.
<b>Lack of Expertise in Advanced Technologies</b>	The integration of the 5 Whys with Industry 4.0 requires a certain level of expertise in advanced technologies such as IoT, AI, and machine learning. Organizations may face challenges if their teams lack the necessary skills to interpret and analyze data generated by these technologies, hindering the effectiveness of the 5 Whys method in addressing root causes.	<b>Training Programs:</b> Invest in training programs to enhance the technological literacy of team members. Provide education on key Industry 4.0 technologies and their applications. Foster a culture of continuous learning to keep teams updated on advancements. Collaborate with external experts or consultants to supplement internal knowledge.

Cont. table 4.

<b>Integration with Cybersecurity Measures</b>	While the 5 Whys method can be applied to cybersecurity incidents in Industry 4.0, there may be challenges in integrating this approach seamlessly with cybersecurity measures. The complex nature of cyber threats and the rapid evolution of attack vectors can pose difficulties in identifying and addressing the root causes of security breaches effectively.	<b>Cybersecurity Training:</b> Ensure that the team responsible for applying the 5 Whys to cybersecurity incidents is well-versed in cyber threats and countermeasures. Establish a cybersecurity training program to keep the team updated on emerging threats. Collaborate with cybersecurity experts to enhance the integration of the 5 Whys with cybersecurity measures.
<b>Limited Application of Traditional Methods</b>	Industry 4.0 introduces novel challenges that may not be effectively addressed by traditional problem-solving methods. The 5 Whys, while powerful, may have limitations in dealing with emerging issues unique to the digitalized manufacturing environment. Organizations may struggle to adapt traditional problem-solving approaches to the intricacies of Industry 4.0 challenges.	<b>Hybrid Problem-Solving:</b> Combine the strengths of traditional problem-solving methods with Industry 4.0-specific approaches. Encourage teams to use a hybrid problem-solving strategy that incorporates proven methodologies alongside Industry 4.0 principles. Foster a culture of flexibility, where teams can adapt problem-solving approaches based on the nature of the challenge at hand.
<b>Resistance to Change and Innovation</b>	Integration with Industry 4.0 may face resistance from individuals or teams unfamiliar with or resistant to change. Embracing advanced technologies and novel problem-solving approaches requires a cultural shift, and reluctance to adopt innovative methods can impede the successful integration of the 5 Whys with Industry 4.0 initiatives.	<b>Change Management:</b> Implement change management strategies to address resistance and foster a culture of innovation. Clearly communicate the benefits of Industry 4.0 integration and the value it brings to problem-solving. Involve employees in the decision-making process and encourage feedback to create a sense of ownership and collaboration.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

## 4. Conclusion

In conclusion, the integration of the 5 Whys method with Industry 4.0 represents a strategic and synergistic approach to problem-solving in the dynamic landscape of smart manufacturing. As industries undergo rapid transformations driven by advanced technologies like automation, artificial intelligence, and the Internet of Things, the complexity of operational challenges has surged, necessitating effective methodologies for root cause analysis and resolution. The 5 Whys method seamlessly aligns with the principles of Industry 4.0, where interconnected systems and data-driven decision-making are central. By posing the question "Why?" iteratively, organizations can move beyond surface-level symptoms and uncover the fundamental root causes of disruptions, inefficiencies, or malfunctions in smart manufacturing processes.

This publication has aimed to shed light on the application of the 5 Whys approach in Industry 4.0 conditions. The basics of the 5 Whys method were explored, emphasizing its simplicity and power in uncovering deeper reasons behind problems. It encourages critical thinking, systematic problem-solving, and collaboration among team members across various industries. The subsequent sections delved into the integration of the 5 Whys method with Industry 4.0 and the Quality 4.0 concept. In the context of smart manufacturing, real-time data and analytics are pivotal, and the 5 Whys method aids in the interpretation of complex data sets. The collaborative nature of the method aligns well with the interdisciplinary requirements of Industry 4.0 initiatives, fostering continuous improvement and innovation.

Key principles of the 5 Whys method were presented in Table 1, providing a concise overview of its guiding principles. These principles emphasize the method's focus on root cause analysis, iterative inquiry, systematic problem-solving, preventing recurrence, collaborative engagement, open-minded inquiry, adaptability to context, and a commitment to continuous improvement. Table 2 highlighted examples of the integration of the 5 Whys method with Industry 4.0, showcasing its application in root cause analysis, iterative problem-solving, structured approach to technological challenges, adaptability to Industry 4.0 dynamics, collaborative exploration in cross-functional teams, continuous improvement within digital transformation, real-time analysis, data-driven decision-making, integration with digital twins, predictive maintenance optimization, cybersecurity incident analysis, machine learning integration, and supply chain resilience.

Table 3 outlined the advantages of integrating the 5 Whys method with Industry 4.0, underscoring its role in enhancing root cause analysis, enabling timely problem resolution, supporting data-driven decision-making, optimizing predictive maintenance, improving cybersecurity measures, providing machine learning-driven insights, enhancing supply chain resilience, and facilitating augmented reality for visual analysis. In Table 4, potential problems associated with the integration of the 5 Whys method with Industry 4.0 were presented, accompanied by suggested overcoming strategies. These problems include data overload and complexity, interconnected system dependencies, a lack of expertise in advanced technologies, integration with cybersecurity measures, limited application of traditional methods, and resistance to change and innovation.

The 5 Whys method emerges as a valuable asset in Industry 4.0 conditions, offering a systematic and insightful approach to problem-solving amid the complexities of smart manufacturing. By embracing this methodology, organizations can navigate the challenges posed by advanced technologies, ensuring resilience and adaptability in the era of Industry 4.0. The integration of the 5 Whys method with Industry 4.0 signifies a strategic alignment of traditional problem-solving approaches with the demands of modern, technology-driven manufacturing, fostering a culture of continuous improvement and collaborative problem-solving.

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## THE USAGE OF SMART LIGHTING IN SMART HOME

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**Purpose:** The purpose of this publication is to present the usage of smart lighting in smart home.

**Design/methodology/approach:** Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.

**Findings:** The integration of smart lighting systems in smart homes signifies a paradigm shift, revolutionizing how individuals engage with and manage the lighting environment in their living spaces. Beyond traditional lighting solutions, smart lighting offers a plethora of advantages, enhancing comfort, energy efficiency, and overall convenience. Remote control capabilities through dedicated mobile applications empower users to make dynamic adjustments based on preferences and daily routines. The adaptability and versatility of smart lighting enable personalized environments tailored to specific activities or moods, further contributing to a transformative user experience. Noteworthy contributions to energy efficiency, automation facilitated by motion sensors, and seamless integration with other smart home devices underscore the system's impact on home automation and security. Despite challenges such as interoperability issues and privacy concerns, the advantages of smart lighting position it as a cornerstone in the broader smart home ecosystem, offering hands-free operation, security integration, and the potential for future innovations. The ongoing evolution of smart homes and advancements in smart lighting technology promise an intelligent, adaptable, and user-centric future, shaping the way individuals perceive and interact with illumination in a more sophisticated, sustainable, and connected living experience.

**Originality/Value:** Detailed analysis of all subjects related to the problems connected with the usage of smart lighting in smart home.

**Keywords:** Smart City, energy efficiency, smart home, smart house, digitalization, smart lighting.

**Category of the paper:** literature review.

## 1. Introduction

The integration of smart lighting systems within smart homes represents a paradigm shift in how individuals interact with and control the lighting environment of their living spaces. Smart lighting goes beyond the conventional on/off switch, offering a myriad of features and functionalities that contribute to enhanced comfort, energy efficiency, and overall convenience.

In the context of smart homes, the usage of smart lighting is integral to creating a technologically advanced and interconnected living space. One of the primary advantages is the ability to control lighting remotely. Through dedicated mobile applications, users can manage and customize their lighting settings from anywhere with the touch of a button on their smartphones or tablets. This remote control capability not only adds a layer of convenience but also allows for the dynamic adjustment of lighting scenarios based on user preferences and daily routines (Alsaedi et al., 2023).

The purpose of this publication is to present the usage of smart lighting in smart home.

## 2. Smart lighting in smart home

Smart lighting is a revolutionary technological advancement that has significantly transformed the way we illuminate our homes and commercial spaces. Unlike traditional lighting systems, smart lighting integrates cutting-edge technology to provide users with unprecedented control, efficiency, and customization. At its core, smart lighting involves the use of connected devices, such as smart bulbs, LED strips, and fixtures, that can be controlled remotely through various means. This control can be achieved through dedicated mobile applications, voice commands via virtual assistants like Amazon Alexa or Google Assistant, or even automation based on sensors and preset schedules (Chaudhari et al., 2023).

One of the key features of smart lighting is its adaptability and versatility. Users have the ability to adjust the brightness and color of the lights to create different moods and atmospheres. Whether it's a warm, cozy ambiance for a relaxing evening or a bright, energetic setting for productivity, smart lighting allows for seamless customization to suit individual preferences. Moreover, smart lighting contributes significantly to energy efficiency and sustainability. With the integration of LED technology, smart bulbs consume less energy compared to traditional incandescent or fluorescent bulbs. The ability to schedule lighting based on occupancy or time of day further reduces unnecessary energy consumption, resulting in lower electricity bills and a smaller environmental footprint (Huda et al., 2024).

Automation is another key aspect of smart lighting that enhances convenience and efficiency. Motion sensors can detect when a room is occupied and automatically turn on or off the lights accordingly. Additionally, users can create personalized automation scenarios, such as gradually dimming the lights as bedtime approaches or simulating sunrise in the morning to wake up more naturally (Wu et al., 2023). Furthermore, smart lighting systems often integrate with other smart home devices, creating a cohesive and interconnected ecosystem. For example, lights can be synchronized with smart thermostats, security cameras, or doorbell cameras to enhance overall home automation. This integration not only streamlines daily routines but also contributes to an enhanced sense of security (Raff et al., 2024).

In commercial spaces, smart lighting plays a pivotal role in creating dynamic and adaptive environments. Offices can optimize lighting conditions based on the time of day or specific tasks, promoting employee well-being and productivity. Retail establishments can utilize smart lighting to enhance the shopping experience, guiding customers through different sections with tailored lighting schemes (Sobhani et al., 2023). As technology continues to advance, the capabilities of smart lighting are likely to expand even further. Innovations such as Li-Fi (Light Fidelity), which uses light to transmit data, may become integral components of future smart lighting systems, offering faster and more secure connectivity.

Smart lighting represents a paradigm shift in how we perceive and interact with illumination. Its combination of customization, energy efficiency, automation, and integration with other smart devices positions it as a cornerstone in the broader ecosystem of smart homes and buildings, contributing to a more intelligent and sustainable future (Ramanujam et al., 2024).

Customization is a key aspect of smart lighting usage in smart homes. Residents can tailor the brightness and color temperature of lights to suit different activities, moods, or time of day. Whether it's creating a warm and cozy ambiance for a relaxed evening or a bright, invigorating atmosphere for focused work, the adaptability of smart lighting ensures that the lighting environment aligns with the occupants' specific needs and preferences (Douha et al., 2023). Energy efficiency is a crucial consideration in the design and implementation of smart lighting systems. The integration of energy-efficient LED technology not only reduces power consumption but also contributes to long-term cost savings (Patheja et al., 2023). Smart lighting goes a step further by allowing users to schedule lighting based on occupancy or time of day, minimizing unnecessary energy usage and promoting a more sustainable approach to home lighting (Afroz et al., 2024).

The interconnected nature of smart homes is further emphasized through the seamless integration of smart lighting with other smart devices. Whether it's syncing with smart thermostats to create a holistic approach to energy management or integrating with security systems for enhanced safety, smart lighting becomes an integral part of a broader ecosystem that operates in harmony to enhance overall home automation (Ameur et al., 2023). Voice control adds an additional layer of sophistication to smart lighting usage. With compatibility

with popular virtual assistants such as Amazon Alexa or Google Assistant, users can simply issue voice commands to control their lights (Valencia-Arias et al., 2023). This hands-free functionality not only enhances convenience but also aligns with the trend towards more intuitive and natural interactions with smart home technology. Moreover, the incorporation of motion sensors ensures that smart lighting systems respond to the immediate needs of occupants. Lights can automatically turn on or off based on detected motion, adding an element of energy efficiency and hands-free operation (Dhaou, 2023). This feature is particularly useful in areas where constant manual control may not be practical, such as hallways or closets (Hussain et al., 2023).

The usage of smart lighting in smart homes transcends traditional lighting paradigms. It embodies a fusion of technological innovation, customization, energy efficiency, and seamless integration with the broader smart home ecosystem. As smart homes continue to evolve, smart lighting remains a cornerstone, enriching the living experience by providing intelligent, adaptable, and user-centric lighting solutions (Rhode et al., 2023).

Table 1 contains descriptions of key features of smart lighting usage.

**Table 1.**  
*Key features of smart lighting usage*

<b>Key Features of Smart Lighting</b>	<b>Description</b>
<b>Remote Control</b>	Users can effortlessly manage and control their lighting system remotely through dedicated mobile applications, providing the flexibility to adjust settings from anywhere with the convenience of a smartphone or tablet.
<b>Customization</b>	Smart lighting allows for precise customization, enabling users to tailor brightness levels and color temperatures to create specific atmospheres. This feature is ideal for setting the mood, enhancing aesthetics, and adapting lighting to different activities.
<b>Energy Efficiency</b>	The integration of energy-efficient LED technology minimizes power consumption, resulting in cost savings on electricity bills and contributing to a more environmentally sustainable approach to lighting.
<b>Automation</b>	Smart lighting systems can be programmed to automate lighting based on various parameters such as time schedules, occupancy sensors, or specific scenarios. This automation enhances energy efficiency and simplifies daily routines for users.
<b>Integration with Smart Home Ecosystem</b>	Seamless integration with other smart home devices, such as thermostats, security cameras, and voice assistants, creates a cohesive ecosystem. This interconnected setup allows for centralized control and enhances the overall efficiency of smart home automation.
<b>Voice Control</b>	Compatibility with popular virtual assistants like Amazon Alexa or Google Assistant enables users to control their lights using simple voice commands. This hands-free functionality adds an extra layer of convenience to smart lighting systems.
<b>Motion Sensors</b>	Motion sensors integrated into smart lighting systems detect occupancy and trigger automatic lighting adjustments. This feature enhances both convenience and energy efficiency by ensuring lights are only active when needed.
<b>Color Adjustment</b>	Beyond traditional white light, smart lighting systems offer color adjustment options, allowing users to change the color of their lights. This feature is not only visually appealing but also adds a dynamic and personalized touch to the lighting environment.

Cont. table 1.

<b>Security Integration</b>	Smart lighting can be synchronized with security cameras and other smart security devices. This integration enhances the overall security of a home by coordinating lighting with surveillance, deterring potential intruders and increasing overall awareness.
<b>Health and Well-being Features</b>	Tunable lighting options support circadian rhythms, positively impacting health and well-being. These features allow users to adjust lighting to mimic natural sunlight, promoting better sleep patterns and overall physical and mental well-being.
<b>Commercial Applications</b>	In commercial settings, smart lighting solutions offer adaptive lighting configurations for offices and retail spaces. These configurations are designed to optimize productivity, create inviting atmospheres, and enhance the overall customer experience.
<b>Firmware Updates and Future Innovations</b>	Regular firmware updates ensure ongoing compatibility and may introduce new features. Additionally, the potential for future innovations, such as Li-Fi technology, can expand the capabilities of smart lighting systems.

Source: (Gøthesen et al., 2023; Alsaedi et al., 2023; Chaudhari et al., 2023; Huda et al., 2024; Husain et al., 2023; Rhode et al., 2023; Basarir-Ozel et al., 2023; Tong et al., 2023; Chen et al., 2023; Douha et al., 2023; Sobhani et al., 2023).

### 3. The advantages and problems of using smart lightings

The adoption of smart lighting in smart homes brings forth a plethora of advantages that transcend the limitations of traditional lighting systems. This technologically advanced approach to illumination not only enhances convenience but also contributes to energy efficiency, security, and overall well-being. One of the primary advantages of incorporating smart lighting into a smart home ecosystem is the unparalleled level of control it offers. With the convenience of remote control through dedicated mobile applications, users can effortlessly customize and manage their lighting settings from anywhere. This flexibility allows for dynamic adjustments, accommodating different activities, moods, or preferences with a simple tap on a smartphone (Bsarir-Ozel et al., 2023).

Customization stands out as another key advantage, as smart lighting systems provide users with the ability to tailor the brightness, color, and ambiance of their lights. This level of personalization empowers occupants to create bespoke lighting environments that complement specific activities, enhancing the overall living experience and fostering a sense of comfort and individuality within the home. Energy efficiency takes center stage in the advantages of smart lighting. The integration of energy-efficient LED technology, coupled with features like scheduling and automation, enables optimal energy consumption. Smart lighting systems can adapt to occupancy patterns and time-based schedules, ensuring that lights are only active when necessary. This not only reduces electricity bills but also aligns with sustainable practices, contributing to a greener and more environmentally conscious home (Hussain et al., 2023).

The seamless integration of smart lighting with the broader smart home ecosystem amplifies its advantages. Centralized control and coordination with other smart devices create a cohesive and intelligent environment. This interconnectedness allows for sophisticated automation scenarios, where lighting can seamlessly interact with other smart systems such as thermostats, security cameras, and voice assistants, enhancing the overall efficiency and functionality of the smart home. Voice control represents a leap forward in user interaction. With compatibility with virtual assistants like Amazon Alexa or Google Assistant, smart lighting becomes effortlessly accessible. Users can issue voice commands to adjust lighting settings, adding a layer of convenience and hands-free control to their smart home experience (Olabode et al., 2023).

Security integration is another significant advantage of smart lighting. By synchronizing with security systems, smart lighting can play a pivotal role in enhancing home security. Integrated lighting scenarios, triggered by sensors or surveillance devices, act as a deterrent and provide additional visibility, contributing to a comprehensive and effective security strategy (Gajdzik et al., 2023; Jonek-Kowalska, Wolniak, 2021, 2022). The health and well-being features of smart lighting contribute to the occupants' overall quality of life. Tunable lighting options that support circadian rhythms can positively impact sleep patterns and create a healthier living environment. By mimicking natural sunlight, smart lighting systems address not only functional lighting needs but also promote physical and mental well-being within the smart home (Tong et al., 2023).

In terms of aesthetics, smart lighting adds a creative and dynamic dimension to home design. The ability to change colors and create visually appealing lighting schemes allows users to transform the ambiance of their living spaces, adapting to different occasions or personal preferences. This flexibility in aesthetics enhances the overall beauty and character of the home. Lastly, the adaptability of smart lighting to future innovations ensures that homeowners can stay at the forefront of technological advancements. Regular firmware updates and the potential integration of emerging technologies, such as Li-Fi, keep the smart lighting system current and future-proof, providing users with a long-lasting and evolving investment in the ever-changing landscape of smart home technology. In conclusion, the advantages of smart lighting in smart homes encompass control, customization, energy efficiency, security, well-being, aesthetics, and future readiness, collectively contributing to an elevated and intelligent living experience (Chen et al., 2023).

Table 2 highlighting the advantages of using smart lighting in smart home.



**Table 2.**  
*Advantages of using smart lighting*

Advantage	Description
<b>Remote Control</b>	Users can conveniently control and customize lighting settings remotely through dedicated mobile applications, providing flexibility and adaptability to different scenarios and preferences from anywhere with a connected device.
<b>Customization</b>	Smart lighting allows for personalized adjustments in brightness, color, and ambiance, catering to specific activities, moods, or time of day. This customization enhances the living experience, allowing occupants to create tailored lighting environments that suit their preferences and contribute to the overall comfort of the home.
<b>Energy Efficiency</b>	Integration of energy-efficient LED technology coupled with scheduling and automation features promotes optimal energy usage. Smart lighting systems can adapt to occupancy and time-based patterns, reducing unnecessary consumption and contributing to long-term cost savings while aligning with sustainable practices.
<b>Integration with Smart Home Ecosystem</b>	Smart lighting seamlessly integrates with other smart home devices, fostering a cohesive ecosystem. This integration allows for centralized control, coordination with other smart systems, and the creation of comprehensive automation scenarios, enhancing the overall efficiency and intelligence of the smart home.
<b>Voice Control</b>	Compatibility with virtual assistants like Amazon Alexa or Google Assistant enables users to control lights using voice commands. This hands-free functionality adds a layer of convenience, allowing occupants to interact with their smart lighting system effortlessly and efficiently, contributing to a more intuitive and user-friendly smart home experience.
<b>Motion Sensors</b>	Incorporation of motion sensors enables automatic adjustments based on occupancy. Lights can turn on or off in response to detected motion, improving energy efficiency and providing hands-free control, particularly in areas where constant manual interaction may not be practical or necessary, such as hallways, bathrooms, or closets.
<b>Security Integration</b>	Synchronization with security systems enhances home security. Smart lighting can be integrated with cameras and other security devices to create dynamic lighting scenarios, acting as a deterrent and increasing overall visibility. This integration contributes to a comprehensive smart home security strategy, providing both functional illumination and an additional layer of safety.
<b>Health and Well-being Features</b>	Tunable lighting options support circadian rhythms and overall well-being. Users can adjust lighting to mimic natural sunlight, promoting better sleep patterns and creating a healthier living environment. These features contribute to the holistic integration of smart lighting into the occupants' daily lives, addressing not only functional needs but also enhancing their physical and mental well-being.
<b>Enhanced Aesthetics</b>	The ability to change colors and create dynamic lighting schemes adds an aesthetic dimension to smart homes. Smart lighting allows users to transform the look and feel of their living spaces, creating visually appealing environments for different occasions, events, or personal preferences. This flexibility in aesthetics adds a layer of creativity and personalization to the overall design and ambiance of the home.
<b>Firmware Updates and Future Innovations</b>	Regular firmware updates ensure ongoing compatibility and may introduce new features. The potential for future innovations, such as Li-Fi technology, adds value by keeping the smart lighting system up-to-date with the latest advancements, expanding functionality, and ensuring a future-proof investment for users in the ever-evolving landscape of smart home technology.

Source: (Gøthesen et al., 2023; Alsaedi et al., 2023; Chaudhari et al., 2023; Huda et al., 2024; Husain et al., 2023; Rhode et al., 2023; Basarir-Ozel et al., 2023; Tong et al., 2023; Chen et al., 2023; Douha et al., 2023; Sobhani et al., 2023).

Table 3 highlighting some of the common problems and challenges associated with the problems of using smart lightings in smart homes.

**Table 3.**  
*Problems of using smart lighting*

<b>Problem</b>	<b>Description</b>	<b>Methods of Overcoming</b>
<b>Interoperability Issues</b>	Incompatibility between different smart lighting devices or platforms may arise, leading to challenges in achieving a seamless and integrated smart home experience.	Prioritize devices from the same manufacturer or those designed to work within a specific ecosystem. Verify compatibility before purchase. Invest in smart home hubs that support multiple protocols for better integration.
<b>Reliability and Connectivity</b>	Issues related to connectivity, such as Wi-Fi outages or device malfunctions, can disrupt the reliability of smart lighting systems, causing inconvenience and potential downtime.	Ensure a robust home Wi-Fi network. Opt for smart lighting systems with local control capabilities, reducing dependence on external servers. Regularly update firmware for improved stability and performance.
<b>Security Concerns</b>	The connectivity of smart lighting introduces potential vulnerabilities, posing security risks such as unauthorized access or hacking, leading to privacy concerns for homeowners.	Implement strong, unique passwords for smart devices. Regularly update firmware to address security vulnerabilities. Consider network segmentation to isolate smart devices from critical home systems.
<b>Cost of Implementation</b>	The initial investment required to implement a comprehensive smart lighting system, including the purchase of smart bulbs, controllers, and other accessories, may be perceived as expensive for some homeowners.	Start with gradual implementation, focusing on key areas. Look for cost-effective smart lighting solutions or consider retrofitting existing fixtures with smart bulbs. Evaluate long-term energy savings for cost justification.
<b>Complexity of Setup and Use</b>	The setup and configuration of smart lighting systems may be perceived as complex for users who are not tech-savvy, potentially leading to frustration or underutilization of the advanced features.	Choose user-friendly smart lighting products with intuitive setup processes. Follow manufacturer-provided guides or seek assistance from customer support. Invest time in learning and exploring the system's capabilities.
<b>Dependency on Power Sources</b>	Smart lighting systems rely on a stable power source, and disruptions such as power outages may render the smart features temporarily unavailable, reverting to conventional lighting control.	Install backup power solutions, such as uninterruptible power supplies (UPS), to maintain functionality during short power outages. Consider hybrid setups that allow manual control in the absence of power.
<b>Software and Firmware Updates</b>	Irregular or cumbersome software and firmware updates may lead to compatibility issues, bugs, or the loss of certain features, impacting the overall performance and functionality of smart lighting systems.	Regularly check for and apply software and firmware updates. Choose smart lighting products from reputable manufacturers with a history of providing timely and reliable updates. Test updates in a controlled environment before applying them.
<b>Privacy Concerns</b>	Smart lighting systems may involve data collection for optimization or user behavior analysis, raising privacy concerns among homeowners who are sensitive to the potential misuse of personal information.	Review privacy policies of smart lighting products. Opt for systems that offer transparent data usage practices. Consider local processing options that minimize reliance on external servers for data storage and analysis.

Cont. table 3.

<b>Limited Compatibility with Fixtures</b>	Some smart lighting solutions may not be compatible with certain types of fixtures or may have limitations in terms of dimming capabilities, restricting the choice of lighting aesthetics for homeowners.	Verify compatibility with existing fixtures before purchasing smart bulbs or switches. Explore product specifications and user reviews to ensure that the chosen smart lighting solution meets specific fixture requirements.
<b>Environmental Impact</b>	The manufacturing and disposal of smart lighting components, particularly batteries in some devices, may contribute to environmental concerns. Additionally, frequent technology upgrades may result in electronic waste.	Choose products with sustainable manufacturing practices. Dispose of electronic waste responsibly through recycling programs. Consider long-term usage and durability when selecting smart lighting solutions.

Source: (Gøthesen et al., 2023; Alsaedi et al., 2023; Chaudhari et al., 2023; Huda et al., 2024; Husain et al., 2023; Rhode et al., 2023; Basarir-Ozel et al., 2023; Tong et al., 2023; Chen et al., 2023; Douha et al., 2023; Sobhani et al., 2023).

## 4. Conclusion

The integration of smart lighting systems in smart homes represents a transformative shift in how individuals interact with and control the lighting environment within their living spaces. The advent of smart lighting brings forth a multitude of advantages that extend beyond conventional lighting solutions, offering enhanced comfort, energy efficiency, and overall convenience. The ability to control lighting remotely stands out as a primary advantage, facilitated through dedicated mobile applications. This remote control capability not only provides convenience but also allows for dynamic adjustments based on user preferences and daily routines. Smart lighting's adaptability and versatility enable users to customize brightness, color, and ambiance, creating personalized environments tailored to specific activities or moods.

Smart lighting's contribution to energy efficiency is pivotal, with LED technology reducing power consumption and scheduling features minimizing unnecessary energy usage. Automation, facilitated by motion sensors and preset schedules, enhances both convenience and efficiency. The seamless integration of smart lighting with other smart home devices further amplifies its impact, creating a cohesive ecosystem that enhances overall home automation and security. Commercially, smart lighting plays a crucial role in creating adaptive environments in offices and retail spaces, optimizing lighting conditions for productivity and enhancing the customer experience. As technology evolves, innovations such as Li-Fi hold the potential to further enhance the capabilities of smart lighting systems, offering faster and more secure connectivity.

However, the adoption of smart lighting is not without its challenges. Interoperability issues, reliability concerns, and security vulnerabilities pose potential obstacles. The cost of implementation and the complexity of setup may deter some users, and dependency on power sources could result in temporary disruptions during outages. Privacy concerns, limited fixture compatibility, and environmental impact also require careful consideration. Despite these challenges, the advantages of smart lighting, including control, customization, energy efficiency, and integration, position it as a cornerstone in the broader ecosystem of smart homes. The hands-free operation through voice control, security integration, health and well-being features, and the potential for future innovations underscore the transformative potential of smart lighting.

The continued evolution of smart homes and the ongoing advancements in smart lighting technology promise an intelligent, adaptable, and user-centric future. As users weigh the advantages against potential challenges, smart lighting remains a key player in shaping the way we perceive and interact with illumination, contributing to a more sophisticated, sustainable, and connected living experience.

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## THE USAGE OF SMART THERMOSTATS IN SMART HOME

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**Purpose:** The purpose of this publication is to present the usage of smart lighting in smart thermostats.

**Design/methodology/approach:** Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.

**Findings:** Smart thermostats stand as a transformative innovation in home automation, reshaping the management of heating and cooling systems in smart homes. This integration introduces a host of advantages that go beyond conventional thermostat functionalities. The ability to remotely control and monitor temperature settings via dedicated mobile applications provides users with unparalleled flexibility and convenience. The seamless integration with popular smart home platforms like Amazon Alexa, Google Assistant, or Apple HomeKit fosters a cohesive and automated living environment by harmonizing with other smart devices. Beyond temperature control, smart thermostats exhibit a dedication to energy efficiency through learning algorithms that optimize settings over time, potentially reducing energy bills. Features such as weather integration, occupancy sensors, and voice control further enhance efficiency and convenience. With a pivotal role in environmental sustainability, these devices promote energy conservation, offer insights into consumption patterns, and support compatibility with renewable energy sources. While acknowledging substantial advantages, potential challenges such as connectivity issues and privacy concerns should be addressed through measures like stable internet connections and prioritizing security features. Smart thermostats embody the fusion of technology, convenience, and sustainability in modern homes, with ongoing evolution poised to further shape intelligent and comfortable living spaces.

**Originality/Value:** Detailed analysis of all subjects related to the problems connected with the usage of smart thermostats in smart home.

**Keywords:** Smart City, energy efficiency, smart home, smart house, digitalization, smart thermostats.

**Category of the paper:** literature review.

## 1. Introduction

Smart thermostats play a pivotal role in the seamless integration of heating and cooling systems within a smart home environment. As a central component of the modern connected home, these intelligent devices leverage advanced technologies to enhance both comfort and efficiency.

One of the primary advantages of incorporating smart thermostats into a smart home ecosystem is the ability to remotely control and monitor temperature settings. Through dedicated mobile applications, users can effortlessly adjust their home's climate from anywhere, providing unprecedented flexibility and convenience. Whether at work, on vacation, or within the confines of their own home, occupants can easily manage heating and cooling preferences at the touch of a button (Bsarir-Ozel et al., 2023).

The synergy between smart thermostats and other smart home devices further contributes to a cohesive living experience. Integration with popular smart home platforms like Amazon Alexa, Google Assistant, or Apple HomeKit allows for seamless communication between devices. Users can create intricate automation scenarios where the thermostat collaborates with lighting, security systems, and other connected devices, promoting a harmonized and efficient home environment (Huda et al., 2024).

The purpose of this publication is to present the usage of smart thermostats in smart home.

## 2. Smart thermostats in smart home

Smart thermostats are innovative devices that have revolutionized the way we control and manage the temperature in our homes. Unlike traditional thermostats, smart thermostats leverage advanced technology to provide users with enhanced convenience, energy efficiency, and customization options (Hussain et al., 2023).

One of the key features of smart thermostats is their connectivity to the Internet of Things (IoT). This connectivity allows users to remotely control and monitor their home's heating and cooling systems through dedicated mobile applications (Olabode et al., 2023). Whether you are at work, on vacation, or simply lounging in another room, the ability to adjust your thermostat settings from your smartphone provides an unprecedented level of flexibility and control (Chaudhari et al., 2023).

Energy efficiency is a significant advantage offered by smart thermostats. Many models come equipped with learning algorithms that analyze your patterns and preferences over time. By understanding your daily routines, these thermostats can automatically adjust the temperature to optimize energy usage, leading to potential cost savings on your energy bills.



Additionally, some smart thermostats integrate weather forecasts and occupancy sensors to make real-time adjustments, further improving efficiency. The integration of voice control technology has added another layer of convenience to smart thermostats. Users can now interact with their thermostats using voice commands, making adjustments hands-free. This feature is particularly beneficial in situations where manual control may be inconvenient or when users have limited mobility.

Compatibility with smart home ecosystems is a notable aspect of smart thermostats. They often integrate seamlessly with popular smart home platforms such as Amazon Alexa, Google Assistant, and Apple HomeKit (Afroz et al., 2024). This interoperability enables users to create comprehensive smart home systems where thermostats can interact with other connected devices, such as smart lighting, security systems, and more, fostering a cohesive and automated living environment (Valencia-Arias et al., 2023).

Smart thermostats also contribute to environmental sustainability by promoting energy conservation. The ability to monitor energy usage, set efficient schedules, and receive insights into consumption patterns empowers users to make informed decisions that reduce their carbon footprint (Dhaou, 2023). In terms of design, smart thermostats typically feature sleek and modern aesthetics, blending seamlessly with contemporary home decor. Touchscreen interfaces, intuitive controls, and user-friendly mobile applications contribute to an overall positive user experience (Raff et al., 2024).

Smart thermostats also demonstrate a keen understanding of user behavior and preferences through learning algorithms (Chen et al., 2023). By analyzing patterns over time, these devices optimize temperature settings automatically, adapting to the occupants' routines. This not only enhances comfort but also contributes to energy efficiency, potentially leading to cost savings on energy bills (Alsaedi et al., 2023).

Incorporating geofencing technology, smart thermostats take personalization to the next level. They can detect the proximity of users to their homes and adjust temperature settings accordingly, ensuring a comfortable environment upon arrival while minimizing unnecessary energy consumption during absences. Moreover, the integration of voice control technology adds an extra layer of convenience. Occupants can interact with their smart thermostats using voice commands, offering hands-free control and simplifying the user experience (Gajdzik et al., 2023; Jonek-Kowalska, Wolniak, 2021, 2022).

The usage of smart thermostats in a smart home transcends mere temperature control. It embodies a holistic approach to modern living, where connectivity, automation, and energy efficiency converge to create an intelligent and comfortable living space (Tong et al., 2023). As technology continues to evolve, the role of smart thermostats in smart homes is likely to expand, offering even more sophisticated features and contributing to the ongoing transformation of our living spaces (Wu et al., 2023).

Table 1 contains descriptions of key features of smart thermostats usage.

**Table 1.**  
*Key features of smart thermostats usage*

<b>Key Features of Smart Thermostats</b>	<b>Description</b>
<b>Remote Connectivity</b>	Enables users to control and monitor thermostat settings remotely via dedicated mobile applications, providing flexibility and convenience.
<b>Learning Algorithms</b>	Analyzes user patterns and preferences to automatically adjust temperature settings over time, optimizing energy usage and potentially reducing energy bills.
<b>Weather Integration</b>	Utilizes weather forecasts to make real-time adjustments, ensuring efficient heating and cooling based on external conditions.
<b>Occupancy Sensors</b>	Incorporates sensors to detect occupancy and adjust temperature settings accordingly, preventing energy wastage in unoccupied spaces.
<b>Voice Control Integration</b>	Allows users to interact with the thermostat using voice commands, enhancing convenience, especially in situations where manual control is impractical.
<b>Smart Home Ecosystem Compatibility</b>	Integrates seamlessly with popular smart home platforms (e.g., Alexa, Google Assistant, HomeKit) to create a cohesive and interconnected smart home environment.
<b>Energy Monitoring and Insights</b>	Provides detailed energy usage data and insights, empowering users to make informed decisions to reduce their carbon footprint and promote environmental sustainability.
<b>Modern Aesthetics and Intuitive Controls</b>	Features sleek and modern designs with touchscreen interfaces and user-friendly controls, enhancing the overall user experience and blending with contemporary home decor.
<b>Geofencing Technology</b>	Utilizes location-based technology to adjust temperature settings based on the user's proximity to home, optimizing comfort and energy efficiency.
<b>Scheduling and Programming</b>	Allows users to create custom heating and cooling schedules, ensuring that the thermostat operates according to individual preferences and daily routines.
<b>Smart Alerts and Notifications</b>	Sends alerts and notifications to users for events such as extreme temperature changes, system malfunctions, or reminders for maintenance tasks, enhancing system monitoring.
<b>Compatibility with HVAC Systems</b>	Supports integration with a wide range of heating, ventilation, and air conditioning (HVAC) systems, ensuring compatibility with various home setups.
<b>Multi-Zone Control</b>	Enables independent temperature control in different zones or rooms of the house, providing personalized comfort levels for each living space.
<b>Adaptive Recovery</b>	Learns and predicts the time needed to reach a set temperature, ensuring the home is comfortable at the scheduled times without unnecessary energy consumption.
<b>Data Security and Privacy Features</b>	Implements robust security measures to protect user data and privacy, addressing concerns related to the connectivity and smart features of the thermostat.
<b>Integration with Renewable Energy Sources</b>	Supports integration with renewable energy sources, allowing users to optimize energy consumption and contribute to a more sustainable and eco-friendly home.
<b>Smart Thermostat Firmware Updates</b>	Offers regular firmware updates to enhance functionality, improve performance, and address potential security vulnerabilities, ensuring a continuously evolving system.
<b>Usage Reports and Analytics</b>	Provides detailed reports and analytics on energy usage, temperature patterns, and system performance, empowering users with insights for better energy management.

Source: (Gøthesen et al., 2023; Alsaedi et al., 2023; Chaudhari et al., 2023; Huda et al., 2024; Husain et al., 2023; Rhode et al., 2023; Basarir-Ozel et al., 2023; Tong et al., 2023; Chen et al., 2023; Douha et al., 2023; Sobhani et al., 2023).

### 3. The advantages and problems of using smart thermostats

Smart thermostats offer a multitude of advantages when integrated into a smart home environment, transforming the way we control and interact with our heating and cooling systems. One of the key benefits is the ability to exercise precise control remotely. Through dedicated mobile applications, users can effortlessly adjust temperature settings from anywhere, ensuring optimal comfort upon arrival and efficient energy usage. The integration of learning algorithms sets smart thermostats apart by adapting to user behavior over time. This not only optimizes energy efficiency by automatically adjusting temperature settings based on daily routines but also contributes to potential cost savings on energy bills (Sobhani et al., 2023).

Compatibility with popular smart home platforms such as Alexa, Google Assistant, or HomeKit allows for seamless integration and coordination with other connected devices. This paves the way for automation scenarios where the thermostat collaborates with lighting, security systems, and more, creating a cohesive and synchronized smart home environment. Geofencing technology takes personalization to the next level. By leveraging location-based services, smart thermostats can detect when users are approaching home and adjust temperatures accordingly. This feature not only enhances comfort but also minimizes energy wastage during periods of absence (Ramanujam et al., 2024).

Voice control adds an extra layer of convenience to smart thermostat usage. Users can interact with their devices using voice commands, providing hands-free control and simplifying the overall user experience. The learning algorithms employed by smart thermostats contribute to a personalized living experience. By analyzing user patterns, these devices automatically tailor temperature settings to individual preferences, ensuring a comfortable environment without the need for constant manual adjustments (Douha et al., 2023).

Smart thermostats also offer data-driven insights through detailed reports and analytics on energy usage, temperature patterns, and system performance. This information empowers users to make informed decisions about energy management, further optimizing efficiency and sustainability. The compatibility of smart thermostats with renewable energy sources, such as geothermal systems, aligns with sustainability goals. This integration allows users to contribute to environmental conservation efforts while optimizing their energy consumption (Afroz et al., 2024).

Regular firmware updates ensure that smart thermostats stay current with the latest technological advancements. These updates not only enhance functionality and performance but also address security concerns, providing users with a reliable and evolving smart home solution. In essence, the advantages of using smart thermostats extend beyond temperature control, offering a holistic and intelligent approach to home comfort, efficiency, and sustainability (Douha et al., 2023).

Table 2 highlighting the advantages of using smart thermostats in smart home.

**Table 2.**  
*Advantages of using smart thermostats*

Advantage	Description
<b>Remote Control</b>	Users can adjust heating and cooling settings from anywhere via dedicated mobile applications, offering convenience and flexibility.
<b>Energy Efficiency</b>	Learning algorithms optimize temperature based on user behavior, promoting energy efficiency and potentially reducing energy bills.
<b>Integration with Smart Home Platforms</b>	Seamless compatibility with popular platforms like Alexa, Google Assistant, or HomeKit enables cohesive automation within the smart home ecosystem.
<b>Geofencing Technology</b>	Utilizes location-based technology to adjust temperature settings based on user proximity, enhancing comfort upon arrival and reducing energy waste during absences.
<b>Voice Control</b>	Integration with voice assistants allows for hands-free control, adding an extra layer of convenience to the user experience.
<b>Automation and Coordination</b>	Collaborates with other smart devices to create automated scenarios, where the thermostat interacts with lighting, security, and more, for a synchronized smart home environment.
<b>Learning Algorithms for Personalization</b>	Learns user patterns over time to automatically tailor temperature settings, providing a personalized and comfortable living experience.
<b>Data-driven Insights</b>	Provides detailed reports and analytics on energy usage, temperature patterns, and system performance, empowering users with information for better energy management.
<b>Geothermal and Renewable Energy Integration</b>	Supports integration with renewable energy sources, contributing to sustainability efforts and allowing users to optimize energy consumption.
<b>Firmware Updates for Continuous Improvement</b>	Regular firmware updates enhance functionality, improve performance, and address security concerns, ensuring the thermostat evolves with advancing technology.

Source: (Gøthesen et al., 2023; Alsaedi et al., 2023; Chaudhari et al., 2023; Huda et al., 2024; Husain et al., 2023; Rhode et al., 2023; Basarir-Ozel et al., 2023; Tong et al., 2023; Chen et al., 2023; Douha et al., 2023; Sobhani et al., 2023).

Table 3 highlighting some of the common problems and challenges associated with the problems of using smart thermostats in smart homes.

**Table 3.**  
*Problems of using smart thermostats*

Problem	Description	Methods of Overcoming
<b>Connectivity Issues</b>	Smart thermostats heavily rely on internet connectivity. If there are network disruptions or Wi-Fi issues, users may experience difficulties in remotely controlling the thermostat.	<ul style="list-style-type: none"> <li>• Ensure a stable and reliable internet connection.</li> <li>• Place the Wi-Fi router in a central location for better coverage.</li> <li>• Consider using a mesh Wi-Fi network for improved coverage.</li> </ul>
<b>Compatibility Challenges</b>	Some smart thermostats may not be compatible with certain HVAC systems or smart home platforms, leading to integration challenges.	<ul style="list-style-type: none"> <li>• Prioritize research to choose a thermostat compatible with your HVAC system.</li> <li>• Check for compatibility with your existing smart home ecosystem before purchasing.</li> <li>• Utilize compatibility check tools provided by manufacturers.</li> </ul>

Cont. table 3.

<b>Privacy and Security Concerns</b>	The connectivity of smart thermostats raises privacy and security issues, as these devices collect data on users' habits and routines. Unauthorized access could compromise sensitive information.	<ul style="list-style-type: none"> <li>• Choose thermostats from reputable manufacturers with a focus on security.</li> <li>• Regularly update firmware to patch security vulnerabilities.</li> <li>• Implement strong passwords and enable two-factor authentication where available.</li> </ul>
<b>Learning Algorithm Limitations</b>	While learning algorithms enhance efficiency, they may not always accurately predict user preferences or routines. This can lead to suboptimal temperature adjustments.	<ul style="list-style-type: none"> <li>• Regularly review and adjust thermostat settings manually to fine-tune preferences.</li> <li>• Provide feedback to the thermostat system when it makes adjustments that do not align with preferences.</li> <li>• Consider thermostats with user-friendly interfaces for easier manual adjustments.</li> </ul>
<b>Initial Cost and Installation</b>	The upfront cost of smart thermostats can be higher compared to traditional thermostats, and installation may require professional assistance, incurring additional expenses.	<ul style="list-style-type: none"> <li>• Look for rebates or discounts offered by utility companies to offset the initial cost.</li> <li>• Explore DIY-friendly models for simpler installation, if applicable.</li> <li>• Consider the long-term energy savings that may offset the initial investment.</li> </ul>
<b>Power Outage Impact</b>	During power outages, smart thermostats may lose functionality or require reprogramming once power is restored. This can disrupt temperature control settings.	<ul style="list-style-type: none"> <li>• Invest in smart thermostats with built-in battery backup capabilities.</li> <li>• Consider auxiliary power solutions, like uninterruptible power supplies (UPS), for critical smart home components.</li> <li>• Have a manual thermostat as a backup for temporary use during power outages.</li> </ul>
<b>Sensor Accuracy and Placement</b>	Inaccurate temperature readings may occur if sensors are poorly placed or if the thermostat is installed in a location that doesn't reflect the actual temperature of the living spaces.	<ul style="list-style-type: none"> <li>• Ensure proper thermostat placement in a central location away from direct sunlight or drafts.</li> <li>• Calibrate sensors regularly according to manufacturer guidelines.</li> <li>• Use additional temperature sensors in different zones for more accurate readings.</li> </ul>
<b>Software Bugs and Glitches</b>	Like any technology, smart thermostats may experience software bugs or glitches that can impact their performance and responsiveness.	<ul style="list-style-type: none"> <li>• Keep firmware and software up to date with the latest releases.</li> <li>• Report bugs to the manufacturer for prompt resolution in future updates.</li> <li>• Follow troubleshooting guides provided by the manufacturer.</li> </ul>
<b>Complexity for Technologically Inexperienced Users</b>	Users unfamiliar with technology may find the setup, configuration, and operation of smart thermostats challenging, leading to underutilization of features.	<ul style="list-style-type: none"> <li>• Choose thermostats with user-friendly interfaces and clear setup instructions.</li> <li>• Seek assistance from customer support or professional installation services if needed.</li> <li>• Utilize online tutorials and resources to familiarize yourself with the device.</li> </ul>
<b>Dependence on External Services</b>	Smart thermostats often depend on external cloud services. If these services experience downtime or discontinuation, it can impact the thermostat's functionality.	<ul style="list-style-type: none"> <li>• Research the reliability and reputation of the manufacturer's cloud services.</li> <li>• Choose thermostats that offer local control options or have fallback mechanisms in case of cloud service disruptions.</li> <li>• Be aware of potential service limitations and have alternative heating or cooling methods available.</li> </ul>

Cont. table 3.

<b>Limited Compatibility with Older HVAC Systems</b>	Some older HVAC systems may not be compatible with the advanced features of smart thermostats, limiting their effectiveness.	<ul style="list-style-type: none"> <li>• Prioritize compatibility checks before purchasing a smart thermostat.</li> <li>• Consider upgrading the HVAC system if compatibility issues persist.</li> <li>• Consult with HVAC professionals for advice on integrating smart thermostats with older systems.</li> </ul>
<b>Overreliance on Automation</b>	Overreliance on automated settings may lead to discomfort if the thermostat fails to accurately predict user preferences or if there are unexpected changes in daily routines.	<ul style="list-style-type: none"> <li>• Regularly review and adjust thermostat settings manually to ensure comfort.</li> <li>• Have alternative heating or cooling methods available for unexpected scenarios.</li> <li>• Use automation as a complement rather than a sole means of temperature control.</li> </ul>

Source: (Gøthesen et al., 2023; Alsaedi et al., 2023; Chaudhari et al., 2023; Huda et al., 2024; Husain et al., 2023; Rhode et al., 2023; Basarir-Ozel et al., 2023; Tong et al., 2023; Chen et al., 2023; Douha et al., 2023; Sobhani et al., 2023).

## 4. Conclusion

Smart thermostats represent a groundbreaking advancement in the realm of home automation, revolutionizing the way we manage and control heating and cooling systems within smart homes. Their integration into the modern connected home brings forth a myriad of advantages that transcend traditional thermostat functionalities. The ability to remotely control and monitor temperature settings through dedicated mobile applications stands out as a primary advantage, offering users unprecedented flexibility and convenience. The synergy with other smart home devices, facilitated by seamless integration with popular platforms like Amazon Alexa, Google Assistant, or Apple HomeKit, contributes to the creation of a cohesive and automated living environment.

Smart thermostats not only excel in temperature control but also showcase a commitment to energy efficiency. Learning algorithms analyze user patterns and preferences, automatically optimizing temperature settings over time to reduce energy consumption and potentially lower energy bills. The incorporation of weather integration, occupancy sensors, and voice control further enhances efficiency and convenience. These devices play a pivotal role in environmental sustainability by promoting energy conservation and offering insights into consumption patterns. Additionally, the compatibility with renewable energy sources aligns with efforts to create eco-friendly living spaces.

While the advantages are substantial, it is essential to acknowledge and address potential challenges associated with smart thermostat usage. Connectivity issues, compatibility challenges, and privacy concerns may arise, requiring users to implement measures such as ensuring stable internet connections, thorough compatibility checks, and prioritizing security features. The learning algorithm's limitations and overreliance on automation are challenges that users can mitigate by providing manual adjustments and maintaining alternative heating or

cooling methods. The initial cost and installation complexities can be addressed by exploring available discounts, opting for DIY-friendly models, and considering long-term energy savings.

Smart thermostats exemplify the fusion of technology, convenience, and sustainability in the modern home. As they continue to evolve, addressing challenges and enhancing user experiences, their role in shaping intelligent and comfortable living spaces is poised to expand further.

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## THE USAGE OF STATISTICAL BALANCED SCORECARD IN INDUSTRY 4.0 CONDITIONS

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**Purpose:** The purpose of this publication is to present the usage of balanced scorecard approach in Industry 4.0 conditions.

**Design/methodology/approach:** Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.

**Findings:** The integration of the Statistical Balanced Scorecard (SBSC) with Industry 4.0 signifies a groundbreaking advancement in performance measurement and management. Through the infusion of advanced statistical methodologies and analytics, the SBSC seamlessly adapts the conventional Balanced Scorecard framework to thrive in the data-rich landscape of Industry 4.0. This evolution extends the financial perspective beyond conventional metrics, employing predictive analytics to forecast trends and optimize resource allocation. Within Industry 4.0, the customer perspective transcends understanding needs, incorporating data analytics to tailor products and services, thereby augmenting customer satisfaction. Critical internal processes benefit from statistical process control and data analytics, fostering efficiency and agility. The learning and growth perspective attains heightened significance by emphasizing digital literacy and innovation to navigate the Industry 4.0 paradigm. Tables 2, 3, and 4 provide comprehensive insights into the adaptation, advantages, and challenges associated with this integration, presenting a holistic framework that positions organizations to excel in the digital era through data-driven decision-making, strategic alignment with technological trends, and an unwavering commitment to continuous improvement.

**Originality/Value:** Detailed analysis of all subjects related to the problems connected with the usage of Balanced Scorecard in Industry 4.0 conditions.

**Keywords:** Industry 4.0; Quality 4.0; quality management; quality methods; balanced scorecard.

**Category of the paper:** literature review.

## 1. Introduction

The Statistical Balanced Scorecard builds upon the traditional Balanced Scorecard framework by incorporating advanced statistical methods and analytics. This adaptation allows organizations to harness the vast amount of data generated in Industry 4.0 environments to derive meaningful insights and drive informed decision-making.

In Industry 4.0 conditions, the financial perspective of the SBSC extends beyond mere monetary metrics to include data-driven financial analyses. This involves leveraging predictive analytics and modeling techniques to anticipate financial trends, optimize resource allocation, and enhance overall financial performance.

The customer perspective in an Industry 4.0 context involves not only understanding customer needs but also utilizing data analytics to personalize products and services. Through the integration of customer feedback, sentiment analysis, and real-time data, organizations can tailor their offerings to meet dynamic customer preferences and expectations (Barsalou, 2023; Maganga, Taifa, 2023).

The purpose of this publication is to present the usage of balanced scorecard approach in Industry 4.0 condition.

## 2. The basics of balanced scorecard approach

The Balanced Scorecard is a strategic management framework that provides organizations with a comprehensive view of their performance. Developed by Robert S. Kaplan and David P. Norton in the early 1990s, this methodology goes beyond financial metrics to incorporate a balanced set of key performance indicators (KPIs) that align with the organization's strategic objectives (Jokovic et al., 2023).

At its core, the Balanced Scorecard emphasizes four perspectives: financial, customer, internal processes, and learning and growth. These perspectives collectively offer a well-rounded evaluation of an organization's health and effectiveness. The financial perspective assesses traditional financial metrics, such as revenue, profit, and return on investment. The customer perspective focuses on understanding and meeting customer needs, ensuring customer satisfaction and loyalty. Internal processes are examined to identify areas for improvement and efficiency. This perspective involves evaluating the organization's operational processes, innovation, and quality management. The learning and growth perspective highlights the importance of human capital, technology, and organizational culture. It recognizes that continuous improvement and development in these areas contribute to long-term success (Gajdzik et al., 2023).

The Balanced Scorecard serves as a communication tool that aligns the entire organization with its strategic goals. By translating the strategy into specific objectives and performance indicators, it provides clarity and direction for employees at all levels. This alignment ensures that everyone within the organization understands their role in achieving the overall strategy. Additionally, the Balanced Scorecard encourages a cause-and-effect relationship among the different perspectives. It prompts organizations to identify how improvements in one area can positively impact another, fostering a more holistic approach to strategic management.

Overall, the Balanced Scorecard is a dynamic and adaptable methodology that enables organizations to measure and manage performance in a way that goes beyond financial outcomes. By considering multiple perspectives and fostering a strategic mindset, it has become a valuable tool for organizations seeking sustained success in today's complex and competitive business environment (Singh et al., 2023).

Internal processes, a critical aspect of the SBSC, are optimized through the application of statistical process control and data analytics. This enables organizations to identify bottlenecks, reduce inefficiencies, and enhance the agility and responsiveness of their operations. Continuous improvement becomes data-driven, ensuring that processes align with strategic objectives in real-time.

The learning and growth perspective in Industry 4.0 conditions emphasizes the importance of cultivating data literacy, digital skills, and fostering a culture of innovation. Statistical analysis of workforce performance, skill development, and organizational culture enables businesses to adapt to technological advancements and stay competitive in a rapidly changing environment.

One of the key advantages of the Statistical Balanced Scorecard in Industry 4.0 is its ability to establish a causal relationship between different performance indicators. By employing advanced analytics, organizations can uncover correlations and dependencies, enabling them to make proactive decisions that positively impact various aspects of their operations.

The adoption of a Statistical Balanced Scorecard in Industry 4.0 conditions empowers organizations to leverage the full potential of data and analytics for strategic performance management. By integrating statistical methods into the traditional Balanced Scorecard framework, businesses can navigate the complexities of Industry 4.0, drive innovation, and achieve sustained success in the digital era (Alrabadi et al., 2023).

Table 1 contains description of balanced scorecard key principles. This table provides a concise overview of the key principles that guide the implementation and effectiveness of the Balanced Scorecard methodology.

**Table 1.**  
*Key principles of balanced scorecard*

Key principle	Description
<b>Four Perspectives</b>	The Balanced Scorecard incorporates four perspectives: Financial, Customer, Internal Processes, and Learning & Growth. These perspectives provide a holistic view of organizational performance.
<b>Strategy Mapping</b>	It involves creating a visual representation of the cause-and-effect relationships between strategic objectives across the four perspectives. This helps in understanding how actions impact outcomes.
<b>Cascading Objectives</b>	Objectives are cascaded from the top level down to individual departments and employees, ensuring alignment with the overall organizational strategy.
<b>Performance Measures</b>	Identifying and selecting key performance indicators (KPIs) for each perspective to quantitatively measure progress toward strategic goals.
<b>Targets and Initiatives</b>	Setting specific targets for each KPI and defining initiatives or actions to achieve these targets. This ensures a clear roadmap for strategy execution.
<b>Integration with Processes</b>	Linking performance measures to day-to-day business processes, ensuring that employees' daily activities contribute to the achievement of strategic objectives.
<b>Continuous Monitoring and Adaptation</b>	Regularly monitoring performance against targets and adapting strategies and initiatives based on feedback and changing business conditions.
<b>Employee Involvement and Communication</b>	Involving employees at all levels in the development and execution of the Balanced Scorecard, and communicating the strategic objectives and their role in achieving them.
<b>Balance Between Short-Term and Long-Term Goals</b>	Striking a balance between short-term financial objectives and long-term strategic objectives to ensure sustainable growth and value creation.
<b>Feedback and Learning Loop</b>	Establishing a feedback loop to capture lessons learned, adjust strategies, and promote a culture of continuous learning and improvement.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

### **3. How balanced scorecard method can be integrated with Industry 4.0 and Quality 4.0 concept**

The integration of the Balanced Scorecard method with Industry 4.0 and Quality 4.0 concepts represents a strategic approach to aligning organizational performance measurement with the transformative technologies and methodologies of the fourth industrial revolution. In the context of Industry 4.0, characterized by the extensive use of digital technologies, automation, and data-driven processes, the Balanced Scorecard adapts by incorporating key performance indicators (KPIs) that reflect the impact of these technologies on various business perspectives. The financial perspective extends beyond traditional monetary metrics to include data-driven financial analytics, such as predictive modeling and risk analysis. The customer perspective involves leveraging real-time data analytics to personalize products and services, enhancing customer satisfaction and loyalty (Maganga, Taifa, 2023).

Internal processes, a critical aspect of the Balanced Scorecard, are optimized through the integration of Industry 4.0 technologies. Statistical process control and advanced analytics are employed to identify inefficiencies, predict maintenance needs, and streamline operations. This ensures that processes are not only efficient but also adaptable to the dynamic changes introduced by Industry 4.0 (Bousdekis et al., 2023).

Quality 4.0, which emphasizes the integration of digital technologies into quality management processes, aligns seamlessly with the Balanced Scorecard. Performance measures related to quality can now include real-time data from sensors, predictive analytics for defect prevention, and continuous monitoring of quality metrics throughout the production process. The Balanced Scorecard, in this context, becomes a tool not only for measuring quality performance but also for driving continuous improvement in quality through data-driven insights (Jonek Kowalska, Wolniak, 2021, 2022).

Moreover, the Learning and Growth perspective of the Balanced Scorecard gains new significance in the Industry 4.0 and Quality 4.0 landscape. Organizations need to foster a culture of digital literacy, data analytics skills, and innovation to adapt to the evolving technological environment. Employee training and development initiatives can be incorporated into the Balanced Scorecard framework to ensure that the workforce is equipped with the skills needed to thrive in the Industry 4.0 era.

The integration of the Balanced Scorecard with Industry 4.0 and Quality 4.0 concepts creates a cohesive framework that not only measures performance across financial, customer, internal processes, and learning and growth perspectives but also ensures that these measurements are aligned with the transformative technologies and methodologies driving the fourth industrial revolution. This strategic alignment enables organizations to leverage Industry 4.0 and Quality 4.0 advancements for sustained success and competitiveness (Antony et al., 2023; Escobar et al., 2023; Antony et al., 2023; Salimbeni, Redchuk, 2023).

Table 2 is listing examples of integration of balanced scorecard method with Industry 4.0. This table provides a concise overview of key aspects that highlight the integration of the Balanced Scorecard with Industry 4.0, emphasizing how each perspective is adapted to leverage the capabilities of the fourth industrial revolution.

**Table 2.**

*Balanced scorecard integration with industry 4.0*

Aspect	Description
<b>Financial Perspective in Industry 4.0</b>	Adapting financial metrics to include data-driven financial analytics in Industry 4.0. This involves leveraging predictive modeling, risk analysis, and real-time financial data to enhance decision-making and align financial objectives with the transformative technologies of Industry 4.0.
<b>Customer Perspective in Industry 4.0</b>	Utilizing real-time data analytics to personalize products and services, improving customer satisfaction and loyalty in the digital era. Integrating customer feedback, sentiment analysis, and data-driven insights to enhance the understanding of customer needs and expectations within the context of Industry 4.0.

Cont. table 2.

<b>Internal Processes in Industry 4.0</b>	Optimizing internal processes through Industry 4.0 technologies. Applying statistical process control, advanced analytics, and automation to identify and eliminate inefficiencies, predict maintenance needs, and streamline operations. Ensuring that processes are not only efficient but also adaptive to the dynamic changes introduced by Industry 4.0.
<b>Learning and Growth in Industry 4.0</b>	Fostering a culture of digital literacy, data analytics skills, and innovation. Integrating employee training and development initiatives into the Balanced Scorecard framework to ensure that the workforce is equipped with the skills needed to thrive in the Industry 4.0 era. Recognizing the importance of human capital and skills development in the digital age.
<b>Cascading Objectives in Industry 4.0</b>	Aligning objectives from the top level down to individual departments and employees, ensuring that strategic goals related to Industry 4.0 are communicated and integrated into daily operations. Cascading objectives helps in achieving alignment across the organization and ensures that everyone understands their role in the Industry 4.0 strategy.
<b>Continuous Monitoring in Industry 4.0</b>	Regularly monitoring performance against targets and adapting strategies based on feedback and changing conditions in the Industry 4.0 landscape. Emphasizing the need for real-time data and analytics to enable proactive decision-making, especially in the dynamic and rapidly evolving environment of Industry 4.0.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

Table 3 is describe the advantages balanced scorecard approach usage in Industry 4.0. This table illustrates how the integration of the Balanced Scorecard with Industry 4.0 brings several strategic advantages, leveraging technological advancements to enhance decision-making, performance management, operational efficiency, customer experience, strategic alignment, and risk management.

**Table 3.**

*The advantages of balanced scorecard integration with industry 4.0*

<b>Advantage</b>	<b>Description</b>
<b>Real-time Decision-Making</b>	Integration with Industry 4.0 enables the Balanced Scorecard to leverage real-time data and analytics. This advantage allows organizations to make informed decisions promptly, responding to dynamic changes in the production environment, market conditions, and customer preferences. The ability to access and analyze data in real-time enhances agility and responsiveness across all business perspectives.
<b>Data-Driven Performance Management</b>	Industry 4.0 provides a wealth of data generated by sensors, IoT devices, and interconnected systems. Integrating the Balanced Scorecard with Industry 4.0 allows organizations to utilize this data for comprehensive and data-driven performance management. This advantage facilitates a more accurate assessment of key performance indicators, leading to proactive management of financial, customer, internal process, and learning and growth objectives.
<b>Optimized Operational Efficiency</b>	The integration of the Balanced Scorecard with Industry 4.0 supports the optimization of internal processes through technologies such as automation, artificial intelligence, and advanced analytics. This advantage enables organizations to streamline operations, identify and eliminate bottlenecks, and improve overall operational efficiency. Industry 4.0 technologies contribute to achieving process-related objectives more effectively.



Cont. table 3.

<b>Enhanced Customer Experience</b>	Industry 4.0 allows for personalized and data-driven customer experiences. When integrated with the Balanced Scorecard, organizations can align their customer perspective with the capabilities of Industry 4.0, resulting in improved customer satisfaction and loyalty. Real-time data analytics and customer feedback mechanisms contribute to the continuous refinement of products and services, ensuring they meet evolving customer expectations.
<b>Strategic Alignment with Technology Trends</b>	The integration of the Balanced Scorecard with Industry 4.0 ensures strategic alignment with the ongoing technological advancements characteristic of the fourth industrial revolution. This advantage allows organizations to stay at the forefront of innovation, adapting their strategic objectives to capitalize on new technologies and maintain a competitive edge in the rapidly evolving digital landscape.
<b>Proactive Risk Management</b>	Industry 4.0 integration enhances the Balanced Scorecard's ability to incorporate predictive analytics and risk management strategies. This advantage enables organizations to proactively identify and mitigate risks associated with financial, operational, and technological factors. The real-time monitoring and predictive capabilities support a more resilient and risk-aware approach to strategic decision-making and goal attainment.

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

Table 4 is describe the problems of balanced scorecard approach usage in Industry 4.0 and methods to overcome them. This table highlights potential problems associated with integrating the Balanced Scorecard with Industry 4.0 and suggests methods to overcome these challenges, focusing on data management, integration complexity, cybersecurity, workforce readiness, financial considerations, and standardization efforts.

**Table 4.**

*The problems of balanced scorecard integration with industry 4.0*

<b>Problems</b>	<b>Description of Problem</b>	<b>Overcoming Strategies</b>
<b>Data Overload and Quality Issues</b>	The influx of data from Industry 4.0 technologies may lead to information overload, making it challenging to discern relevant data and ensure data accuracy and quality.	<ul style="list-style-type: none"> <li>• Implement data governance and quality control measures to ensure data accuracy and reliability.</li> <li>• Utilize advanced analytics tools and algorithms to filter and analyze relevant data.</li> <li>• Establish clear data management protocols and standards.</li> </ul>
<b>Integration Complexity</b>	Integrating Industry 4.0 technologies with the Balanced Scorecard may be complex due to the diversity of systems, devices, and data sources. The compatibility and seamless integration of these technologies can pose challenges.	<ul style="list-style-type: none"> <li>• Conduct a comprehensive analysis of existing systems and technologies to identify compatibility issues.</li> <li>• Invest in middleware solutions or platforms that facilitate smooth integration.</li> <li>• Collaborate with experienced IT professionals and vendors for seamless implementation.</li> </ul>
<b>Cybersecurity Risks</b>	Industry 4.0 introduces a higher level of connectivity, increasing the vulnerability to cybersecurity threats. The integration of the Balanced Scorecard with Industry 4.0 may expose sensitive data to potential cyber risks.	<ul style="list-style-type: none"> <li>• Implement robust cybersecurity measures, including encryption, firewalls, and regular security audits.</li> <li>• Provide cybersecurity training to employees to enhance awareness and prevent potential breaches.</li> <li>• Stay informed about the latest cybersecurity threats and updates.</li> </ul>

Cont. table 4.

<b>Skill Gaps and Workforce Resistance</b>	The transition to Industry 4.0 may require new skills and competencies that the existing workforce may lack. Resistance to change from employees accustomed to traditional processes can hinder successful integration.	<ul style="list-style-type: none"> <li>• Invest in comprehensive training programs to upskill the workforce in digital literacy and Industry 4.0 technologies.</li> <li>• Foster a culture of continuous learning and change management to address resistance.</li> <li>• Involve employees in the transition process and communicate the benefits of Industry 4.0.</li> </ul>
<b>Costs and Return on Investment (ROI)</b>	The upfront costs associated with implementing Industry 4.0 technologies can be substantial. Achieving a positive ROI and demonstrating the tangible benefits of integration may be challenging in the short term.	<ul style="list-style-type: none"> <li>• Conduct a thorough cost-benefit analysis before implementation to assess the potential return on investment.</li> <li>• Prioritize technology investments based on their strategic impact and alignment with organizational goals.</li> <li>• Monitor and evaluate performance metrics regularly to demonstrate the long-term benefits.</li> </ul>
<b>Lack of Standardization</b>	The lack of standardized frameworks and protocols in the Industry 4.0 landscape can lead to interoperability challenges and hinder seamless integration with the Balanced Scorecard.	<ul style="list-style-type: none"> <li>• Advocate for industry-wide standardization efforts to establish common protocols.</li> <li>• Collaborate with technology partners that adhere to recognized standards.</li> <li>• Stay informed about emerging standards and update integration strategies accordingly.</li> </ul>

Source: (Almeida, Abreu, 2023; Jokovic et al., 2023; Khourshed, Gouhar, 2023; Maganga, Taifa, 2023; Liu et al., 2023; Amat-Lefort et al., 2023; Alrabadi et al., 2023; Singh et al., 2023; Barsalou, 2023; Antony et al., 2023; Saihi et al., 2023; Sureshchandar, 2023; Swarnakar et al., 2023; Gimerska et al., 2023; Salimbeni, Redchuk, 2023; Yanamandra et al., 2023; Escobar et al., 2023; Bousdekis et al., 2023; Antony et al., 2023).

## 4. Conclusion

In conclusion, the integration of the Statistical Balanced Scorecard (SBSC) with Industry 4.0 represents a strategic leap forward in performance measurement and management. By incorporating advanced statistical methods and analytics, the SBSC adapts the traditional Balanced Scorecard framework to the data-rich environment of Industry 4.0. This adaptation extends the financial perspective beyond traditional metrics, leveraging predictive analytics to anticipate trends and optimize resource allocation.

The customer perspective in Industry 4.0 goes beyond understanding needs; it embraces data analytics to personalize products and services, enhancing customer satisfaction. Internal processes, a critical aspect of SBSC, benefit from statistical process control and data analytics, optimizing efficiency and agility. The learning and growth perspective gains significance by emphasizing digital literacy and innovation to navigate the Industry 4.0 landscape. The traditional Balanced Scorecard, developed by Kaplan and Norton, provides a foundational understanding of strategic management, emphasizing financial, customer, internal processes, and learning and growth perspectives. It serves as a communication tool aligning the organization with strategic goals, fostering a cause-and-effect relationship among perspectives.

The SBSC optimizes internal processes through statistical analysis, making continuous improvement data-driven. Learning and growth emphasize skills needed in Industry 4.0, aligning human capital with technological advancements. The SBSC establishes causal relationships between indicators, enabling proactive decision-making. The integration of the Balanced Scorecard with Industry 4.0 and Quality 4.0 aligns organizational performance measurement with transformative technologies. Financial metrics adapt to data-driven analytics, the customer perspective embraces real-time data, and internal processes optimize through Industry 4.0 technologies. Quality 4.0 aligns with the Balanced Scorecard, driving continuous improvement through data-driven insights.

Table 2 highlights aspects of Balanced Scorecard integration with Industry 4.0, emphasizing adaptation across financial, customer, internal processes, learning and growth, cascading objectives, and continuous monitoring. Table 3 outlines the advantages of this integration, such as real-time decision-making, data-driven performance management, optimized operational efficiency, enhanced customer experience, strategic alignment, and proactive risk management. Table 4 addresses potential problems and suggests overcoming strategies, including data governance, integration analysis, robust cybersecurity measures, comprehensive training programs, thorough cost-benefit analysis, and advocacy for standardization.

The integration of the Balanced Scorecard with Industry 4.0, enhanced by statistical methods, positions organizations to thrive in the digital era. It empowers data-driven decision-making, strategic alignment with technology trends, and continuous improvement, paving the way for sustained success and competitiveness.

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