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THE USE OF INFORMATION AND COMMUNICATION TECHNOLOGIES AND THE EFFECTS OF INNOVATIVE ACTIVITIES

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Purpose: Contemporary enterprises operate in conditions of high volatility and complexity of the environment. One of the most dynamic dimensions of this environment are infrastructural and technological factors, in which the development of ICTs can be located. ICTs are currently an essential set of tools for implementing processes, also in the area of innovative activities. Therefore, the article focuses on the importance of utilizing ICTs in enterprises and the effects of innovative activities that may be supported by the implementation of ICTs.
Design/methodology/approach: The study employs an inductive approach. The diagnostic survey method (CAWI technique) was used. A statistical analysis of quantitative data was also used. Principal component factor analysis (PCA) was performed to develop composite indexes (*CU-effects* and *CI-enterprise*), and the values of Spearman's rho correlation coefficients were determined. The empirical study was conducted on a sample of 260 large innovative enterprises in Poland in December 2024. The survey covered the area of 16 voivodeships in Poland.
Findings: The study revealed that the average level of complexity in the potential impact of ICTs on innovative activities, as well as the average level of complexity in the importance of ICTs' use in an enterprise, is at a moderately high level. Moreover, the higher the complexity of the importance of ICTs in an enterprise, the higher the values of the potential impact of these technologies on the effects of innovative activities and the complexity of the potential impact of ICTs on the effects of innovative activities.
Research limitations/implications: The article does not aim to generalize its findings to the population of innovative enterprises operating in Poland. The set of these units is highly diverse, and the research sample did not account for the proportions between the individual attributes of the companies in the population. Moreover, the analyses were based on the opinions of respondents, which errors and subjectivity could influence. The study primarily aimed to assess the general situation regarding the importance of ICTs in innovative companies, considering their potential impact on the effects of innovative activities. The directions for further research primarily involve identifying cause-and-effect relationships between the use of various technologies, systems, and ICT tools, and the effects of innovative activities.
Practical implications: Companies should pay closer attention to the benefits that may result from implementing ICTs in innovative processes. Greater attention should also be paid to the overall importance of ICTs in the activities of enterprises. Companies should estimate the potential impact of ICTs on innovation processes and develop their own procedures in this area, which may lead to increased efficiency and effectiveness in implementing various ICTs.

Originality/value: The research results presented in this study refer to Polish conditions and expand existing knowledge on the dependence between the use of ICTs and the context of achieving specific effects of innovative activities. The survey covers the most innovative sectors in Poland, and the respondents are owners or managers. Thus, the results can serve as a valuable source of guidance for executives on whether to implement ICTs and what the potential benefits may be (not only financial, but also market, process, and others).
Keywords: information and communication technologies, innovative activities, innovative enterprise.
Category of the paper: research paper.

1. Introduction

Modern enterprises, including those engaged in innovative activities, are undergoing (to varying degrees) digital transformation, in which ICTs have taken the form of the primary tool for dynamizing intra-organizational transformations (process management), as well as the relations of enterprises with external entities, e.g., as part of the implementation of projects (Łobejko, 2020; Woźniak et al., 2024). ICTs can be understood as a family of "technologies that process, collect and transmit information in electronic form" (GUS, 2009). In other words, ICTs are a set of solutions that includes both hardware, software, telecommunications networks, web applications, and modern data and information management models (Ziemba, 2018). These include 5G technology, cloud computing, big data, the Internet of Things, industrial internet, optical fibre, data centres, advanced applications, end devices, as well as online communication tools and collaboration platforms (Jagiełło, 2024; Gil, 2025; Knosala et al., 2024). Therefore, it can be assumed that today they are a kind of "core" of business models, competitiveness, and market position, as well as cooperation and opening new fields for innovation, becoming one of the key success factors (Modern360, 2024; Gil, 2025). ICTs "power" enterprises (and their subsystems, e.g., innovative, financial, HR, marketing, etc.) with useful information resources and tools for their processing, as well as constitute a "bridge" between the enterprise and the broadly understood market. In principle, ICTs can be considered a kind of "meta-resource" of innovative enterprises that permeates and integrates other resource classes. The skilful use of these technologies (regardless of the specific tools, systems, etc. being discussed in a given company) may be a prerequisite not only for the operational activities of innovative entities, but also for their strategic resilience and business continuity (Zaskórski, Woźniak, 2024).

Therefore, this article highlights the importance of utilizing ICTs in enterprises, as well as the potential impact that these technologies can have on the effects of innovative activities. This issue seems, "at first glance", simple. It can be assumed with a high degree of probability that ICTs are implemented on a large scale in enterprises (including innovative ones) and play a significant role in the implementation of various processes that support innovative activities,

yielding beneficial effects. Nevertheless, this is not always the case, and the approach to perceiving the role of ICTs in enterprises may be ambiguous. Even the implementation of ICTs is not always planned and "provided" with the operational awareness of the managerial staff.

This article presents literature considerations and the results of empirical research, looking for answers to the following questions: *What is the level of the complexity of the potential impact of the use of ICTs on the effects of innovative activities, and the importance of the use of these technologies in the enterprise?*, as well as *How is the relationship between the importance of the use of ICTs and the potential impact of the use of these technologies on the effects of innovative activities?* The primary objective of this article is to explore the relationship between the use of ICTs and their potential impact on the effects of innovative activities. The study consists of five main parts: (1) Introduction; (2) Theoretical background of the study – specification of the importance of ICTs in the activities of enterprises and their impact on processes in the enterprise; (3) Methodological assumptions of the study; (4) Description of the results; and (5) Discussion and Conclusions.

2. The importance of ICTs in an enterprise and ICTs' impact on the effects of innovative activities

ICTs are widely used in supporting the activities of enterprises (including innovative ones), both in the perspective of short- and long-term activities (Łobejko, 2020). It can be assumed that ICTs are essential primarily in terms of (Figure 1):

- support for innovative processes, as well as dynamization and structuring of the development of innovations (products, services) – we can refer here to the issues of:
  - improving knowledge management mechanisms – digitized archiving, analysis, and sharing of data and information stimulate the learning process, allowing for better use of information resources from previous projects and faster implementation of innovations (García-Álvarez, 2015);
  - shortening the time of development and commercialization of new products/services – examples include digital twin or computer simulations, which are the basis for agile prototyping and testing of solutions (Zhu et al., 2021);
  - personalization of innovative processes – ICTs (e.g., artificial intelligence) enable the individualization of innovation on a mass scale (Marszycki, 2023);
  - reducing barriers to innovation through the use of ICT tools in marketing, communication, and cooperation with stakeholders;

- shaping and updating the company's strategy – it is necessary to refer here primarily to the possibility of integrating information resources about the company and its environment from various sources, as well as significantly improving the processes of processing and updating information resources while maintaining consistency with the pace of development of the company and the entities with which it interacts on the market (mainly customers and competitors); In this case, tools that enable the anticipation of changes in the broadly understood environment, and allows the increase in the flexibility of the company and update the development strategy, are essential (Wang, Qi, 2020; Shirazi, Hajli, 2021; Alam et al., 2022);
- improving communication and cooperation processes – at this point, it is necessary to refer primarily to enabling enterprises to enter permanent or temporary virtual and network structures (e.g. the open innovation model can be indicated here) (Sopińska, Dziurski, 2018; Nalepka, 2020); In addition, internal information and communication integration in the company is also noteworthy, related, for example, to the unblocking of communication channels between employees or between the operational and strategic levels (Jagiełło, 2024);
- support for general managerial processes – here the attention can be paid to, for example, the processes of decision-making, planning and forecasting, organizing activities, monitoring processes and the state of resources, motivating, controlling and evaluating, or reporting; In principle, every management function can be supported by ICT solutions to a large extent today (Łukasik, Zaskórski, 2025); If a company decides to engage ICTs to improve general management processes, it should be aware of entering an advanced "path" of digital transformation;
- knowledge resource management and transformation of the enterprise into a model of a "learning" or even "intelligent" unit – ICTs are the basis not only for gathering the so-called organizational knowledge, but also for its verification, e.g., in terms of completeness, consistency, reliability, etc.; Moreover, ICTs (e.g. artificial intelligence) can support humans (business owners, top managers, lower management) in partial knowledge creation – but such an activity is relatively risky (Jarmooka et al., 2020); In addition, ICTs are now becoming a "tool" for agile adaptation of enterprises to the environment (e.g. by restructuring internal relations and communication channels, as well as creating new, up-to-date knowledge, based on the analysis of experience and possible errors);
- effective data collection and analysis – this can accelerate decision-making processes and increase the level of decision accuracy; Data collection and analysis can take place either automatically or with the active participation of a human; It is also worth referring here to the issue of using ICTs in identifying information needs (Łukasik, Zaskórski, 2025).

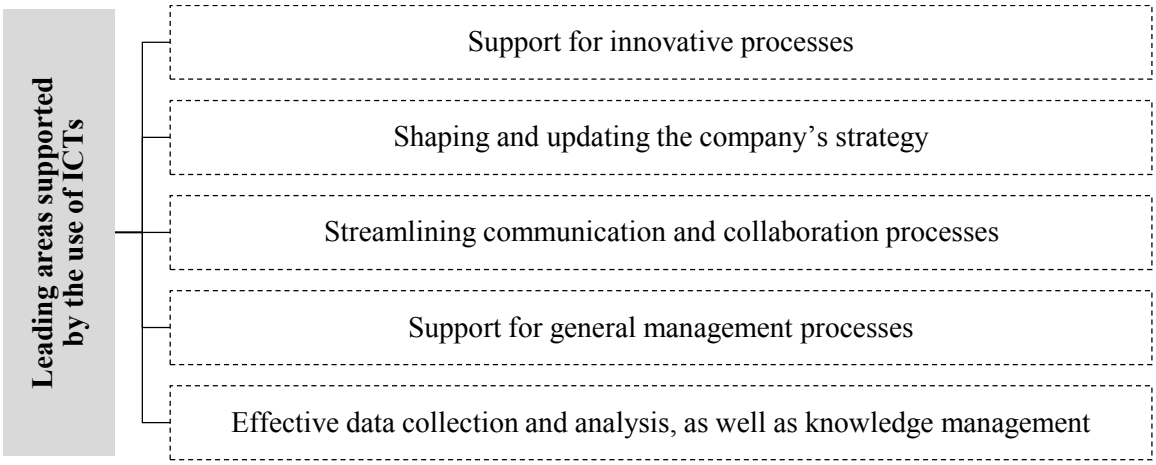

Figure 1. Leading areas supported utilizing ICTs.

Source: own elaboration.

Considering the content above, it can be assumed that the potential impact of the use of ICTs on the effects of innovative activities refers primarily to:

- information and infrastructure integration of the enterprise and its better information "embedding" in the environment, as well as better recognition of the complexity, structure, and dynamics of the enterprise's environment (the context in which it operates and implements innovative processes) (Roger et al., 2022);
- increase operational efficiency, e.g., by automating and digitizing simple, repetitive activities (Cuevas-Vargas et al., 2016; Zhu et al., 2021; Pypłacz, Sasak, 2022);
- faster decision-making and more efficient planning, including through real-time data analytics (Zaskórski, Woźniak, 2024);
- updating and hyperscaling business models (the ability to enter new markets faster and globalize operations); It is worth referring here, for example, to the use of e-commerce platforms, digital marketing, and the sale of online services (Pakulska, Poniatowska-Jaksch, 2021);
- better management of resources (mainly human, material, and financial) – this should be indicated by reducing the number of mistakes made, greater involvement of employees in the performance of tasks, or generating greater profits, higher financial efficiency of processes, ensuring financial liquidity and expansion/modernization of ICT infrastructure, etc. (Perechuda, 2015; Gërguri-Rashiti et al., 2017; Idota et al., 2021);
- reducing the phenomenon of "digital exclusion" of the company and its employees (Sobocka-Szczapa, 2017; gov.pl, 2022);
- developing a network of relationships – we can mention here the use of digital platforms and the assumptions of the sharing economy model (Poniatowska-Jaksch, Sobiecki, 2016);
- reducing the level of risk, e.g., operational or personnel risk (Yunis et al., 2017; Wang et al., 2024);

- improving the quality of customer service and creating new shopping experiences (e.g., personalization of service and offer, as well as the use of omnichannel strategies) (Maciejewski, 2025).

Because of the considerations above, it can be noted that ICTs can have a multi-faceted impact on the implementation of innovative processes and the appearance of numerous effects (mainly beneficial for the company). In this case, we can also distinguish specific dimensions of the impact of ICTs on the effects of innovative activities (Figure 2), which interact and complement each other:

- integrative and relational – attention should be paid here to the integration of the results of the company's activities (i.e. innovations) with the existing offer of this entity, as well as to the integration of the company with the market (users, business partners, etc.) and its needs, requirements, and limitations in relation to innovation;
- HR and competency-based – this dimension mainly refers to stimulating the development of digital competences of employees (the so-called creative class), which is responsible, among other things, for the conceptual stage in innovative processes; This dimension is also related to motivating employees to cooperate and share knowledge in the conditions of ICTs (fast file transfer, monitoring of work progress online, etc.);
- financial – it is related, among other things, to cost reduction in innovative processes (free or low-cost technologies with high efficiency and reliability); Costs can also be reduced as a result of lowering employee errors and erroneous management decisions, as well as shortening the implementation of specific processes – this can have a significant impact on the price and availability of innovations in the market; The financial dimension is also related to enabling the company to achieve higher profits from innovative activities;
- market – is primarily concerned with increasing the company's ability to develop and implement the innovations expected by users and increasing the company's market share;
- infrastructural and technological – ICT infrastructure is being improved, which may affect the broadly understood quality of innovation and the quality of innovative processes, as well as may increase the effectiveness of innovation distribution (digital channels and digitized customer service);
- managerial and process – this dimension refers primarily to support management and owners in knowledge management and decision-making in the field of market analysis, developing a list of new functions/options for created innovations and shaping/stimulating the scalability of the business model, or in planning further adjustments in innovative processes; This dimension may also refer to the shortening of activities in innovative processes.

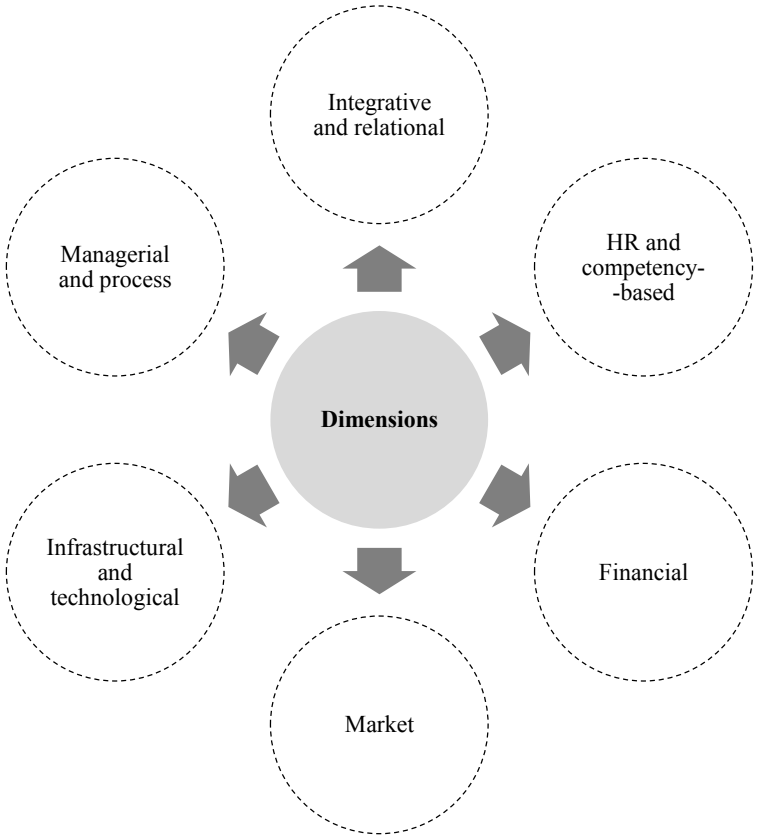

Figure 2. Dimensions of the impact of ICTs on an innovative enterprise.
Source: own elaboration.

Based on the content above, it can be inferred that ICTs can have a significant and beneficial impact on the innovative activities of enterprises and the outcomes they achieve. The use of ICTs itself should be of great importance in shaping innovative processes and providing them with the required and appropriate conditions (infrastructural, informational, process-related, etc.).

3. Methods

3.1. Research objective, questions, and hypotheses

The subject of the study is the general relationship between the importance and use of ICTs and their potential impact on the effects of innovative activities. The study highlights two main aspects: (1) the importance of the use of ICTs in the enterprise, and (2) the potential impact of the use of ICTs on the effects of innovative activities. In other words, the study aims to highlight the coexistence of the phenomena of importance and the use of ICTs, as well as their potential impact on achieving various business and managerial effects (Table 1).

Therefore, the main objective of the study is to estimate the relationship between the importance of the use of ICTs and their potential impact on the effects of innovative activities, as well as to estimate the level of the complexity: (1) of the potential impact of the use of ICTs on the effects of innovative activities, and (2) of the importance of the use of ICTs in the enterprise.

Three research questions were asked in the study:

[RQ–1] *What is the average level of the complexity of the potential impact of ICTs on the effects of innovative activities?*

[RQ–2] *What is the average level of the complexity of the importance of the use of ICTs in the enterprise?*

[RQ–3] *What is the relationship between the complexity of the importance of the use of ICTs in the enterprise and the potential impact of the use of these technologies on the effects of innovative activities?*

Justification for [RQ–1; RQ–2; RQ–3]: These questions do not directly refer to the research of other authors, as they focus on the "complexity" of the potential impact of ICTs on the effects of innovative activities and the complexity of the importance of ICTs' use in the enterprise. As a rule, the authors explore the issue of the impact of ICTs on innovative activities and the general importance of ICTs in the implementation of processes and tasks, but do not expand the research to include the aforementioned "complexity" – which is the proposal of the author of this article and refers to both the importance of ICTs and their impact in various areas and aspects of innovative activities of enterprises. However, referring to the studies of García-Álvarez (2015), Cuevas-Vargas et al. (2016), Gërguri-Rashiti et al. (2017), and Jameel et al. (2017), it can be noted that ICT is usually of great importance in enterprises and has a fairly substantial impact on the activities of companies (e.g., innovative), mainly in terms of the efficiency of innovative processes, competitiveness, and market position of the company, shortening the time of product/innovation development and information resource management. In addition, in the context of the research questions above, the following studies are relevant: Jarmooka et al. (2020), who indicate that ICTs are essential in improving the management of information resources, including knowledge; Idota et al. (2021), who note that ICTs are necessary in the context of increasing management engagement and increasing the level of employee motivation; and Azam et al. (2024), who argue that ICTs are essential in improving the openness of the enterprise. Because ICTs are relatively important and can potentially have a beneficial and substantial impact on the effects of innovative activities, the study will attempt to estimate the level of the "complexity" of this importance and impact in the conditions of innovative enterprises operating in Poland.

The research hypotheses relating to [RQ–3] are as follows (Figure 3):

[H–1] There is a strong and positive correlation between the complexity of the importance of the use of ICTs in the enterprise, and the potential impact of the use of these technologies on the effects of innovative activities.

[H–2] There is a strong and positive correlation between the complexity of the importance of the use of ICTs in the enterprise, and the complexity of the potential impact of the use of these technologies on the effects of innovative activities.

Justification for [H–1; H–2]: These hypotheses, like the research questions above, do not directly refer to the research of other authors, as they focus on the "complexity" of the potential impact of the use of ICTs on the effects of innovative activities and the complexity of the importance of the use of ICTs in the enterprise. However, the basis for the hypotheses above is the research of Loukis et al. (2013) and Koraca (2021), which empirically show that there is usually a strong and positive relationship between the use of ICTs and the effects of business activities. The hypotheses [H–1; H–2] extend the research mentioned above to the specific functioning of innovative enterprises operating in Poland.

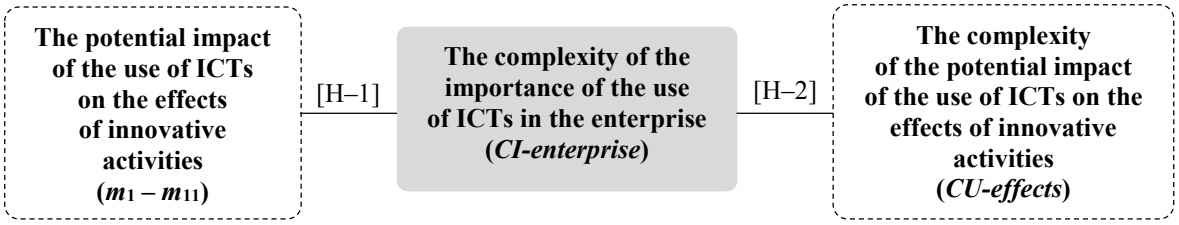

Figure 3. Research hypotheses.

Source: own elaboration.

At this point, it should be clearly noted that the study is not intended to determine the impact of the use of ICTs on the effects of innovative activities. The potential impact of ICT use is estimated by respondents using a 5-point scale (where "1" means "very low impact" and "5" means "very strong impact") and reflects the position of owners or managers in innovative companies. In this way, the estimated impact serves as the basis for constructing one of the variables used in subsequent analyses, namely, the complexity of the potential impact of ICTs' use on the effects of innovative activities (*CU-effects*) (1). The result of the analyses will be an estimate of the level of correlation (co-occurrence) between the specified processes, i.e., the importance of using ICTs in the enterprise and the potential impact of their use on the effects of innovative activities.

3.2. Scope of the study and research methods

The subjective, spatial, and temporal scope of the study was determined. The study was conducted on a random sample, using a stratified sampling method (Rószkiewicz, 2021). The numbering of PKD departments determined the layers. The respondents were business owners or managers responsible for computerization/digitization processes, innovative

processes, or project management. The survey covered only large enterprises (employing at least 250 people) operating in Poland in the most innovative sectors. The study focuses on this set of enterprises because they prioritize high quality in innovative processes, characterized by economies of scale in innovative activities, and do not exhibit fundamental resource limitations (technological, financial, and personnel) in implementing innovative processes and digitizing their activities. The selection of these sectors was made based on statistics published in the reports of the Polish Development Fund (Kolasa, 2021, 2024). Only one respondent from each randomized company was included in the research sample. A prerequisite was to answer "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 past 5 years of your activity on the market?* The baseline study was conducted in December 2024. It covered the last five years of innovative activities by the companies selected for the research sample, i.e., the period from January 2020 to December 2024. The survey covered the area of 16 voivodeships in Poland.

The empirical study used an inductive approach primarily, which allows for the generalization of phenomena (Sułkowski, 2012; Dobrzycka, 2014; Wojciechowska, 2016). The study also considered elements of the deductive approach, mainly at the stage of querying domestic and foreign literature sources. This was the basis for the development of the CAWI questionnaire. At this point, it is worth emphasizing that the inductive approach played a leading role in the study (Bogdanienko, 1983; Piórkowska, 2021). The study also used methods of analysis and synthesis (Hajduk, 2012). Furthermore, it is essential that a narrative review method was used at the stage of querying the literature. The empirical method was a diagnostic survey (Karbownik, 2017) conducted using the CAWI survey. The technique of statistical analysis of quantitative data was also used (Apanowicz, 2005; Zaborek, 2009; Sudoł, 2012). The basic research and analytical tools were:

- CAWI questionnaire (contained: one screening question, the main part – nineteen detailed questions requiring respondents to evaluate metrics on a 5-point scale ("1" meant "very low importance/impact", and "5" meant "very strong importance/impact"), and a metric – five questions);
- PS IMAGO PRO (ver. 10.0) software, and MS Excel.

The analytical methods and techniques that have been used to verify the research hypotheses are as follows:

- verification of the reliability of the 5-point scale for the specific questions (metrics) included in the survey – using Cronbach's alpha coefficient (for each of the questions, this coefficient took a value above 0.6, i.e., the limit value);
- factor analysis using the principal component analysis method (PCA) – to develop composite indexes (*CU-effects* and *CI-enterprise*);
- Spearman's rho correlation coefficient.

To complement the interpretation of the results and answer the research questions, basic descriptive statistics were used.

The basis for constructing two composite indexes, *CU-effects* (1) and *CI-enterprise* (2), was a list of processes and effects of innovative activities, assessed by respondents on a 5-point scale in terms of the importance or potential impact of ICTs. The list of these processes and effects is included in Table 1, which takes the form of the so-called detailed metrics required in PCA analysis. At this point, it should be clearly noted that this is not a comprehensive set of both the effects of innovative activities that may be potentially affected by ICTs, and the processes in which the use of ICTs is essential. The set of effects was developed mainly based on the following studies: García-Álvarez (2015), Cuevas-Vargas et al. (2016), Gërguri-Rashiti et al. (2017), Wang and Qi (2020), Zhu et al. (2021), Idota et al. (2021), and Azam et al. (2024). In turn, the set of processes was created primarily based on the following studies: Jarmooka et al. (2020), Wang and Qi (2020), Idota et al. (2021), Shirazi and Hajli (2021), Alam et al. (2022), Jagiełło (2024), and Łukasik and Zaskórski (2025). Both sets were aggregated – primarily to simplify the analysis, but also due to research limitations (research costs).

Table 1.
Detailed metrics included in the analysis

Detailed metrics	
Potential impact of the use of ICTs – effects	
m_1	Reducing employee errors
m_2	Increasing the level of specialization in the market
m_3	Increasing the company's market share / Increasing the number of customers
m_4	Increasing the number of innovations/new solutions/products/services developed
m_5	Effective and planned implementation of the company's budget assumptions
m_6	Increasing the company's financial liquidity
m_7	Reducing the business's total cost of ownership
m_8	Increasing profits
m_9	Increasing the volume of sales of products/services
m_{10}	Reducing the time spent on planning and preparing business processes
m_{11}	Reducing the time to develop innovations/new solutions/products/services
The importance of the use of ICTs in the enterprise – processes	
m_1	Providing the required data and information in innovative processes
m_2	Ensuring continuity/sustainability of innovative processes
m_3	Networking of innovative processes (openness to cooperation with external entities)
m_4	Support for decision-making processes
m_5	Support for data analysis in the company
m_6	Support for market analysis
m_7	Support for design processes
m_8	Support for conceptual/creative processes

Source: own elaboration.

At this point, we will proceed to describe the methodology for constructing composite indexes, CU-effects (1), and *CI-enterprise* (2). The *CU-effects* index (the complexity of the potential impact of the use of ICTs on the effects of innovative activities) shows, in a simplified way, how many areas and to what extent ICTs can potentially influence the effects of innovative activities of enterprises. On the other hand, *the CI-enterprise* index (the complexity of the

importance of the use of ICTs in the enterprise) refers to how many processes and at what level ICTs can be important in the activities of innovative enterprises.

The study decided to use composite indexes because they enable (Nardo et al., 2005):

- conducting a holistic analysis;
- considering a relatively large number of the detailed metrics and grouping them into thematically coherent components;
- quantification and assessment of phenomena (which by their nature are complex and relatively difficult to quantify).

To verify the quality of the data, the reliability of the scale was analysed using Cronbach's alpha coefficient. For the complete list of meters (Table 1), the Cronbach's alpha coefficient was 0.864 for the *CU-effects* index and 0.802 for the *CI-enterprise* index. The methodological recommendations developed by the OECD (2008) were used in constructing both indexes. Stages have been completed (Nardo et al., 2005):

- determining the scope of measurement and the legitimacy of using a composite index;
- selection of the detailed metrics (m_i);
- evaluation of the quality of empirical data;
- assessment of the relationship between the detailed metrics;
- assigning component weights and aggregating them to a composite index.

Table 2.
Information about the data analysed and reliability statistics

		N	**%**
Observations	Included	260	100
	Excluded*	0	0
	Total	260	100
Index	**Cronbach's alpha**		**Number of items**
CU-effects	0.864		11
CI-enterprise	0.802		8

Note. * Excluded by observations due to all variables in the analysis.

Source: own elaboration.

The results of implementing the first three stages are presented above. In evaluating the relationship between detailed metrics and the aggregation of components into composite indexes, the method of factor analysis, specifically principal component analysis (PCA), was employed (Hudrliková, 2013). To verify the correctness of the PCA analysis, the Kaiser-Meyer-Olkin (KMO) coefficient and Bartlett's sphericity test were used. The limit value of the KMO index is assumed to be between 0.5 and 0.7 (Williams et al., 2012). Bartlett's sphericity test indicated that hypotheses with uncorrelated coefficients can be rejected (significance level less than 0.001) (Table 3). Further analysis of PCA is justified and methodologically correct.

Table 3.
Kaiser-Mayer-Olkin and Bartlett's tests

Index		*CU-effects*	*CI-enterprise*
KMO measure of sample adequacy		0.914	0.849
Bartlett's sphericity test	Approximate Chi-Square	845.721	469.773
	df	55	28
	Significance	<0.001	<0.001

Source: own elaboration.

In further analysis, the method of extracting principal components using Varimax rotation was employed. Factor analysis provided the basis for classifying the detailed metrics into a single component in both constructed indexes (Table 4).

The formula of the *CU-effects* index (the complexity of the potential impact of the use of ICTs on the effects of innovative activities) is as follows (it is an arithmetic mean) (1):

$$CU\text{-}effects = 1 \cdot C1 = 1 \cdot (m_1+m_2+m_3+m_4+m_5+m_6+m_7+m_8+m_9+m_{10}+m_{11})/11. \quad (1)$$

And the formula of the *CI-enterprise* index (the complexity of the importance of the use of ICTs in the enterprise) is as follows (it is an arithmetic mean) (2) :

$$CI\text{-}enterprise = 1 \cdot C1 = 1 \cdot (m_1+m_2+m_3+m_4+m_5+m_6+m_7+m_8)/8. \quad (2)$$

Table 4.
Total variance explained

Component	Initial eigenvalues			Sums of load squares after extraction		
	Total	**% of variance**	**% cumulated**	**Total**	**% of variance**	**% cumulated**
CU-effects						
C1	4.671	42.460	42.460	4.671	42.460	42.460
C2	0.924	8.404	50.864			
C3	0.825	7.501	58.364			
C4	0.757	6.881	65.246			
C5	0.650	5.910	71.156			
C6	0.621	5.645	76.801			
C7	0.595	5.405	82.206			
C8	0.556	5.056	87.262			
C9	0.522	4.741	92.003			
C10	0.478	4.346	96.349			
C11	0.402	3.651	100.000			
CI-enterprise						
C1	3.367	42.093	42.093	3.367	42.093	42.093
C2	0.870	10.874	52.967			
C3	0.794	9.928	62.895			
C4	0.701	8.761	71.656			
C5	0.653	8.162	79.818			
C6	0.628	7.849	87.667			
C7	0.567	7.094	94.761			
C8	0.419	5.239	100.000			

Note. The method of extracting the factors – principal components.

Source: own elaboration.

The following section of the article presents the specification of the research sample.

3.3. Description of the research sample

The size of the research sample (N = 260 enterprises) can be considered representative. The determination of the minimum sample size for 183 innovative enterprises was carried out based on the methodology proposed by Sopińska and Dziurski (2018). The population size was determined based on data published by the Statistics Poland (GUS, 2023a, 2023b), which were current at the time of survey design.

Referring to the first attribute of enterprises, it can be noted that in each of the ten layers of enterprises (designated by PKD departments), there were 10% of respondents:

- food production [Department No. 10], and beverages production [Department No. 11];
- manufacture of textile products [Department No. 13], and manufacture of clothing [Department No. 14];
- manufacture of chemicals and chemical products [Department No. 20];
- manufacture of basic pharmaceutical substances and medicinal products, and other pharmaceutical products [Department No. 21];
- manufacture of computers, electronic and optical products [Department No. 26], and manufacture of electrical equipment [Department No. 27];
- manufacture of motor vehicles, trailers and semi-trailers, excluding motorcycles [Department No. 29];
- warehousing and transport support services [Department No. 52];
- activities related to the production of films, video recordings, television programs, sound, and music recordings [Department No. 59];
- telecommunications [Department No. 61], and software and IT consultancy activities, and related activities [Department No. 62];
- insurance, reinsurance, and pension funds, excluding compulsory social insurance [Department No. 65].

Considering the age of the surveyed enterprises (i.e., the number of years of operation on the market), it is notable that the research sample is dominated by entities operating for 6 to 10 years (48.85%). On the other hand, enterprises operating for 11 to 15 years account for 27.30%, and those operating for over 15 years – 23.85%. Considering the criterion of the scale of innovative activities, it can be noted that the most significant percentage in the research sample is entities operating on a regional scale (1-8 voivodeships in Poland), at 38.85%, and on a national scale (9-16 voivodeships in Poland), at 30.38%. A large percentage of the sample is also represented by entities with an average annual turnover of at least PLN 6 million (52.70%), as well as in the range of PLN 3 to 6 million (41.15%). Considering the spatial distribution of the surveyed entities, it is notable that the most significant percentage of the sample consists of innovative enterprises located in the following voivodeships: Mazowieckie (19.23%), Dolnośląskie (10.38%), Śląskie (10.00%), and Małopolskie (8.85%).

4. Results

The analysis of the results obtained should begin with answering the first two research questions:

[RQ–1] *What is the average level of the complexity of the potential impact of ICTs on the effects of innovative activities?*

[RQ–2] *What is the average level of the complexity of the importance of the use of ICTs in the enterprise?*

For this purpose, composite indexes *CU-effects* (1) and *CI-enterprise* (2) have been developed.

The developed formulas of indexes (1) and (2) provided the basis for determining descriptive statistics (Table 5). The distribution of the values of both indexes is characterized by a relatively weak left-sided skewness, indicating that a slight majority of the values of these indexes (representing the average ratings of respondents) are higher than the mean. Because each of the detailed metrics included in the construction of both indexes (1) and (2) was evaluated on a 5-point scale, it can be assumed, to put it simply, that these indexes assume mean values at a moderately high level (*CU-effects* – 3.54; *CI-enterprise* – 3.49) – the median for the 5-point rating scale is at the level of 3.00. Thus, both the average level of the complexity of the potential impact of the use of ICTs on the effects of innovative activities, and the average level of the complexity of the importance of the use of ICTs in the enterprise, are at a moderately high level.

Table 5.
Descriptive statistics

Statistics	***CU-effects***	***CI-enterprise***
Mean	3.54	3.49
Median	3.45	3.50
Dominant	3.00*	3.00*
Standard deviation	0.644	0.639
Variance	0.414	0.409
Skewness	—0.022	—0.258
Kurtosis	0.561	1.640
Gap in value	3.91	3.75
Minimum value	1.09	1.25
Maximum value	5.00	5.00

Note. * There are many modal values. The lowest value is given.

Source: own elaboration.

On the other hand, the answer to the research question [RQ–3]: *What is the relationship between the complexity of the importance of the use of ICTs in the enterprise and the potential impact of the use of these technologies on the effects of innovative activities?*, requires verification of the [H–1] and [H–2] hypotheses. For this purpose, the values of Spearman's rho correlation coefficient were calculated (Table 6).

In the case of [H–1], the correlation values between the values of the *CI-enterprise* index and the values of the potential impact of the use of ICTs on individual effects of innovative activities were determined (in this case, reference was made to eleven effects) (Table 6). In all cases, a moderate or moderately weak positive, statistically significant correlation was noted. Therefore, the [H–1] hypothesis must be falsified.

In turn, for verification [H–2], the values of the Spearman's rho correlation coefficient between the values of the *CI-enterprise* and *CU-effects* indexes were determined (Table 6). In this case, the value of the correlation coefficient was 0.586, indicating a moderately strong correlation (and statistically significant). However, the [H–2] hypothesis must be falsified.

Table 6.
Spearman's rho correlations

Metrics	Potential impact of the use of ICTs – effects		*CI-enterprise*
m_1	Reducing employee errors	**Correlation coefficient**	**0.379***
		Significance (bilateral)	<0.001
m_2	Increasing the level of specialization in the market	**Correlation coefficient**	**0.488***
		Significance (bilateral)	<0.001
m_3	Increasing the company's market share / Increasing the number of customers	**Correlation coefficient**	**0.394***
		Significance (bilateral)	<0.001
m_4	Increasing the number of innovations/new solutions/products/services developed	**Correlation coefficient**	**0.322***
		Significance (bilateral)	<0.001
m_5	Effective and planned implementation of the company's budget assumptions	**Correlation coefficient**	**0.339***
		Significance (bilateral)	<0.001
m_6	Increasing the company's financial liquidity	**Correlation coefficient**	**0.323***
		Significance (bilateral)	<0.001
m_7	Reducing the business's total cost of ownership	**Correlation coefficient**	**0.345***
		Significance (bilateral)	<0.001
m_8	Increasing profits	**Correlation coefficient**	**0.301***
		Significance (bilateral)	<0.001
m_9	Increasing the volume of sales of products/services	**Correlation coefficient**	**0.347***
		Significance (bilateral)	<0.001
m_{10}	Reducing the time spent on planning and preparing business processes	**Correlation coefficient**	**0.449***
		Significance (bilateral)	<0.001
m_{11}	Reducing the time to develop innovations/new solutions/products/services	**Correlation coefficient**	**0.445***
		Significance (bilateral)	<0.001
CU-effects		**Correlation coefficient**	**0.586***
		Significance (bilateral)	<0.001

Note. * Correlation significant at 0.01 (bilateral).

Source: own elaboration.

Referring more broadly to the research question [RQ-3], it should be noted that this relationship is, in general, positive and at a moderate level. This can be interpreted in such a way that the higher the complexity of the importance of the use of ICTs in the enterprise (assessed by the respondents), the higher the values of the potential impact of the use of these technologies on the effects of innovative activities.

5. Discussion and Conclusions

The research conducted has shown that, in principle, the increase in the complexity of the importance of ICTs in an enterprise corresponds to the rise in the complexity of the potential impact of the use of these technologies on the effects of innovative activities, as well as an increase in the value of the potential impact of the use of ICTs on specific (single) effects of innovative activities. The results obtained confirm the positively verified hypotheses put forward in the studies of Loukis et al. (2013) and Koraca (2021), which indicated that there is usually a strong and positive relationship between the use of ICTs and the effects of enterprises' activities. Of course, hypotheses [H–1; H–2] verified in this study are not entirely identical to those verified by Loukis et al. (2013) and Koraca (2021). However, their message is similar.

The research results above should be considered a favourable situation, mainly from the perspective of innovative companies' investments in various modern ICTs, and thus striving for a higher quality of innovative processes and innovations. However, individual companies should estimate the value of this dependency on their own and consider it in the broader context of the market, technological, social, and other conditions in which they operate or will continue to operate.

The results obtained are also consistent with the studies of García-Álvarez (2015), Cuevas-Vargas et al. (2016), Gërguri-Rashiti et al. (2017), Jameel et al. (2017), Jarmooka et al. (2020), and Azam et al. (2024). They confirm that ICTs are generally of moderate importance in enterprises and have a moderately high impact on innovative activities (reference to the [RQ-1; RQ–2] research questions). Examples include increasing the efficiency of innovative processes, enhancing the level of competitiveness and openness within the company, reducing product development time, and effectively managing information resources.

Summarizing the research, it can be inferred that the use of ICTs in innovative enterprises is a significant and well-justified activity in the current socio-economic environment. ICTs enable, among other things, the operation in global circumstances while reducing the costs of developing innovative processes, facilitating the hyper-scalability of business models, improving communication within enterprises, as well as between the company and external stakeholders, and supporting the reduction of task completion time. There are many potential benefits resulting from the implementation and use of ICTs in innovative activities. However, to achieve such effects, attention should be paid to the general importance of ICTs within the company and in individual processes that support and dynamize innovative activities. Such processes include, among others, providing the required data and information, networking innovative processes, supporting decision-making processes, conducting data and market analysis, and supporting design processes. The level of awareness among owners of innovative companies and executives about the importance of ICTs within their companies is of great importance. The implementation of various solutions available on the market does not always

result in satisfactory support for innovative activities and measurable benefits, such as shortening the time to action, reducing costs, etc. It may be crucial to assign an appropriate role to these solutions during the planning stage of ICTs' implementation. Then it will be easier to estimate the overall relationship between the use of ICTs and the results obtained. Summarizing the considerations above, it can be assumed that companies should pay more attention to the benefits that can result from implementing information and communication technologies in innovative processes. Companies should estimate the potential impact of ICTs on innovative processes and develop their own procedures in this area, which can lead to increased efficiency and effectiveness in implementing various ICT solutions.

At this point, it is worth noting that the aim of the article was not to fully generalize the conclusions for the population of innovative enterprises operating in Poland. The set of these entities is diverse, and the research sample did not consider the proportions between individual attributes of enterprises in the population. Moreover, the analyses were based on the opinions of respondents, which could be subject to errors and bias in the assessment. The aim of the study was primarily to assess the overall situation regarding the importance of ICTs in innovative enterprises in comparison with their potential impact on the effects of innovative activities.

Considering the content above, it can be assumed that the directions of further research should focus on identifying the cause-and-effect relationships between the use of various ICT technologies, systems, and tools, and the effects of innovative activities in Polish innovative enterprises.

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References

1. Alam, K., Ali, M., Erdiaw-Kwasie, M., Shahiduzzaman, M., Velayutham, E., Murray, P., Wiesner, R. (2022). Impact of ICTs on Innovation and Performance of Firms: Do Start-ups, Regional Proximity and Skills Matter? *Sustainability*, *No. 14(10)*, pp. 1-18.
2. Apanowicz, J. (2005). *Metodologiczne uwarunkowania pracy naukowej*. Warszawa: Difin.
3. Azam, M., Ameur, H., Ftiti, Z., Hunjra, A., Louhichi, W. (2024). The Role of ICTs on Innovation Process of Environment and Energy Convergence. *IEEE Transactions on Engineering Management*, *No. 71*, pp. 4418-4440.
4. Bogdanienko, J. (1983). *Podstawy badań naukowych*. Warszawa: Szkoła Główna Planowania i Statystyki.
5. Cuevas-Vargas, H., Estrada, S., Larios-Gómez, E. (2016). The Effects of ICTs As Innovation Facilitators for a Greater Business Performance. Evidence from Mexico. *Procedia Computer Science*, *No. 91*, pp. 47-56.
6. Dobrzycka, M. (2014). Strategie badawcze stosowane w naukach ekonomicznych. In: K. Kuciński (Ed.), *Naukowe badanie zjawisk gospodarczych. Perspektywa metodologiczna* (pp. 281-301). Warszawa: Wolters Kluwer.
7. García-Álvarez, M. (2015). Analysis of the effects of ICTs in knowledge management and innovation: The case of Zara Group. *Computers in Human Behavior*, *No. 51*, pp. 994-1002.
8. Gërguri-Rashiti, S., Ramadani, V., Abazi-Alili, H., Dana, L., Ratten, V. (2017). ICT, Innovation and Firm Performance: The Transition Economies Context. *Thunderbird International Business Review*, *No. 59*, pp. 93-102.
9. Gil, Ł. (2025). *Czym jest ICT (Information and Communications Technology)? — Definicja, znaczenie, różnice, role i perspektywy rozwoju*. Retrieved from: https://nflo.pl/baza-wiedzy/czym-jest-ict-definicja-znaczenie-role/, 27.10.2025.
10. gov.pl (2022). *Kompetencje cyfrowe*. Retrieved from: https://www.biznes.gov.pl/pl/portal/004171, 20.10.2025.
11. GUS (2009). *Technologie informacyjno-komunikacyjne*. Retrieved from: https://stat.gov.pl/metainformacje/slownik-pojec/pojecia-stosowane-w-statystyce-publicznej/1893, pojecie.html, 28.07.2025.
12. GUS (2023a). *Działalność przedsiębiorstw niefinansowych w 2022 roku*. Retrieved from: https://stat.gov.pl/obszary-tematyczne/podmioty-gospodarcze-wyniki-finansowe/przedsiebiorstwa-niefinansowe/dzialalnosc-przedsiebiorstw-niefinansowych-w-2022-roku,2,19.html, 15.05.2024.
13. GUS (2023b). *Działalność innowacyjna przedsiębiorstw w Polsce w latach 2020-2022*. Retrieved from https://stat.gov.pl/obszary-tematyczne/nauka-i-technika-spoleczenstwo-informacyjne/nauka-i-technika/dzialalnosc-innowacyjna-przedsiebiorstw-w-polsce-w-

latach-2020-2022,14,10.html#:~:text=W%20latach%202020%E2%80%932022%20aktywno%C5%9B%C4%87,%2D%2029689%2C1%20mln%20z%C5%82, 15.05.2024.
14. Hajduk, Z. (2012). *Ogólna metodologia nauk*. Lublin: KUL.
15. Hudrliková, L. (2013). Composite indicators as a valuable tool for international comparison: The Europe 2020 example. *Prague Economic Papers*, *No. 22(4)*, pp. 459-473.
16. Idota, H., Taher, S., Tsuji, M. (2021). The Impact of ICTs and Business Strategy on Innovation Activities: Empirical Evidence From Japanese SMEs. In: C. Martins, P. Rodrigues (Eds.), *Competitive Drivers for Improving Future Business Performance* (pp. 154-177). Pennsylvania: IGI Global Scientific Publishing.
17. Jagiełło, A. (2024). *7 najważniejszych cech platform do współpracy online*. Retrieved from: https://www.bitrix24.pl/articles/7-najwazniejszych-cech-platform-do-wspolpracy-online.php, 10.10.2025.
18. Jameel, A.S., Mohammed, A.-K., Noor, Z.M. (2017). A review of the impact of ICT on business firms. *International Journal of Latest Engineering and Management Research*, *Vol. 2, Iss, 1*, pp. 15-19.
19. Jarmooka, Q., Fulford, R., Morris, R., Barratt-Pugh, L. (2020). The mapping of information and communication technologies, and knowledge management processes, with company innovation. *Journal of Knowledge Management*, *No. 25*, pp. 313-335.
20. Karbownik, K. (2017). Możliwości wykorzystania kwestionariuszy badawczych w zarządzaniu. *Zeszyty Naukowe Politechniki Częstochowskiej. Zarządzanie*, *No. 25(2)*, pp. 176-183.
21. Knosala, R., Buchwald P., Kostrzewski, M., Oleszek, S., Szajna, A. (2024). *Zastosowanie innowacyjnych technologii informatycznych*. Warszawa: PWE.
22. Kolasa, M. (2021). *Innowacyjność Polski. Chartbook. Marzec 2021*. Warszawa: PFR. Retrieved from: https://pfr.pl/dam/jcr:e5033692-ad46-45fb-89b9-df90a04744b1/%20PFR_Innowacje_202103.pdf, 11.05.2024.
23. Kolasa, M. (2024). *Innowacyjność Polski. Zestawienie. Czerwiec 2024*. Warszawa: PFR. Retrieved from: https://pfr.pl/dam/jcr:17771705-de20-457b-b4b0-a120033c9a73/PFR_Innowacje_202406-17062024.pdf, 09.06.2024.
24. Koraca, D. (2021). How ICT affects business processes. In: W. Karwowski, T. Ahram, M. Milicevic, D. Etinger, K. Zubrinic (Eds.), *Human Systems Engineering and Design (IHSED2021): Future Trends and Applications. AHFE (2021), International Conference. AHFE Open Access, Vol. 21* (pp. 1-9). AHFE International, USA.
25. Łobejko, S. (2020). Digital transformation and innovativeness of enterprises. *Optimum. Economic Studies*, *No. 2(100)*, pp. 36-46.
26. Loukis, E., Soto-Acosta, P., Pazalos, K. (2013). Using structural equation modelling for investigating the impact of e-business on ICT and non-ICT assets, processes and business performance. *Operational Research. An International Journal*, *Vol. 13*, pp. 89-111.

27. Łukasik, S., Zaskórski, P. (2025). Information resources and their exploration in cyberspace as a component of the business potential of modern organizations. *Modern Management Systems*, *No. 20*, pp. 15-32.
28. Maciejewski, D. (2025). *Jakie technologie zmieniają przyszłość e-commerce?* Retrieved from: https://techsetter.pl/jakie-technologie-zmieniaja-przyszlosc-e-commerce/, 17.10.2025.
29. Marszycki, M. (2023). *11 trendów technologicznych, które napędzają e-commerce*. Retrieved from: https://itwiz.pl/11-trendow-technologicznych-ktore-napedzaja-e-commerce/, 17.10.2025.
30. Modern360 (2024). *Transformacja cyfrowa – co to jest, przykłady i jakie ma korzyści?* Retrieved from: https://modern360.pl/transformacja-cyfrowa-co-to-jest-przyklady-i-jakie-ma-korzysci/, 26.10.2025.
31. Nalepka, A. (2020). *Budowa i doskonalenie struktury organizacyjnej*. Kraków: Wydawnictwo Uniwersytetu Ekonomicznego w Krakowie.
32. Nardo, M., Saisana, M., Saltelli, A., Tarantola, S. (2005). *Tools for Composite Indicators*. Brussels: European Commission.
33. OECD (2008). *Handbook on Constructing Composite Indicators. Methodology and User Guide*. Brussels: OECD.
34. Pakulska, T., Poniatowska-Jaksch, M. (2021). *Platformizacja korporacji transnarodowych*. Warszawa: Szkoła Główna Handlowa.
35. Perechuda, K. (2015). *Advanced Business Models*. Wrocław: Publishing House of Wrocław University of Economics.
36. Piórkowska, K. (2021). Wnioskowanie na podstawie badań ilościowych. In: Ł. Sułkowski, R. Lenart-Gansiniec, K. Kolasińska-Morawska (Eds.), *Melody badań ilościowych w zarządzaniu* (pp. 245-273). Łódź: Wydawnictwo Społecznej Akademii Nauk.
37. Poniatowska-Jaksch, M., Sobiecki, R. (Ed.) (2016). *Sharing economy (gospodarka współdzielenia)*. Warszawa: Szkoła Główna Handlowa.
38. Pypłacz, P., Sasak, J. (2022). RPA jako narzędzie automatyzacji i optymalizacji procesów. *Organizacja i Kierowanie*, *No. 2(191)*, pp. 173-188.
39. Roger, M., Shulin, L., Sesay, B. (2022). ICT Development, Innovation Diffusion and Sustainable Growth in Sub-Saharan Africa. *SAGE Open*, *No. 12(4)*.
40. Rószkiewicz, M. (2021). Dobór próby w badaniach ilościowych. In: M. Rószkiewicz, K. Mazurek-Łopacińska, A. Sagan (Eds.), *Dobór próby we współczesnych badaniach marketingowych* (pp. 13-32). Szczecin: Uniwersytet Szczeciński.
41. Shirazi, F., Hajli, N. (2021). IT-Enabled Sustainable Innovation and the Global Digital Divides. *Sustainability*, *No. 13(17)*, pp. 1-24.

42. Sobocka-Szczapa, H. (2017). Wykluczenie cyfrowe pracujących a podejmowanie decyzji w organizacji. *Zeszyty Naukowe Politechniki Śląskiej. Seria: Organizacja i Zarządzanie*, *No. 113*, pp. 409-419.
43. Sopińska, A., Dziurski, P. (2018). *Otwarte innowacje. Perspektywa współpracy i zarządzanie wiedzą*. Warszawa: Szkoła Główna Handlowa.
44. Sudoł, S. (2012). *Nauki o zarządzaniu. Podstawowe problemy i kontrowersje*. Warszawa: PWE.
45. Sułkowski, Ł. (2012). *Epistemologia i metodologia zarządzania*. Warszawa: PWE.
46. Wang, J., Ho, C., Shan, Y. (2024). Does cybersecurity risk stifle corporate innovation activities? *International Review of Financial Analysis*, *Vol. 91*.
47. Wang, Z., Qi, Z. (2020). Analysis of the influences of ICTs on enterprise innovation performance in China. *Managerial and Decision Economics*, *No. 42(2)*, pp. 474-478.
48. Williams, B., Brown, T., Onsman, A. (2012). Exploratory factor analysis: A five-step guide for novices. *Australian Journal of Paramedicine*, *No. 8(3)*, pp. 1-13.
49. Wojciechowska, R. (2016). *Logika procesu badawczego w ekonomii*. Warszawa: Szkoła Główna Handlowa.
50. Woźniak, M., Sliż, P., Wycinka, E. (2024). Wpływ implementacji technologii ICT na dojrzałość procesową i projektową na przykładzie dużych organizacji w Polsce. *Studia i Prace Kolegium Zarządzania i Finansów*, *No. 195*, pp. 245-266.
51. Yunis, M., El-Kassar, A., Tarhini, A. (2017). Impact of ICT-based innovations on organizational performance: The role of corporate entrepreneurship. *Journal of Enterprise Information Management*, *No. 30*, pp. 122-141.
52. Zaborek, P. (2009). Qualitative and quantitative research methods in management science. In: M. Strzyżewska (Ed.), *Selected methodological issues for doctoral students* (pp. 41-50). Warsaw: Warsaw School of Economics.
53. Zaskórski, P., Woźniak, J. (2024). Sprawność informacyjna a odporność na ryzyko utraty ciągłości działania współczesnej organizacji. *Studia i Prace Kolegium Zarządzania i Finansów*, *No. 199*, pp. 55-77.
54. Zhu, F., Li, Q., Yang, S., Baležentis, T. (2021). How ICT and R&D affect productivity? Firm level evidence for China. *Economic Research – Ekonomska Istraživanja*, *No. 34*, pp. 3468-3486.
55. Ziemba, E. (Ed.) (2018). *Czynniki sukcesu i poziom wykorzystania technologii informacyjno-komunikacyjnych w Polsce*. Warszawa: CeDeWu.