JACEK WOŹNIAK*

DIGITIZATION OF INNOVATIVE ENTERPRISES IN POLAND

Introduction

Innovative enterprises are today perceived as entities that can keep up with local, regional, and national challenges and fit into global trends [Ridley, 2020; Czyżewska, 2020] and, in principle, can undertake competitive competition in a planned and conscious manner, focusing on shaping competitive advantages (in the areas of product, process, management and organization, marketing, etc. [Zastempowski, 2016]), using the potential of the environment [Woźniak, 2021]. Innovative companies are also perceived as learning, intelligent, open to the environment, and dynamic [Kuś, 2020].

However, it is worth considering how innovative companies approach the digitization of their operations and whether they thus fit into a kind of global megatrend related to the widespread and large-scale digitization of management processes [Ellitan, 2020]. If this is the case, it may mean that innovative companies recognize the importance of this megatrend and understand that they are conducting their business in the conditions of the so-called Industry 4.0 [Alaloul et al., 2018; Rymarczyk, 2020] – fitting into this trend and at the same time taking advantage of it.

Nowadays, ICTs (Information and Communication Technologies) constitute a significant set of tools companies can use in various ways to support their growth and development [Al Busaidi et al., 2019; Alam et al., 2022; Lei et al., 2024]. Over the past dozen or so years, the rapid advancement of technologies that improve data management and communication has been clearly observable. Innovative enterprises, to operate systemically, should develop every aspect of their business [Wojnicka-Sycz, 2020: 145 et seq.] – not only manufacturing processes, distribution, or contacts with customers and subcontractors, but also information resource management and digitization of both core and support processes. This is particularly important

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for ensuring their sustainable and stable development in a globalized world [Sysko-Romańczuk, 2021: 180–181]. This tendency is clearly reflected in market trends. For example, according to a study conducted in 2023 on behalf of PARP[1] [Piotrowski et al., 2023: 13], "regardless of whether or not they conduct innovative activities, as many as 94.3% of entrepreneurs indicated that they use at least one of the information and communication technologies. Companies use them for marketing, sales, or customer contacts. Broadly understood communication with the market is one of the basic areas in which digital technologies are used. This has not changed fundamentally compared to the situation in 2021, even though company websites also continued to appear in the first place regarding frequency. Importantly, innovative companies use all solutions more often, which can be considered a manifestation of a general attitude towards modern solutions". These results indicate that enterprises (including those conducting innovative activities) use various ICTs to shape their development.

Moreover, Zaskórski and Woźniak [2023: 58] emphasize the importance of a holistic and systemic approach to implementing ICT technologies and techniques, as evidenced by the following statement: "Virtualization of modern business organizations is becoming a method of increasing their efficiency and business continuity. The phenomenon of potential synergy is a premise for the constructive interaction of effects of the entire system. Connecting multiple entities to conduct joint activities through access to integrated information resources increases security and business continuity. It is also the basis for making rational decisions by shaping the necessary level of situational awareness". An important note is that innovative companies do not necessarily have to implement ICTs independently – they can enter into relationships with business partners with their infrastructure.

It is also worth referring to Wu [2023: 68], who notes that the effective implementation of ICT technologies and techniques requires both digital leadership and digitization strategy within the enterprise. Without these elements, it is impossible to develop innovative activities and maintain the entrepreneurial potential of the organization. Research findings by Ren et al. [2023: 8] note that the degree of digitization of enterprises is positively correlated with the so-called level of digital awareness of managers. Improving the digital competencies of employees, providing regular training in the use of specific ICT tools, and improving the efficiency of their application can significantly increase the overall effectiveness and performance of organizations, including innovative ones [Hempell et al., 2004; Vidas-Bubanja, Knežević, 2010; Wang, Qi, 2021]. In turn, Valdez et al. [2018: 3 et seq.] combine the issue of the use of ICT technologies and techniques with the improvement of knowledge management, which can significantly support innovation processes. ICTs can also strengthen the phenomenon of "electronic social entrepreneurship" by integrating ICTs with efforts

[1] Polish Agency for Enterprise Development.

to meet social needs and deliver value to stakeholders – an approach expected to lead to sustainable business operations [Javed et al., 2021]. This is particularly important for innovative companies that „build" their business models on value, perceived, among others, through the prism of so-called positive social impact.

Summing up the above considerations, it is possible to quote the words of Trzepizur [2020: 16], who states that "ICTs have a key impact on a company's level of innovation. They are an overriding element in eliminating restrictions that prevent innovation. The higher the availability rate of technology in an organization, the easier and more efficient it is to innovate". However, at this point, it is worth recalling the observation of Erdiaw-Kwasie et al. [2022: 1], who note that "new business opportunities and models continue to emerge using ICTs; however, not every business can leverage these opportunities via technology". This shows that every innovative enterprise should implement such technologies that are a direct response to its specific needs while also taking into account its limitations – whether informational, financial, human, competence-based, or relational. Therefore, the conscious and intelligent use of ICTs is about companies moving from the state of "doing digital" to "being digital" [Deloitte, 2022: 3–4]. The state of "being digital" means, above all [Deloitte, 2022: 4]:

- "Moving beyond transactions creating a meaningful, differentiated, and personalized experience for customers and patients.
- Enabling more evidence-based decision-making (…),
- Modernizing processes/systems across the entire value chain and in core functions.
- Leveraging data/analytics to create actionable insights that drive growth and operational efficiency.
- Breaking down functional silos to create empowered and accountable multidisciplinary teams that drive and track investment decisions and performance.
- Enhancing business agility to keep pace with the constant changes".

A planned digitization strategy and conscious investment in ICTs are essential to achieving these outcomes. Thus, the above content suggests that the advanced digitization of innovation-related activities is crucial for innovative companies to operate effectively and deliver value to both internal and external stakeholders.

This article assesses the scale of ICT use in Polish innovative enterprises. Its main objective is to confirm that innovative enterprises operating in Poland, which have successfully implemented at least ten innovations (in the form of a service, product, or project) for their customers over the last five years, effectively exploit the potential of ICTs. Therefore, the article is not intended to fill a specific research gap but to relate the specific characteristics of Polish innovative enterprises operating in the digital economy to findings from other authors and to current trends in digitization. The goal is, therefore, to "superstructure" existing theory, not to create new theoretical categories within the concept of the innovative enterprise.

The study consists of five main sections, which address the following issues: literature review, specification of the research methodology, results description, discussion and conclusions, and an outline of research limitations and directions for further research.

1. Literature review

1.1. The essence of digitization of innovative enterprises and the digitization strategy

Digitization of enterprises refers to the introduction of digital technologies aimed at improving the efficiency and competitiveness of business operations. It is a key component of modern business development and involves the integration of information and communication technologies (ICTs) into various areas of company's activities. In other words, the digitization of an enterprise is a transformation process in which traditional analog processes are replaced by digital technologies, enabling automation, optimization of business processes, and improved data management [Semenchuk, Lichenko, 2023; Volianska-Savchuk et al., 2023]. Volianska-Savchuk et al. [2023] and Kulinich and Sternyuk [2023] identify the automation and optimization of not only business but also management processes as fundamental aspects of enterprise digitization, including in the case of enterprises engaged in innovative activities. The authors claim that automation contributes, among other things, to increased efficiency and reduced operating costs. On the other hand, Semenchuk and Lichenko [2023], as well as Gudz and Pilnyk [2022], highlight the support of data management. In their opinion, the introduction of digital tools enables better data collection, processing, and analysis, thereby supporting decision-making. Research by Kovtunenko and Lozan [2024] and Buluy et al. [2023] indicates that digitization stimulates both product and process innovation, enhancing a company's competitiveness and its ability to adapt to changing market conditions. This is expanded by research by Shishmanov and Marinova [2023] and Kilyar et al. [2021], which point out that digitization facilitates the creation of more personalized customer experiences and fosters more effective communication and collaboration with business partners. In other words, digitization enables modern enterprises to innovate by integrating digital technologies into both internal and external processes, creating new business models. Bouncken et al. [2019] and Wang et al. [2023] note that companies can use digital technologies such as cloud computing, big data analytics, and artificial intelligence to develop new products and services. Companies undergoing digital transformation can improve their performance by allocating resources to experiment with business models and implement new strategies. Research by Bouwman et al. [2019] shows that deeper

involvement in such practices leads to better financial and market performance for innovative companies. Higón's research [2012] led to the same conclusions. It is worth emphasizing here that according to Vilaseca-Requena et al. [2007], the intensive use of ICTs in marketing and cooperation increases the innovativeness of enterprises, accelerating processes and reducing the so-called barriers to innovation. This is important because investment in ICTs and knowledge exchange are crucial for companies to cope with a dynamic global environment, as Scuotto et al. [2017] and Higón [2012] highlight.

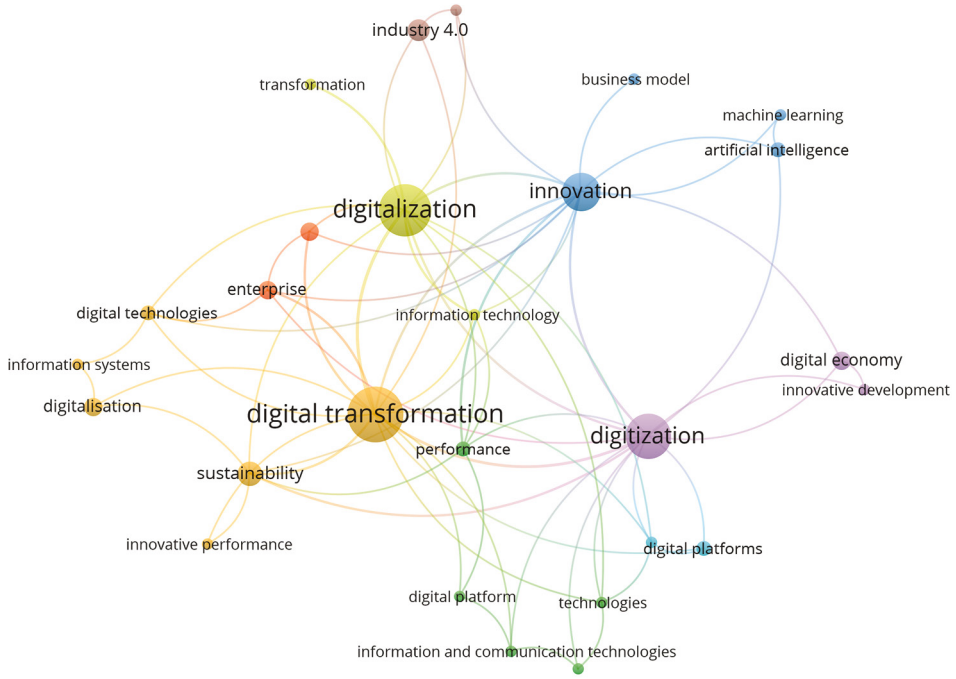
Summing up the above content, digitization has become a key driver of innovation in companies in recent years, offering new opportunities for value creation and process optimization. It is important to emphasize that, in the context of innovative companies, digitization plays a crucial role in transforming business models and enhancing market competitiveness. Kovtunenko and Lozan [2024] argue that digitization enables companies to innovate in products, processes, marketing, and organizational structures, thereby contributing to competitive advantage and increasing the efficiency of innovation activities. This is confirmed by research conducted by Wang et al. [2023], which shows that digital technologies – such as cloud computing, big data analytics, and artificial intelligence – facilitate the development of new products and services. This is also confirmed by Li's [2020] research, which indicates that digitization allows companies to adopt a variety of business models to serve distinct market and product segments.

Expanding on the above content, reference can be made to the research of Parida et al. [2019], suggesting that the digitization of enterprises also requires innovation in business models, such as the transition to advanced service models, which is necessary to exploit the potential of digital technologies fully. These authors [Parida et al., 2019] also note that business model innovation is key to achieving sustainability benefits and delivering and capturing value. To improve the business models of innovative entities in the context of digital transformation, attention should be paid to the need for appropriate organizational and employee competencies and adaptation to new working conditions and digital identities [Rachinger et al., 2019; Bouncken et al., 2019].

The above considerations regarding the essence and importance of digitization for innovative enterprises can be confirmed by analyzing keywords from texts (articles, chapters, reports, documents, etc.) published in the Scopus database in 2015–2025. The query to the database was limited to three words: "digitization," "innovative," and "enterprise." Considering only those words defining the subject area of the analysis was a deliberate procedure. The approach was to include as many publications as possible in the study and, consequently, to analyze as many potential keywords from these publications as possible regarding interconnections and co-occurrence. The Scopus database generated a list of 112 documents published in English, from which keywords

were extracted. From all the documents, 475 different so-called author's keywords[2] were extracted and covered by those publications. The minimum number of times each keyword appears in publications is two. From the forty keywords obtained this way, 13 words that did not fit the subject of the analysis were removed. In this way, the final set of keywords was obtained, based on which a map of links (Figure 1) was developed on the issues of digitization of innovative enterprises. VOSviewer software was used to create the map.

Figure 1. Factors related to the digitization of enterprises – a map of connections



Source: own study using VOSviewer (ver. 1.6.20).

The map (Figure 1) indicates that the terms "digital transformation", "digitization," and "digitalization" occur most frequently and display the highest number ofconnections. The term "innovation" is also of considerable importance. Specific keyword clusters have formed around these central concepts. First, it is worth noting the high number of connections and the noticeable proximity of keywords related to digitization, particularly those associated with information and communication technologies. These terms appear frequently and in various forms across the selected articles. In addition to categories referring to internal organizational changes – such as

[2] These are the keywords provided directly by the authors of the publication and included in the abstracts.

those involved in innovation processes – some terms extend into the broader context of enterprise digitization, including references to concepts like "Industry 4.0" and the "digital economy." The map analysis (Figure 1) also highlights the importance of developing a strategy for digitizing innovative entities. This is evidenced by the presence of keywords related to business models, the long-term development of innovative companies, and broader themes such as the digital economy and digital transformation.

The digitization strategy is essential for innovation actors who want to survive and thrive in the digital age [Chanias et al., 2019; Parviainen et al., 2022]. As Warner and Wäger [2019] and Matt et al. [2015] note, digitization involves not only the adoption of modern technologies but also the transformation of business models, processes, and organizational structures to address new challenges and capitalize on the opportunities offered by digital technologies. Formulating a digitization strategy is a dynamic and iterative process that requires continuous learning and action. That is why the research results by Kringelum et al. [2024] are particularly relevant – they emphasize that developing digital competencies among managers and employees is essential for effectively implementation of a digitization strategy. In addition, Kringelum et al. [2024] stress that discussing and clearly communicating the vision and strategic direction of enterprise digitization is crucial. Such communication provides all stakeholders – including employees and customers – with a shared understanding of the goals and direction of the transformation. Ribeiro [2022], on the other hand, highlights leadership, innovation, and organizational structure as the key factors in shaping and developing the digitization strategy of innovative entities. While the above-mentioned research and analyses focus primarily on the managerial dimension, this alone is not sufficient to define a fully developed digitization strategy. A valuable complement is offered by Oriekhova and Kharchenko [2024], who argue that the issue of information resources and the implementation of relevant ICTs must be considered. They identify three critical aspects: (1) selecting appropriate technologies and tools that best align with the needs and objectives of the innovative company, (2) ensuring information security, and (3) analyzing and planning the information and infrastructure resources necessary for implementing digital technologies.

1.2. ICTs used in innovative enterprises

At this point, it is essential to consider which technologies can potentially be implemented and developed in innovative enterprises to create and enhance digital strategies. According to the analyses by Zaskórski and Woźniak [2023: 55–58], the key ICT tools include data analysis (including Big Data), the Internet of Things, cloud computing, and artificial intelligence. In the opinion of these authors, ICT technologies

and techniques related to business virtualization processes are also noteworthy. Similar conclusions were drawn by Park et al. [2020], who identified Bid Data, the Internet of Things, and cloud computing as key technologies driving innovation and playing a vital role in innovative entities. These technologies are essentials for enabling modern applications and services through efficient data processing, analysis, and process automation. In addition, Park et al. [2020] highlight the potential of artificial intelligence (AI) in supporting automation and optimization, as well as the role of blockchain technology in ensuring data security and privacy – factors that are increasingly critical in today's innovative landscape. The relevance of Internet-based computing technologies is pointed out by Lyytinen and Rose [2003], who describe them as disruptive innovations. According to these authors, such technologies fundamentally alter how ICT is applied in enterprises, including innovative ones, leading to profound changes in application portfolios and development practices.

Other authors also emphasize the importance of the technologies mentioned above. Knosala et al. [2024] highlight the role and importance of several ICT tools and techniques, including cloud computing, artificial intelligence, mobile technologies, augmented and virtual reality, and blockchain. The authors note that these solutions will continue to evolve, contributing both to improved business operations and to enhancing everyday life [Knosala et al., 2024: 314–316]. What is more, they emphasize that ICTs are not only innovations but also divers of innovative activity within enterprises. Therefore, their application is essential in the current conditions of a rapidly changing and broadly defined external environment [Knosala et al., 2024: 9–12].

In turn, Jurdeczka [2020] notes that artificial intelligence technology plays an essential role in enterprise development, including in organizations engaged in innovative activities. The author highlights the aspects of ethical concerns associated with ICT solutions, particularly in the areas of data manipulation and security [Jurdeczka, 2020: 57–59]. On the other hand, Marczak [2018: 129 et seq.] raises the issue of using the potential of cloud computing technology in shaping enterprise development, drawing attention not only to its benefits but also to the risks associated with implementing this technology. On the other hand, Łobejko [2018: 73 et seq.] like Zaskórski and Woźniak, points to the growing significance ofdata analysis technologies, particularly business intelligence, Big Data, and artificial intelligence solutions.

Integrated information management systems are also used in the activities of innovative enterprises. Kyriakou et al. [2016] indicate that ERP (Enterprise Resource Planning) and CRM (Customer Relationship Management) systems should be implemented in innovative activities. They can be widely used in enterprises to support product and process innovations. Research by Kyriakou et al. [2016] shows that these systems positively impact innovation, with e-sales systems being compelling drivers of product innovation.

Focusing on supporting innovation processes (from an internal organizational perspective), it is worth referring to the research of Scuotto et al. [2017], which highlights the importance of technologies supporting collaboration and teleworking. They are helpful because they enable effective communication in project teams and the exchange of knowledge (also with external entities).

1.3. The complexity of digitization

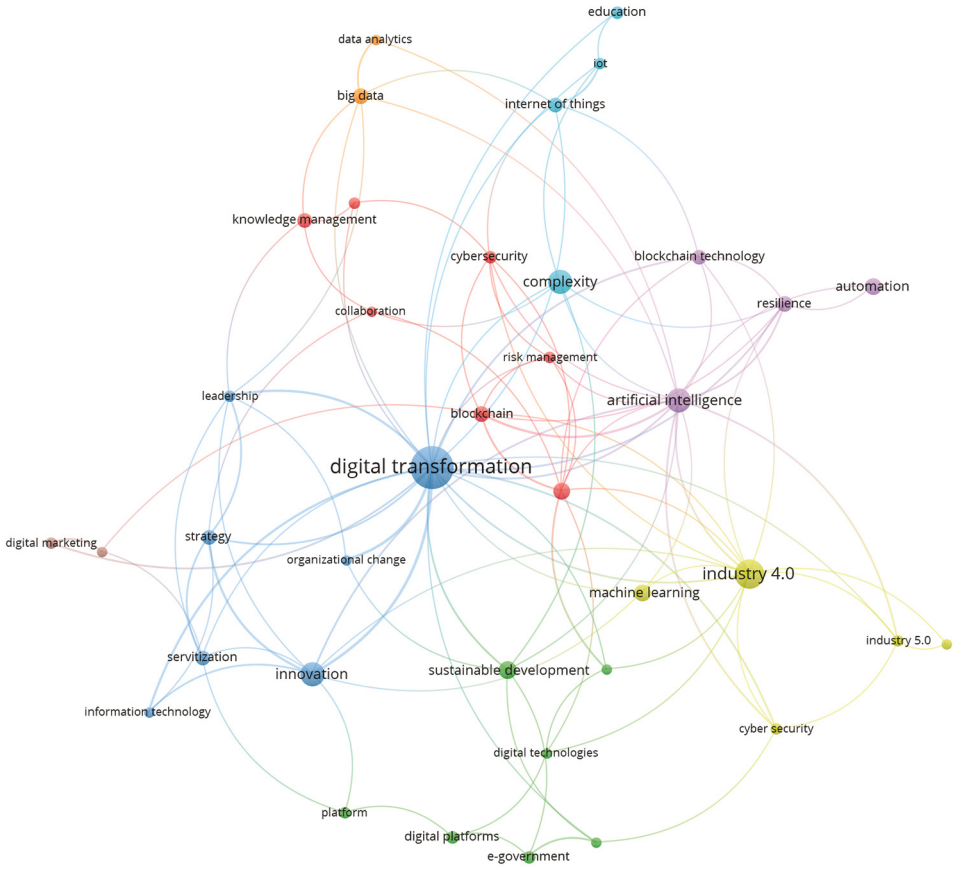
Digitization is a complex process affecting various aspects of enterprises' functioning [Park, Mithas, 2020], including their structures, processes, and business models. In their research, Urbach et al. [2018] and Snow et al. [2017] note that introducing digital technologies such as social media, cloud computing, the Internet of Things, and artificial intelligence is changing how innovative enterprises operate and collaborate. Thus, digitization requires a strategic and cultural alignment of digital technologies within the enterprise [Vendraminelli et al., 2022] and in stakeholder relations. This requires a change in management [Snow et al., 2017; Cortellazzo et al., 2019] and innovative activities. In addition, as digital technologies evolve, enterprise architectures are becoming increasingly complex. Therefore, these entities must identify and avoid unnecessary complexity in ICT implementation [Revina et al., 2021]. That is why it is so important to use only those technologies that can effectively support the development of innovative activities. The complexity of digitization can, therefore, be described as the number of ICT technologies implemented and used in the company and the scope of their functions. It is also essential that the complexity of the digitization of enterprises results from the relationship between various organizational dimensions (functional areas, e.g., sales, marketing, production, finance, etc.) and the requirements of innovative processes. In a business context, this complexity is further determined by the need to integrate new digital technologies into existing IT systems [Lakemond et al., 2021].

Also, in addressing the issue of the complexity of digitization of enterprises, an analysis of keywords from texts (articles, chapters, reports, documents, etc.) published in the Scopus database in 2015–2025 was conducted. The database query was limited to two terms: "digitization" and "complexity". This was a deliberate approach aimed at including as many relevant publications as possible and, consequently, analyzing a broad range of potential keywords from these publications in terms of their mutual connections and co-occurrence. The Scopus database generated a list of 884 documents, from which 39 keywords related to the activities of innovative enterprises were selected for analysis[3]. The minimum threshold for keyword occurrence was set at five,

[3] These are the keywords provided directly by the authors and included in the abstracts, which are part of the abstract.

ensuring that the keywords included in the study were not randomly or individually indicated by the authors in the literature on the subject. To visualize the network of connections, the VOSviewer software was used (Figure 2).

Figure 2. Factors related to the complexity of enterprises' digitization – a map of connections



Source: own study using VOSviewer (ver. 1.6.20).

The structure of the keywords indicates that the so-called "complexity of digitization" is primarily understood as the implementation and application of various ICT technologies and techniques, e.g., "blockchain technology", "Internet of Things", "artificial intelligence", "Big Data", as well as "digital platforms". The link map also presents the complexity of digitization in managerial terms, e.g., knowledge management, data analysis, risk management, shaping corporate resilience, leadership, organizational change, and strategic planning.

2. Research methodology

2.1. Research problem and research questions

The subject of the study was the digitization of innovative enterprises in Poland, and the objective is to assess the scale of ICTs' use in Polish innovative enterprises. Its main aim is to confirm that innovative enterprises operating in Poland that successfully implemented at least ten innovations (in the form of a service, product, or project) for their customers in the last five years of their activity exploit the potential of ICTs. The research refers to the ratings and opinions of respondents. The research problem concerns which technologies and with what frequency are used in Polish innovative enterprises, i.e., how these entities shape the digitization of their activities. The study posed the following research questions:

[RQ-1] How do innovative companies approach the digitization strategy?

[RQ-2] Which ICT technologies and techniques are most often implemented in innovative enterprises?

[RQ-3] What is the complexity of digitization of innovative enterprises?

Answering the above questions requires a clear definition of the study's scope and a detailed specification of the research methods.

2.2. Scope of the study and research methods

The study's objective, subjective, spatial, and temporal scope was determined (Table 1).

Table 1. Scope of the empirical study

Scope	Description
Objective scope	The digitization of innovative enterprise in Poland. The research focuses exclusively on the implementation of essential ICT technologies and techniques.
Subjective scope	The study was conducted on a random sample (proportional stratified sampling – the strata were determined by the numbering of PKD sections) of innovative enterprises [Rószkiewicz, 2021: 24–26]. Respondents were business owners or managers responsible for digitization processes, innovation management, or project management (one respondent per surveyed company). The research sample included two hundred large enterprises operating in Poland. Enterprises were eligible to participate if they answered "yes" to the screening question: Have you successfully implemented at least ten innovations (in the form of a service, product, or project) for your customers in the last five years of your activity on the market? The study focused on Poland, as the main objective was to present how Polish innovative enterprises approach the implementation of ICT technologies and techniques in the context of global trends. The exclusive focus on large enterprises is justified by the fact that such entities are typically not subject to severe constraints (e.g., financial or human resource limitations). Therefore, they can conduct innovative processes and implement innovations on a relatively large scale in the market. Large entities also have more outstanding resource capabilities and more significant needs in terms of IT infrastructure development and ICT implementation.

cont. Table 1

Scope	Description
Spatial scope	The study covered the entire territory of Poland, with the surveyed enterprises located in all sixteen voivodeships.
Temporal scope	The survey was conducted in June 2024 and covered the last five years of business activity, January 2019 – December 2023. The IPC Research Institute (Wrocław) collected the empirical data. The study considered the previous five years of business activity, as it was believed that this period would be sufficient for companies to successfully implement at least ten innovations (in the form of a service, product, or project) for their customers. A longer extended period could cause problems for respondents (old projects that are no longer primarily remembered).

Source: own study.

Both inductive and deductive approaches were used in the study [Sułkowski, 2012: 95 et seq.; Dobrzycka, 2014: 281 et seq.; Wojciechowska, 2016: 116 et seq.]. However, the inductive approach played the leading role in the study. This is because implementing the survey objective requires collecting detailed answers from respondents. Based on these answers, it is possible to make specific generalizations regarding the approach of innovative enterprises from Poland to the use of the potential of ICT. The inductive approach also provides a basis for determining the differences between individual surveyed entities, which can further improve the quality of the inference process. The study used methods of analysis and synthesis [Hajduk, 2012: 119]. The leading empirical method was a diagnostic survey [Karbownik, 2017: 177 et seq.] in a CAWI (Computer-Assisted Web Interview) survey. The study decided to use the CAWI survey because it allows for the effective collection of empirical data, reaching precisely selected respondents. In addition, the CAWI survey reduces costs, which was important in the case of the study described. The CAWI survey allows the respondents to answer at a convenient time and place without pressure from an external interviewer (from the research company). The respondents can think carefully about the answers, which leads to a higher quality of empirical data. In addition, the statistical analysis technique of quantitative data was used [Sudoł, 2012: 136–145; Apanowicz, 2005: 57 et seq.; Zaborek, 2009: 41–49]. The primary research tool was the CAWI questionnaire, which contained a metric – five questions, the central part – eleven detailed questions requiring respondents to assess them on a 5-point scale (the value "1" meant very rarely, and "5" – very often), five single-choice detailed questions, as well as one screening question. In addition, PS IMAGO PRO 10.0 and MS Excel software were used (for calculating descriptive statistics, performing factor analysis PCA and cluster analysis – *k*-means method, and sketching graphs).

2.3. Description of the research sample

The research sample (N=200) included only large enterprises (i.e., those employing at least 250 employees) operating in Poland's most innovative sectors[4]. Proportional random sampling was applied within strata (with the activity profile – PKD department- defining the strata).) Ten strata were identified, encompassing fourteen PKD departments. Accordingly, 10% of entities were included in each stratum (Table 2).

Table 2. Leading business profile (N=200)

PKD department	Description	%
	Production	
10	Food production	10
11	Beverage production	
13	Textile production	10
14	Clothing production	
20	Chemical and chemical products production	10
21	Essential pharmaceutical substances, as well as medicines and other pharmaceutical products production	10
26	Computer, electronic, and optical products production	10
27	Electrical equipment production	
29	Motor vehicles, trailers, and semi-trailers production (excluding motorcycles)	10
	Services	
52	Warehousing and service activities supporting transport	10
59	Activities related to the production of films, video recordings, television programs, sound and music recordings	10
61	Telecommunications	10
62	Software and IT consulting activities and related activities	
65	Insurance, reinsurance, and pension funds (excluding compulsory social security)	10

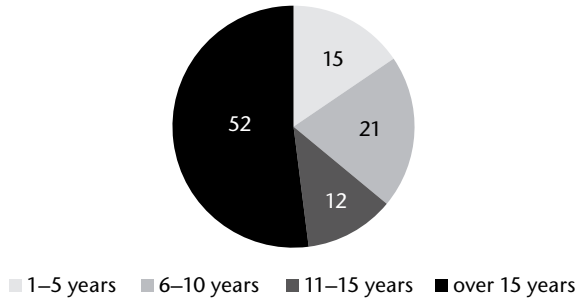
Source: own study.

Considering the age criterion, it should be noted that the research sample was dominated by entities operating on the market over 15 years (52% of responses) (Figure 3). On the other hand, considering the scale of operations, it can be noted that the most significant percentage of enterprises operated nationally (9–16 voivodeships in Poland) – 35%. A relatively substantial percentage were also entities operating on a regional scale (1–8 voivodeships in Poland) – 27% and internationally (at least one country in the world outside Europe – including Poland) – 24%. The smallest percentage were enterprises conducting innovative activities on a European scale – at

[4] When selecting sectors, reference was made to statistics published in [Kolasa, 2021: 27; 2024: 11–14, 36].

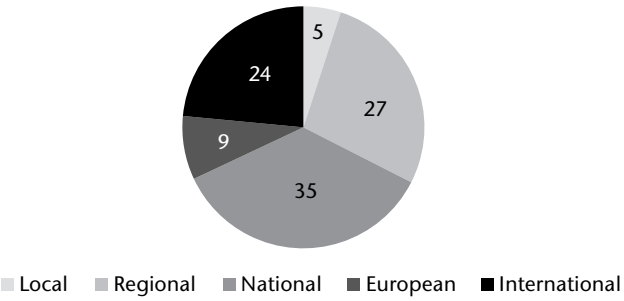
least one country in Europe outside Poland (9%) and local – one city/commune/district (5%) (Figure 4).

Figure 3. Age of the surveyed enterprises (N = 200)



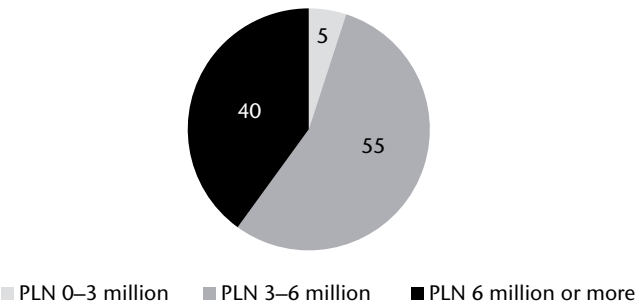
Source: own study.

Figure 4. The scale of the surveyed enterprises' operations (N=200)



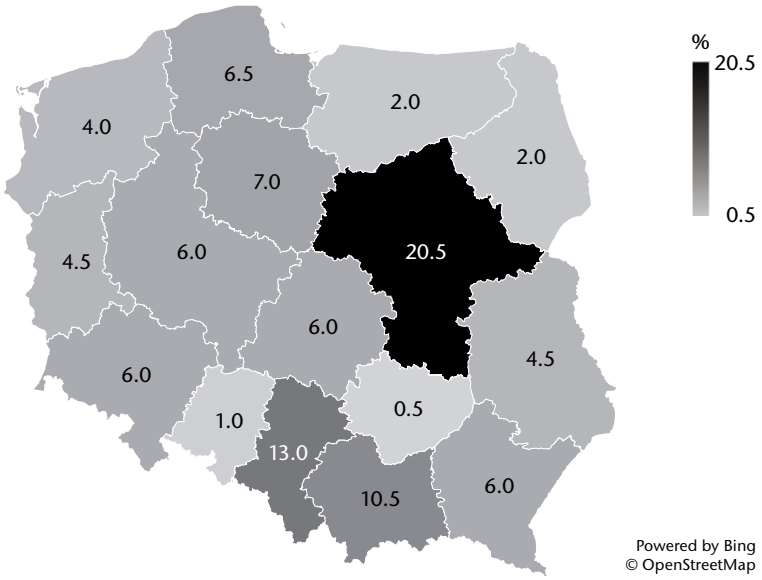
Source: own study.

Figure 5. Average annual turnover of the surveyed enterprises – values in PLN million (N = 200)



Source: own study.

Figure 6. Voivodeships in which the surveyed enterprises were located (N = 200)



Source: own study.

Most surveyed entities showed an average annual turnover of PLN 3 6 million (55%). A significant number of enterprises had a turnover of PLN 6 million or more (40%) (Figure 5). Considering the spatial distribution of the surveyed enterprises, it should be noted that most were in the following voivodeships: Mazowieckie (20.5%), Małopolskie (10.5%) and Śląskie (13.0%) (Figure 6).

Given the characteristics of the research samplepresented above, it should be noted that it is diversified. The sample size (N=200) may be considered representative. The minimum sample size for a designated population of large innovative enterprises is 183 entities[5]. Therefore, the study's author assumes that the conclusions from the analyses can be partially generalized and applied to the entire population. However, the author knows that each innovative company operates according to its own "mechanisms," so individual conclusions should be profiled in improving management in specific enterprises.

[5] The calculations were based on the methodology contained in the publication [Sopińska, Dziurski, 2018: 78–79]. Data on the size of the population were determined based on data published in December 2023 (state at the end of 2022) contained in [GUS, 2023a: 16; 2023b: 30].

3. Empirical results

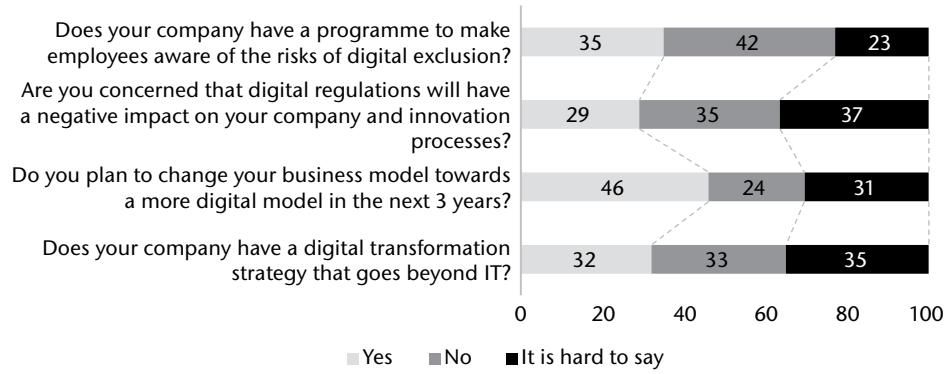
When considering the digitization of innovative enterprises, it is first worth focusing on how companies of this class approach the digitization strategy. A relatively large percentage of respondents indicated that (Figure 7):

- the company does not have a program to make employees aware of the risks of digital exclusion (42%), or it is difficult to answer whether such practices are in place (23%),
- the company does not have a digital transformation strategy that goes beyond the IT area (33%), or it is difficult to answer whether such a strategy exists (35%).

However, it is promising that a significant percentage of the surveyed companies plan to change their business model towards a more digital model in the next three years (46%) and are not afraid that regulations on digital technologies will hurt the company and innovation processes (35%) (Figure 7).

Another issue in shaping the digitization strategy is the planned investments in digital technologies. A significant percentage of respondents said they plan to invest in digital technologies at the same level as before (30%) or on a larger scale than in previous years (28%) in the next twelve months. Only 7% of respondents declared a reduction in the scope of investments (Figure 8).

Figure 7. Approach to the digitization strategy (N=200)

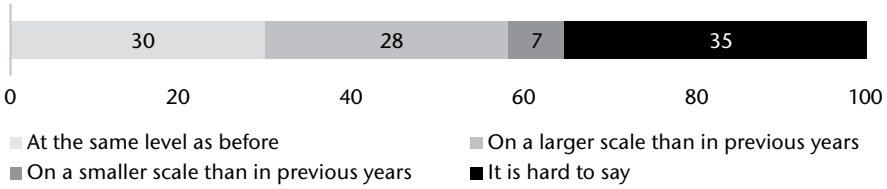


Source: own study.

Another issue considered was which ICT technologies and techniques are most frequently implemented in innovative enterprises (as part of innovative processes). The study identifies eleven essential ICT technologies and techniques that are currently available and can be implemented in enterprises (Table 6). The selection of ICT technologies and techniques was based on the following studies: [Zaskórski, Woźniak,

2023: 49–58; Knosala et al., 2024: 13 et seq.; Marczak, 2018: 129 et seq.; Jurdeczka, 2020: 40 et seq.; Łobejko, 2018: 66 et seq.]. At this point, however, it should be noted that the author is aware that more ICT techniques and technologies could be implemented in business activity. Still, due to the limited research budget and the complexity of the issues, it was necessary to select the most popular solutions and aggregate them into specific coherent sets of technologies[6].

Figure 8. Approach to digital investments (N=200)



Source: own study.

Each of the technologies included in the study was rated by respondents using a 5-point scale, where the value "1" meant very infrequent use of the technology, and "5" indicated widespread use. Based on the respondents' answers, the most used ICT technologies and techniques are wireless networks (average application frequency \ of 3.86), firewalls (3.54), VPN (3.46), network protocols (3.33), and cloud computing (3.00). All the ICT technologies and techniques mentioned above received average ratings of at least 3.00, which corresponds to the median value on the 5-point rating scale. On the other hand, the least frequently used ICT solutions, in the respondents' opinion, are artificial intelligence (average frequency of application: 2.42) and the Internet of Things (2.60) (Table 3).

Another issue analyzed is the complexity of the digitization of innovative enterprises. The factor analysis method (principal components method) was used to estimate this complexity, and the CD_{IE} composite index (the complexity of digitization of innovative enterprises) was developed as a weighted average. The CD_{IE} indicator indicates how often ICT technologies and techniques included in the survey are used on average. Therefore, the CD_{IE} indicator says – in some simplification – about the complexity of the digitization of innovative enterprises. The analysis used the methodology of constructing the above indicator, referring to eleven partial meters (Table 3). The CD_{IE} composite index was used in the study because it enables: (1) conducting a holistic analysis, (2) quantifying and evaluating phenomena (which by their nature are complex and relatively difficult to quantify),

[6] The study did not consider, e.g., blockchain, augmented reality, virtual reality, and 5G technologies.

as well as (3) considering a large number of partial meters and grouping them into thematically coherent components [Nardo et al., 2005].

Table 3. Frequency of use of ICT technologies and techniques in innovation processes (N = 200)

No.	ICT technologies and techniques – partial meters	Mean
m1	**Wireless networks**, such as Wi-Fi and Bluetooth	3.86
m2	**Virtualization**, i.e., techniques that allow multiple operating systems to run on a single physical server, e.g., VMware, VirtualBox	2.82
m3	**Network protocols**, i.e., sets of rules and conventions that enable communication between devices on a network, e.g., TCP/IP, HTTP, SMTP	3.33
m4	**Firewalls**, i.e., systems that protect networks against unauthorized access, e.g., iptables, Cisco ASA	3.54
m5	**VPN**, i.e., a technology that enables a secure connection between remote locations, e.g., OpenVPN, IPsec	3.46
m6	**Cryptography**, i.e., data encryption techniques, e.g., AES, RSA, SHA-256	2.88
m7	**Cloud computing**, i.e., the use of computing resources and data storage in the cloud, e.g., Amazon AWS, Microsoft Azure	3.00
m8	**Big Data**, i.e., technologies for processing vast amounts of data, e.g., Hadoop, Spark	2.91
m9	**IoT** – Internet of Things, i.e., technology that enables communication between devices such as smart TVs, refrigerators, or cars, e.g., Raspberry Pi, Arduino	2.60
m10	**DNS**, i.e., a system for translating domain names into IP addresses, e.g., BIND, Google Cloud DNS	2.87
m11	**Artificial intelligence**	2.42

Source: own study.

Table 4. Alfa Cronbach statistics (N=200)

Cronbach's alfa	Number of partial meters
0.841	11

Source: own study.

To verify the quality of the data, the scale reliability analysis was performed using Cronbach's alpha coefficient. For the complete list of eleven measures, Cronbach's alpha factor was 0.841 (Table 4). The methodological recommendations developed by the OECD [2008] were applied to constructing the CD_{IE} indicator. The adopted methodology included the following steps [Nardo et al., 2005]: (1) determining the scope of measurement and the legitimacy of the use of the composite indicator; (2) selection of sub-meters; (3) assessing the quality of empirical data; (4) evaluation of the relationship between partial meters; (5) assigning component weights and their aggregation into a composite index.

The results of the first three stages are presented above. In assessing the relationship between partial measures and the aggregation of components to the CD_{IE}

composite index, the factor analysis method (using principal components analysis – PCA) was used [Hudrliková, 2013]. The Kaiser-Mayer-Olkin coefficient[7] and the Bartlett sphericity test were used to verify the correctness of the PCA analysis application. The KMO coefficient took the value of 0.867. The Bartlett sphericity test showed that the hypothesis of uncorrelated coefficients could be rejected (significance level lower than 0.001) (Table 5). Further PCA analysis is justified and methodically correct.

Table 5. The Kaiser-Mayer-Olkin test and the Bartlett test (N = 200)

KMO measure of sampling adequacy		0.867
Bartlett sphericity test	Approximate chi-square	702.887
	df	55
	Significance	<0.001

Source: own study.

Table 6. Totals of squares of loads after rotation (N=200)

Component	Initial eigenvalues			Totals of squares of loads after rotation		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
No. 1 (C1)	4.435	40.319	40.319	3.119	28.355	28.355
No. 2 (C2)	1.300	11.820	52.139	2.616	23.783	52.139

Source: own study.

Table 7. Rotated components' matrix (N=200)

No.	ICT technologies and techniques	Component	
		No. 1	No. 2
m1	Wireless networks	–0.176	0.574
m2	Virtualization	0.247	0.603
m3	Network protocols	0.220	0.713
m4	Firewalls	0.296	0.739
m5	VPN	0.416	0.519
m6	Cryptography	0.452	0.596
m7	Cloud computing	0.642	0.348
m8	Big Data	0.753	0.267
m9	IoT – Internet of Things	0.811	0.000
m10	DNS	0.763	0.195
m11	Artificial intelligence	0.542	0.119

Method of extracting factors – principal components.
Rotation method – Varimax with Kaiser normalization. The rotation has reached convergence in three iterations.

Source: own study.

[7] The KMO cut-off is assumed to be between 0.5 and 0.7 [Williams et al., 2012].

Table 8. Components' weights (N = 200)

Component	Partial meters	Component weight
No. 1 (C1)	m7–m11	0.54
No. 2 (C2)	m1–m6	0.46
SUM:		**1.00**

Source: own study.

In further analysis, the principal components method with Varimax rotation was used. The rotation has converged after three iterations. Factor analysis provided the basis for classifying eleven measures into two components, with the sum of their squared loadings after rotation accounting for approximately 52% of the total variance (Table 6). Assigning the measures to the components of the CD_{IE} index based on a matrix of rotated components (Table 7) made it possible to assign weights to these components – the weights were normalized by sums of squared charges, which correspond to the part of the variance explained by a given component (Table 8).

The formula for the CD_{IE} (the complexity of digitization of innovative enterprises) indicator is as follows:

$$CD_{IE} = 0.54 \cdot C1 + 0.46 \cdot C2 = (0.54 \cdot (m7 + m8 + m9 + m10 + m11)/5) + \\ + (0.46 \cdot (m1 + m2 + m3 + m4 + m5 + m6)/6).$$

Table 9. Descriptive statistics – the CD_{IE} indicator (N = 200)

Statistics	Value
Mean	3.0161
Median	3.0453
Dominant	2.69*
Standard deviation	0.81288
Variance	0.661
Skewness	–0.255
Kurtosis	–0.171
Coefficient of variation	27%
Range	3.71
Minimum	1.08
Maximum	4.78

* There are many modal values. The smallest value is specified.

Source: own study.

The developed CD_{IE} indicator formula served as the basis for calculating basic descriptive statistics (Table 9). The distribution of the index values is slightly left-skewed, indicating that a small majority of individual respondents' average ratings

exceeded the overall mean. Given that each partial measure used in the construction of the CD_{IE} indicator was rated on a 5-point scale, the indicator's average value (3.0161) can be interpreted as moderate – close to the scale's median of 3.00.

At this point, it should be noted that the study assumes that the higher value of the CD_{IE} index indicates a greater complexity of the digitization of innovative enterprises. This assumption is based on the respondents' view that the more frequently various ICT techniques and technologies are implemented and used, the more permanently they become embedded in the enterprise infrastructure and form a basis for a deliberate increase in the complexity of its digitization. Thus, the complexity of the digitization of innovative companies is moderate.

Table 10. Clusters of enterprises – the criterion of the values of the CD_{IE} indicator

	Cluster		
	No. 1	No. 2	No. 2
	Enterprises with the lowest digitization complexity values	Enterprises with moderate digitization complexity values	Enterprises with the highest digitization complexity values
Stand (CD_{IE})	–1.46254	–0.05355	1.16928
N	41	103	56
%	20.5	51.5	28

Source: own study.

An essential complement to the above results is the identification of enterprise clusters characterized by low, moderate, and high levels of digitization complexity. The research sample is dominated by entities characterized by moderate complexity of digitization of innovative activities – 103 enterprises (51.5%) (Table 10).

4. Discussion and conclusions

Summing up the findings concerning the formulation of digitization strategies, it is important to highlight the relatively high percentage of "It is hard to say" responses (ranging from 23% to 37%). This may indicate that the digitization strategy is currently not a primary focus for business owners or managers responsible for computerization/digitization, innovation, or project management. This situation is potentially problematic, as it reveals a lack of preparedness among a significant proportion of the surveyed enterprises to address the challenges of digital transformation in the context of the global economy. It also suggests a possible disconnect between innovation processes and digital transformation initiatives over the long term. Thus, there is a certain lack of consistency with the studies by Chanias et al. [2019] and Parviainen et al. [2022],

which indicated that the digitization strategy is essential for innovation actors who want to survive and thrive in the digital age. It should be noted here that companies generally think about their digitization and act related to planning, implementing, and executing the digitization strategy. However, this is not a clear trend related to their general development and systematic strengthening of their position in the market. It can be partially assumed that the results obtained are consistent with the findings of Wu [2023], as well as Ren et al. [2023] on the legitimacy of developing a digitization strategy and increasing employees' awareness (including executives responsible for innovation processes) in this area.

Referring to the results regarding the implementation of ICT technologies and techniques, it should be noted that the respondents declare more frequent use of solutions closely related to cybersecurity. This is a positive finding, as it indicates that business owners and managers are aware of digital threats that may arise during innovative processes – processes which, as is commonly known, rely heavily on know-how and knowledge, the disclosure of which may lead to tangible losses for the company and the loss of market position. Consequently, this is directly related to the „stability" of the company in the marketplace. The above results can be considered consistent with the research and recommendations of Oriekhova and Kharchenko [2024], who note that the implementation of ICTs should consider the need to ensure security information, as well as with the findings of Jurdeczka [2020].

In addition, respondents declared relatively rare use of technologies and techniques related to data processing and transmission, such as the Internet of Things, artificial intelligence, and Big Data. This situation may raise some reflection., as, in production processes, technologies as IoT and Big Data are currently – also in Poland – the basis for implementing technologically advanced processes in large, innovation-driven. Therefore, a low rating by respondents may indicate either a lack of awareness regarding the use of these technologies or – more concerning – their actual absence, which may suggest a certain degree of technological backwardness among the surveyed entities. It is also concerning from the perspective highlighted by Volianska-Savchuk et al. [2023] and Kulinich and Sternyuk [2023], who noted in their research that implementing ICTs can significantly enhance process automation and optimization. In addition, by failing to implement and apply the technologies, companies risk missing out on what Kovtunenko and Lozan [2024] and Buluy et al. [2023] emphasize in their research – namely, the stimulation of product and process innovation, increased competitiveness, and improved adaptability to changing market conditions. Artificial intelligence also received a low average rating in terms of frequency of use. However, it should be emphasized that in the survey, respondents referred to the last five years of their companies' operations, while artificial technology in Poland has gained importance only in the past one or two years. Companies are still "learning" how to use this technology effectively. The lack of large-scale use of AI adaptation may

deprive innovative companies of what Park et al. [2020] notes as essential support for process automation and optimization. In relation to the above results, it should be noted that they are somewhat diverge from the findings of Zaskórski and Woźniak [2023], Knosala et al. [2024], Jurdeczka [2020], Marczak [2018] and Łobejko [2018], as these studies emphasize the relatively high importance of technologies such as artificial intelligence, IoT, Big Data, and cloud computing.

In conclusion, it is also worth addressing the complexity of digitization in innovative enterprises. The study showed that this complexity is at a moderate level. However, the question arises: is this a favorable or unfavorable situation? In principle, it can be assumed that a moderate level of complexity is sufficient for innovative entities to carry out their core activities. Simply put, specific ICT techniques and technologies are used at a minimum adequate level to fulfill their tasks in value chains. Moreover, assessing the complexity of digitization depends on the specific characteristics of a particular company and should be interpreted accordingly. In other words, as the empirical study has shown, innovative companies do not require a highly developed level of digitization in their innovative activities. They are at the level of "doing digital" rather than "being digital", according to the Deloitte report [2022]. A high level of digitization complexity is not a prerequisite for innovative companies to function correctly and deliver value to their stakeholders. Nevertheless, the systematic development of the digitization strategy should be pursued by these entities.

Based on the research conducted, the following implications for management practice can be identified:

1. Rules (procedures) for shaping and improving the digitization strategy in an innovative enterprise should be developed. It is also essential to audit whether such a strategy already exists in the company. If it does, it should be systematized and integrated into the overall system of managing innovative activities.
2. Developing a strategy for digitizing innovative activities should begin with raising awareness among business owners and managers regarding the current level of digitization – i.e., which technologies and techniques are already in use, and which are not. This will help identify a technological gap within the company. However, when addressing this gap, it is advisable to consider only those ICTs that can generate value in innovation processes (for both internal and external customers). Although enterprises today have broad implementation possibilities, it is important to remain cautious of overinvesting in ICT, which may be dangerous for innovative entities and weaken their market position.
3. One way to improve the digitization strategy may be to assess the level of complexity of the company's digitization. This parameter can be used to define milestones for the development of digital innovation activities. While it can be a helpful tool, it is also associated with certain risks. The construction of the indicator/parameter (as proposed in the article) is based on assessing the frequency of use of specific

ICT techniques and technologies. It should be noted that, over time, and with the company's so-called "digital evolution", some technologies may lose relevance, while others may gain importance. Therefore, an increase in the company's digitization level does not necessarily imply in the value of the digitization complexity indicator.

4. The digitization of enterprises requires the development of a dedicated budget, which should consider account not only the costs of acquiring ICT techniques and technologies but also their maintenance in the broadest sense. This will serve as the basis for calculating the effectiveness of ICT investments.

When managing innovative enterprises while simultaneously striving for their systematic digitization, it is worth remembering that the digital competencies of employees must be improved. Although this issue was not the subject of the research, it remains significant, as enhancing employee competencies can reduce resistance to the implementation of new ICT tools and, in turn, increase their effectiveness in innovation processes. This should be one of the key components of enterprises' digitization strategy.

5. Research limitations and directions for further research

The empirical study was conducted on a sample of enterprises that do not fully reflect the structure of the population (i.e., the proportions between individual enterprise characteristics are not maintained). Therefore, generalization to the entire population was not possible. In addition, the CAWI questionnaire considered only selected ICT technologies and techniques (eleven in total) that can be implemented, and a highly generalized conclusion was drawn from this sample regarding the complexity of the digitization in these entities. The analyses deliberately excluded specific IT tools and systems. This was primarily due to the need to aggregate individual technologies into thematically coherent categories – so that respondents would not feel overwhelmed by the number of items to be evaluated and could focus on providing a reliable assessment of only the key ones. However, due to this approach, the conclusions obtained are less detailed. A similar simplification applies to the evaluation of actions taken by the surveyed companies in shaping their digitization and ICT investment strategies. The CAWI questionnaire focused only on a few key issues. The simplifications listed above also resulted from the study's financial limitations.

Therefore, there is a need to conduct further research. One potential direction is the assessment of the importance and scale of the use of simple tools, applications, and IT systems in innovative processes (which were omitted in this study). Another area worth considering is the identification of specific assumptions made by innovative

companies when shaping and improving their digitalization strategies. Future research may also be focus on identifying both the positive and negative effects of digitization in innovative enterprises in Poland.

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DIGITIZATION OF INNOVATIVE ENTERPRISES IN POLAND

Abstract

Nowadays, digitizing processes is considered one of the primary "ways" to improve enterprises and strengthen their position in the market. However, the question arises to what extent innovative companies use specific ICT techniques and technologies to conduct and develop their activities. To answer this question, a study was conducted on the complexity of digitization in innovative enterprises in Poland. The survey took place in June 2024 and covered a sample of two hundred large innovative companies across Poland (in all 16 voivodeships). The respondents were business owners or managers responsible for computerization/digitization processes, innovation activities, or project management. A diagnostic survey was used, applying the CAWI technique. The study aims to confirm that innovative enterprises operating in Poland – which successfully implemented at least ten innovations (in the form of a service, product, or project) for their customers over the past five years – are indeed exploiting the potential of ICTs. The survey showed that: (1) enterprises generally consider digitization and take actions related to the planning of a digital strategy, through this is not yet a standard or widespread practice; (2) innovative companies are primarily focused on investing in ICTs over the next 12 months, (3) the most commonly used ICT technologies and techniques include wireless networks, firewalls, VPNs, network protocols, and cloud computing, as well as (4) the overall complexity of digitization in innovative enterprises is at a moderate level.

Keywords: digitization, innovative enterprise, ICTs, digital strategy

JEL Classification Codes: D83, O32

CYFRYZACJA PRZEDSIĘBIORSTW INNOWACYJNYCH W POLSCE

Streszczenie

Cyfryzacja procesów uznawana jest współcześnie za jedną z podstawowych „dróg" do doskonalenia przedsiębiorstw, a także umacniania ich pozycji na rynku. Pojawia się jednak pytanie, w jakim stopniu przedsiębiorstwa innowacyjne wykorzystują określone techniki i technologie teleinformatyczne, aby prowadzić i rozwijać swoją działalność. Chcąc udzielić odpowiedzi, przeprowadzono badanie poświęcone problematyce złożoności cyfryzacji przedsiębiorstw innowacyjnych Polsce. Badanie przeprowadzono w czerwcu 2024 roku na

próbie 200 dużych przedsiębiorstw innowacyjnych zlokalizowanych na terenie całej Polski (16 województw). Respondentami byli właściciele przedsiębiorstw lub menedżerowie odpowiedzialni za procesy informatyzacji/cyfryzacji, procesy innowacyjne lub zarządzanie projektami. Zastosowano metodę sondażu diagnostycznego – z wykorzystaniem techniki CAWI. Celem badania jest potwierdzenie, że przedsiębiorstwa innowacyjne działające w Polsce, które w ciągu ostatnich pięciu lat swojej działalności z sukcesem wdrożyły dla swoich klientów co najmniej dziesięć innowacji (w postaci usługi, produktu lub projektu), wykorzystują potencjał technologii teleinformatycznych. Badanie wykazało, że: (1) przedsiębiorstwa z reguły myślą o swojej cyfryzacji i podejmują działania związane z planowaniem strategii cyfryzacji i jej wdrażaniem oraz realizacją, ale nie jest to „standardem" i bardzo częstą praktyką, (2) przedsiębiorstwa innowacyjne raczej są ukierunkowane na inwestowanie w technologie teleinformatyczne w perspektywie najbliższych 12 miesięcy, (3) najczęściej stosowanymi technologiami i technikami teleinformatycznymi są: sieci bezprzewodowe, zapory sieciowe, VPN, protokoły sieciowe, a także cloud computing, jak również (4) złożoność cyfryzacji przedsiębiorstw innowacyjnych jest na umiarkowanym poziomie.

Słowa kluczowe: cyfryzacja, przedsiębiorstwo innowacyjne, technologie teleinformatyczne, strategia cyfrowa

Kody klasyfikacji JEL: D83, O32