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ICT Technology Implementation and the Level of Process Maturity in an Organization

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Abstract

Purpose: The main objective of the article is to identify selected ICT technologies supporting higher levels of organizational process maturity.
Design/methodology/approach: The research was conducted with the use of the following methods: bibliometric analysis, literature review and statistic methods. The empirical procedure was carried out on a non-random sample of 48 large organizations operating in Poland, using the CAWI technique.
Findings: The empirical research carried out proved the existence, in the group of the organizations examined, of a statistically significant relationship between the implementation of *artificial intelligence* (AI), *cloud computing* (CC) and *robotic process automation* (RPA) technologies and, respectively, the third and fourth levels of process maturity, in accordance with the adopted multicriteria model of process maturity assessment (MMPM).
Research limitations/implications: The burden of the presented empirical investigation results primarily arises from the applied technique of non-probabilistic research sample selection. This makes the obtained results limited to the examined sample of organizations.
Originality/value: The originality of this article fills the cognitive gap consisting in the shortage of publications that present the relationship between the degree of implementation of ICT technology and the level of process maturity. The presented article addresses this gap by indicating a statistical relationship between the implementation of *artificial intelligence* (AI), *robotic process automation* (RPA), *cloud computing* (CC) technology and the level of process maturity of the organization.

Keywords: ICT, technology, smart world, process maturity, business process management.

JEL: O320, O330

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Wdrożenie technologii ICT a poziom dojrzałości procesowej organizacji

Streszczenie

Cel: identyfikacja wybranych technologii ICT wspierających wyższe poziomy dojrzałości procesowej organizacji.

Metodologia: badanie zostało zrealizowane z wykorzystaniem metod, takich jak analiza bibliometryczna, przegląd literatury, metody statyczne oraz sondażowe badanie opinii na próbie 48 dużych organizacji funkcjonujących w Polsce.

Wyniki: zrealizowane postępowanie dostarczyło dowodów na to, że w badanej grupie jednostek istnieje statystycznie istotna zależność między implementacją technologii *artificial intelligence* (AI) oraz *cloud computing* (CC) i *robotic process automation* (RPA) a odpowiednio trzecim i czwartym poziomem dojrzałości procesowej według przyjętego modelu MMPM.

Ograniczenia/implikacje badawcze: uzyskane wyniki badania obciążone są przede wszystkim wybraną nieprobabilistyczną techniką doboru próby, co powoduje ograniczenie uzyskanych wniosków do badanej grupy organizacji.

Oryginalność/wartość: oryginalność tego artykułu wypełnia lukę poznawczą, polegającą na niedostatku publikacji przedstawiających relacje między stopniem implementacji technologii ICT a poziomem dojrzałości procesowej. Przedstawiony artykuł wypełnia tę lukę, wskazując statystyczne zależności między wdrożeniem *artificial intelligence* (AI), *robotic process automation* (RPA) i *cloud computing* (CC) a poziomem dojrzałości procesowe organizacji.

Słowa kluczowe: ICT, technologia, smart world, dojrzałość procesowa, zarządzanie procesami biznesowymi.

1. Introduction

In the era of digital economy, contemporary organizations seek new solutions enabling a dynamic response to the changing geometry of external factors. The turbulent nature of the environment in which organizations operate is determined by the changes induced by the dynamic reconfiguration of customer needs and expectations, shortening life cycles of organizations, hypercompetition, as well as factors of the epidemic nature (the COVID-19 pandemic). This creates conditions in which both researchers and management luminaries seek opportunities in the development of information and communication technology to derive the benefits of such technology implementation in the context of business process management.

A literature review based on the Web of Science and Scopus databases, revealed a cognitive gap that pointed to a lack of research presenting the relationship between the degree of ICT implementation and the level of organizational process maturity. There are not either publications that attempt to identify the degree of ICT implementation or those assessing the level of organizational process maturity. This implies that the traditional information systems used in business process management may not be sufficient enough in the context of seizing the opportunities generated in

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the digital economy (Del Giudice & Straub, 2011; Bresciani, Ferraris, & Del Giudice, 2018). This means that, from a cognitive perspective, it is important to identify the ICT technologies whose implementation in an organization will generate a system state in which they will be consciously used within the sphere of processes identification, formalization, measurement and management in an organization.

As a result, the research problem was outlined by means of two research questions (RQs):

RQ1: *Which modern ICT technologies support business process management (BPM)?*

RQ1: *Which of the ICT technologies researched can be identified as having the potential to support achievement of higher levels of process maturity in organizations?*

With regard to the research problem outlined as such, the main objective of the article was formulated, which was to identify the ICT technologies supporting business process management in organizations. Two sub-objectives were established to achieve the main objective. The first one was to identify the ICT technologies used in the analyzed group of organizations, while the second one involves an attempt to assess the relationship between the degree of the identified ICT technology implementation and the level of process maturity in organizations.

To achieve such set objectives, the following research methods were used: bibliometric analysis, literature review, opinion poll and statistical methods. In the cognitive layer of the study, the resources of the Web of Science Core Collection (WoS) knowledge base were used. The empirical study was carried out in 2020–2021 on a non-probabilistically selected research sample of 48 large organizations operating in Poland. The criterion for the organization selection included employment size exceeding 250 employees.

2. Modern Technologies in the Era of Smart World – Theoretical Background

Viewing the issue from the manufacturing, marketing, financial and management perspectives, innovation constitutes a key success factor for the contemporary companies grappling with the new challenges of conducting business in the smart world era. These challenges include, inter alia: the ongoing globalization processes (Ying, Chang, & Lee, 2014), the need to face the competition on international markets (Tallman, Luo, & Buckley, 2018), the internationalization of firms under transition and operating on emerging markets (TEMs) (Igwe, Rugara, & Rahman, 2022), the digitalization process requiring companies to become more agile, invest in more organic structures, reinforce standardization and automation (Almeida, Duarte Santos, & Monteiro, 2020), or the maintenance of security in the use of strategic resources of a relational and informational nature (in particular, maintaining the security of the information processed via social networks) (Hekkala, Väyrynen, & Wiander, 2012).

As predicted by Ma et al. (2005), it is assumed that "*the future world will possibly be a highly computerized physical world known as the smart world (SW), which is created on both cyberspaces and real spaces. (…) The smart world is aimed at offering novel ubiquitous services in the right place, right time and right means with some kinds/levels of smart or intelligent behaviors*". Riekki & Mämmelä (2021) take one step further in their reflections by presenting a vision of a developing world that is both sustainable and smart: "*Prosperity for the people and the planet is achieved with intelligent systems that sense their environment, make proactive decisions on actions advancing their goals, and perform the actions on the environment.*" Summing up the above, the smart world era "*is an integrated cyber-physical-social-thinking hyperspace (…), it includes physical-based coordination, social-inspired interactivity, brain-abstracted cooperativity, and cyber-enabled homogeneity*" (Ning et al., 2015), thus the use of ICT technology is crucial for the survival and development of contemporary businesses.

It should be noted that although the vision of digital world (cyber world) seems futuristic, the concept of smart world is not a new idea. Already in the 1990s, Weiser (1991) presented a vision of smart world era development, stressing that "*a great number and variety of computers with different sizes and functions will be everywhere, so ubiquitous around us and pervasive in our environmen*t". The concept of smart world itself has been characterized in the subject matter literature in various ways, i.e., as a prospect assuming the use of artificial intelligence, which will be ubiquitous – encompassing physical objects, the cyber space, communities, and human thought (Liu et al., 2019), as integration of real and cyber spaces (Ma et al., 2005), as ubiquitous intelligence (Ma et al., 2015), or a new era (Ning et al., 2015). The literature emphasizes that projects are implemented in two primary categories of the areas aimed at development of ubiquitous intelligence: architecture and industrialization (Liu et al., 2019). The projects implemented in the area of architecture specifically address such issues as: smart space (Levonevskiy, Vatamaniuk, & Savelievm, 2018), smart grid (Hao & Tao, 2022; Saxena, Kumar, & Nangia, 2021), smart structure (Karami & Akbarabadi, 2016), smart machine (Gerrish, 2018; Anderson, Gisby, McKay, O'Brien, & Calius, 2012), smart university (Rico-Bautista et al., 2022). The second area of project implementation as part of smart world development concerns industrialization, in particular: smart city (Mua, Haershana, & Wu, 2022; Sharifi, Allam, Feizizadeh, & Ghamar, 2021), smart village (Kealey, 2022), smart community (Sung, Shih, & Perng, 2022), smart home (Perez, Mazzaro, Pierson, & Kotz 2022; Agee, Gao, Paige, McCoy, & Kleiner, 2021), smart building (Shen, 2019), smart factories (Dördüncü, 2021), smart agriculture (Dansana, Sahoo, & Mishra, 2022) and others,

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i.e.: smart forestry (Tognetti, Smith, & Panzacchi, 2022), smart farming (Verma, Chandnani, Bhatt, & Sinha 2022), smart education (Pandey, Singh, Singh, & Khan, 2022), smart health care (Malathi & Kavitha 2022). The selection presented here is not exhaustive of all research areas addressing the topic of smart world; nevertheless, it indicates the immense complexity and extensive coverage of the topic, which permeates many facets of human life and work.

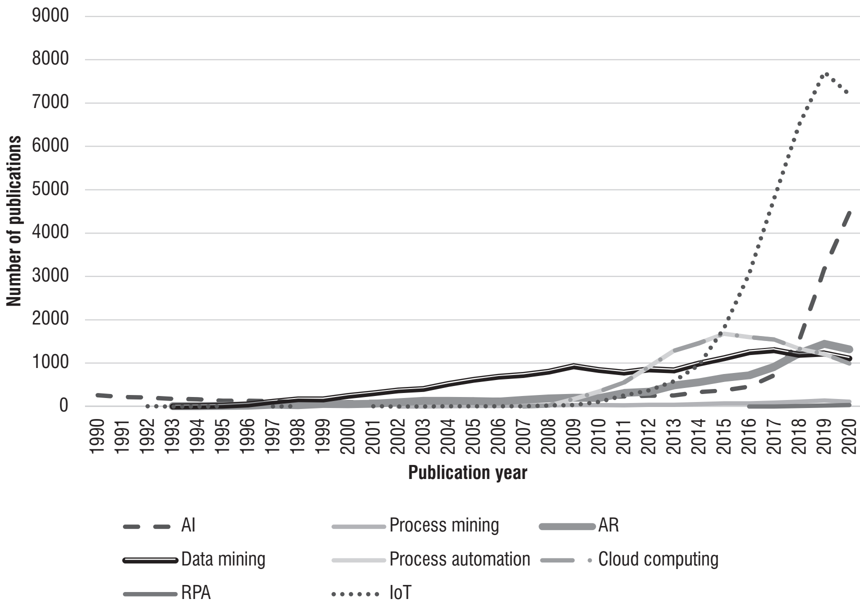
The literature review resulted in an identification of the ICT technologies included in the empirical investigation carried out. On the basis of studies described in the literature, the implementation thereof was indicated as a potential to support business process management. They have been classified as:

- unstructured data set analysis (Big Data) (Dezi, Santoro, Gabteni, & Pellicelli, 2018; Rialti, Marzi, Silic, & Ciappei, 2018);
- artificial intelligence (AI) (Tapsoba & Xiao, 2017; Paschek, Luminosu, & Draghici, 2017; Sidorova & Rafiee, 2019);
- robotic process automation (RPA) (Aguirre & Rodriguez, 2017; Mendling, Decker, Hull, Reijers, & Weber, 2018; Sliż, 2019; Mora & Sánchez, 2020);
- data mining (Sliż, 2019);
- process mining (Bitkowska, Sliż, Tenbrink, & Piasecka, 2020);
- Internet of Things (IoT) (Cherrier & Deshpande, 2017; Hussein, Hamed, & Eldeen, 2018; Janiesch et al., 2020);
- cloud computing (*solutions*) (Levina, Novikov, & Borremans, 2018);
- augmented reality (AR) (Fraga-Lamas, Fernández-Caramés, Blanco-Novoa, & Vilar-Montesinos, 2018);
- process automation (PA) (Aysolmaz, İren, & Demirörs, 2013; Holzmüller-Laue, Schubert, Göde, & Thurow, 2013; Aguirre & Rodriguez, 2017).

The outlined catalog of ICT technologies should not be viewed as a closed set. The existence of other technologies is worth mentioning here, e.g., flexible production lines (Dalenogare, Benitez, Ayala, & Frank, 2018), integrated engineering systems (Abramovici, 2007) or simulations of virtual models (Babiceanu & Seker, 2016). The technologies indicated, relevant to specific economic sectors and the organizations operating within those sectors, were not included in this study; nevertheless, an assessment of the degree of their implementation and impact on the maturity level in organizations requires the use of qualitative methods (e.g., observation), followed by much broader quantitative research based on the empirical facts examined, with a purposeful sampling criterion (e.g., manufacturing organizations).

The first step of the research process involved an attempt to identify, based on the Web of Science Core Collections knowledge base resources, the interest in the technologies mentioned, expressed by the number of publications (Figure 1).

Figure 1
The number of works on selected ICT technologies published between 1990 and 2020



Note: Search for a category 'title' in all the Web of Science Categories.

Source: Own elaboration based on the Web of Science Core Collection.

As Figure 1 indicates, an increase in researchers' interest in the described ICT technologies supporting BPM can be noticed, starting in 2010. It should be emphasized here that the issues examined are interdisciplinary in nature for the publications identified were classified in most of the Web of Science Categories, with particular emphasis on computer-science-related categories.

Based on the literature review, in which the issues of process management and modern technologies intersect, a set of factors supporting technology development in the process management sphere has been outlined:

- reduced cost of modern information technology purchase and use;
- process-mining possibilities;
- exploration of possibilities for big data collections generated in the environment and within an organization;
- continuously increasing computing power and implementation of cloud solutions for data mining;
- use of communication technologies enabling creation of virtual teams;
- digitalization of archival data sets.

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3. Methodology

The empirical procedure was carried out on a non-random sample of 48 large organizations operating in Poland, selected by means of convenience sampling. It should be emphasized here that large organizations are identified in the article according to the employment size criterion. This means that the group surveyed only includes those organizations which declared a level of employment exceeding 250 employees. The study was carried out in 2020–2021, using the CAWI technique. The survey questionnaire was sent to middle and lower management and specialist employees (process owners, quality management system specialists). 300 organizations operating in Poland were invited to participate in the survey; answers were received from 60 entities (response rate = 0.2), 14 out of which did not meet the employment size criterion. It should be emphasized that the number of surveyed organizations is determined by the structure of entities in Poland. Only 0.2% of 2 150 600 organizations operating in Poland are classified as large organizations (Skowrońska & Zakrzewski, 2020). Moreover, due to convenience sampling, the sample cannot be representative in a statistical approach.

In the research procedure, a multi-criteria model (MMPM) was used to assess the process maturity in organizations. The characteristics of MMPM model levels have been presented in Table 1.

Table 1
Characteristics of the maturity assessment model used

Level	Description
Level 1 – an organization showing weak symptoms of a process approach	The organization is characterized by the elements dominant in the functional approach to management. The multi-level, vertical, hierarchical structure prevents horizontal preorientation. In the long-term dimension, there are no single symptoms that could indicate a change in management orientation. The term 'process' is not used in the organization, or it is equated with the notion of a task.
Level 2 – processes have been identified and formalized	As a result of a formalized process architecture in the organization, decisions are made regarding the necessity of formalized process measurement. At the second level of maturity, symptoms indicating the measurement of main processes are visible. The simultaneous orientation towards tasks and results prevents comprehensive process measurement. The term 'process' is used correctly in the organization.
Level 3 – processes have been measured	In an organization characterized by the third level of maturity, processes are identified and formalized or explored. A process assessment measurement system is additionally designed and implemented, taking the level of external customer satisfaction into account. Symptoms indicating that the management decisions are made based on the process measurement system designed can occur at this level.

Tab. 1 – continued

Level	Description
Level 4 – processes are managed	A process organization, in which all the specified criteria indicating a correctly identified, formalized and measured process architecture have been met. Such an organization is focused on the search for new solutions resulting from the attempt to flexibly respond to external impulses. Managerial decisions are oriented towards process-generated effects and the compatibility thereof with customer needs and expectations. A system of external and internal training improves the inter-employee knowledge transfer. The desired leader role is to manage the diffusion of knowledge in interdisciplinary teams established and oriented towards task execution and problem solving across the entire organization.
Level 5 – processes are under improvement	An organization at this level is characterized by continuous process improvement. As a result of process measurement and the improvement secured by all employees, the organization seeks new areas of added value generation. An internal marketization mechanism is implemented in the organization. Process management is based on the results of a designed measurement system, with particular emphasis on the assessment of the level of customer satisfaction, from an external and internal perspective. Based on an analysis of the process effect, corrective actions are taken, aimed at continuous process improvement, based on the customer requirements.

Source: Own elaboration based on Sliż, 2018.

Detailed assumptions of the MMPM model have been presented in the works by Sliż (2018, 2021). The research questionnaire was extended to include questions about the degree of modern ICT technology implementation. The rationale behind the MMPM model use pertained to the level of its operationalization, the research questionnaire availability, and the way of organization classification into one of five levels of maturity. The predominant rationale for the MMPM model selection was the possibility of objective assessment. This means that the construction of the research questionnaire enables an assessment of the degree of process solution implementation (implementation of business process management elements), based on the symptoms of processivity.

It should be emphasized that the level of reliability of the applied tool was verified with the use of the Cronbach's alpha estimate – in this research its value was 0.8. Due to the questions asked in the research questionnaire that contained a dichotomous scale, the obtained results were considered satisfactory and consistent with the limit of acceptability of the research tool described in the literature. (Hair et al., 2010).

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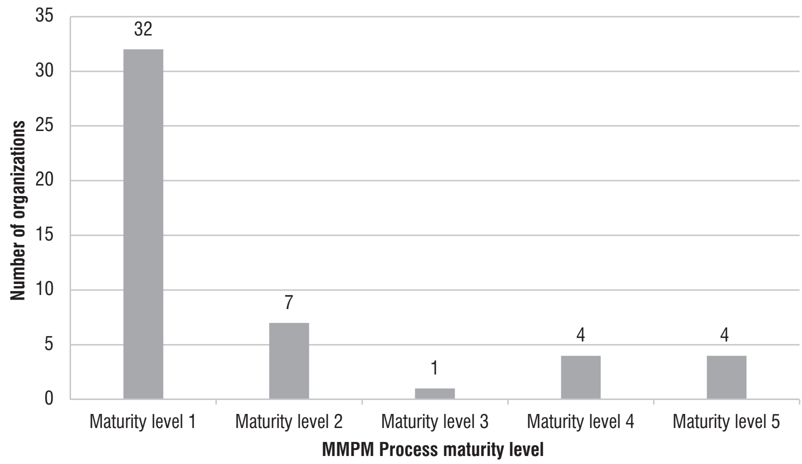
4. Research Results

In the first instance, on the basis of 48 correctly completed questionnaires, an attempt was made, based on the assumptions of the MMPM model adopted, to assess the organization process maturity within one of five levels (Figure 2).

Figure 2
Assessment of maturity level in the surveyed group of organizations



Note: N = 48.

Source: Own elaboration based on the study carried out in 2020–2021.

The MMPM maturity model used has been broadly described in a publication by Sliż (2018). Among the group of entities examined, 32 – the largest number of entities – were qualified within level 1, identified as a state in which process management elements have not been implemented in an organization. 7 organizations were qualified within level 2, i.e., a maturity level in which business processes are identified and formalized in the form of process documentation (process descriptions or graphic maps of process flow). One organization was qualified within level 3, characteristic of organizations in which processes are identified, formalized and measured. In the surveyed group of entities, a system of process management that is based on implemented measurement systems was identified in 4 organizations. Level 5, characteristic of organizations in which processes are being improved, was observed in 4 of the examined organizations (Sliż, 2018).

As shown in Figure 2, the largest number of surveyed organizations was qualified within level 1 and level 2 (level characteristics are presented in Table 1). This is in line with the research results that concern process maturity of organizations in Poland. A detailed list of the mentioned research studies is presented in a work by Sliż (2021, pp. 180–185).

Next, an attempt was made to identify the ICT technologies applied in the surveyed group of entities. The respondents were presented with selected information and communication technologies and asked to declare the implementation thereof. The response distribution is shown in Figure 3.

Figure 3
The share of ICT technologies used in the surveyed group of organizations

Note: N = 48

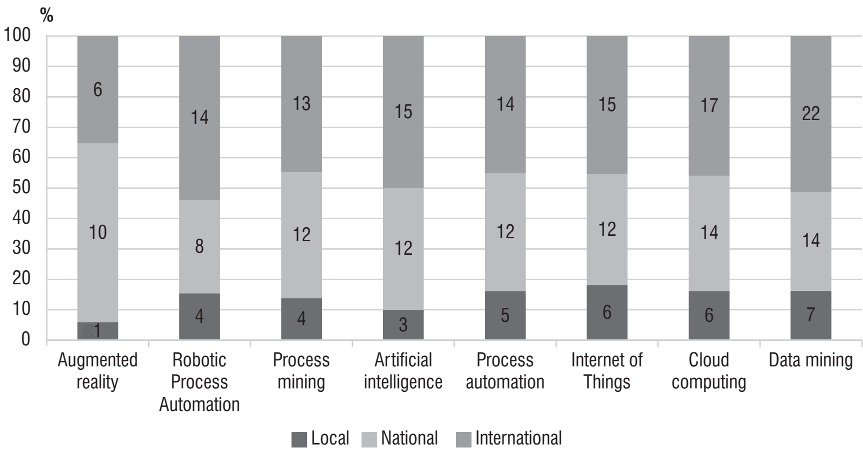
Source: Own elaboration based on the study carried out in 2020–2021.

The results obtained via the survey indicate that in the examined group of large organizations, a widespread use of data mining and cloud computing technology can be observed, regardless of their declared type of activity. The survey also indicated that the entities under examination which declared that their dominant activity was production-oriented use process automation and the Internet of Things technologies. In the organizations indicating that the core business was trade-oriented, the implementation of such technologies as augmented reality and artificial intelligence was declared. In service-oriented organizations, in turn, a significant share of such technologies as robotic process automation and process mining was observed.

Figure 4 presents the declared share of the ICT technologies applied in the surveyed group of organizations, in distribution by the scope of operation: local, national or international.

As Figure 4 indicates, an increase in the scope of operation positively affects the degree of selected ICT technology use, with a clear trend of a high share in organizations declaring the national reach.

Figure 4
The ICT technologies used, in distribution by the scope of operation

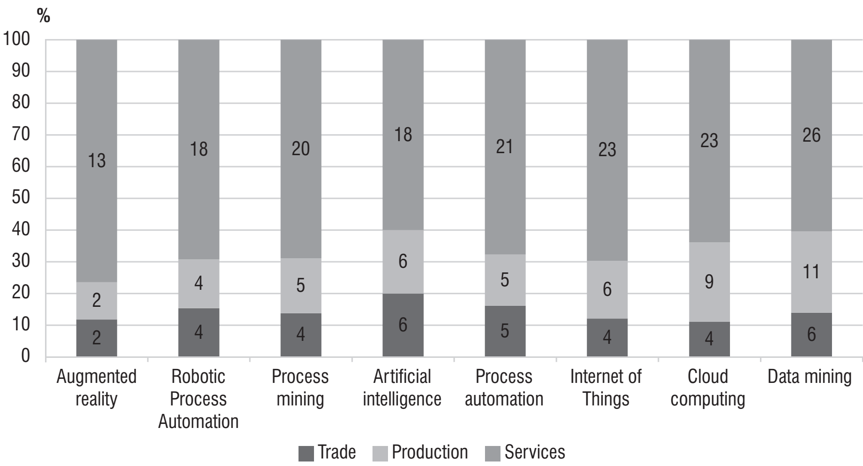


Source: Own elaboration based on the study carried out in 2020–2021.

Figure 5, in turn, shows the declared share of ICT technology use in the examined group of organizations, in distribution by the type of dominant genotype activity, i.e., trade, production, or service.

As Figure 5 shows, the dominance of organizations conducting service-oriented genotype activities is clearly discernible. Among the surveyed group

Figure 5
The ICT technologies used, in distribution by dominant activity

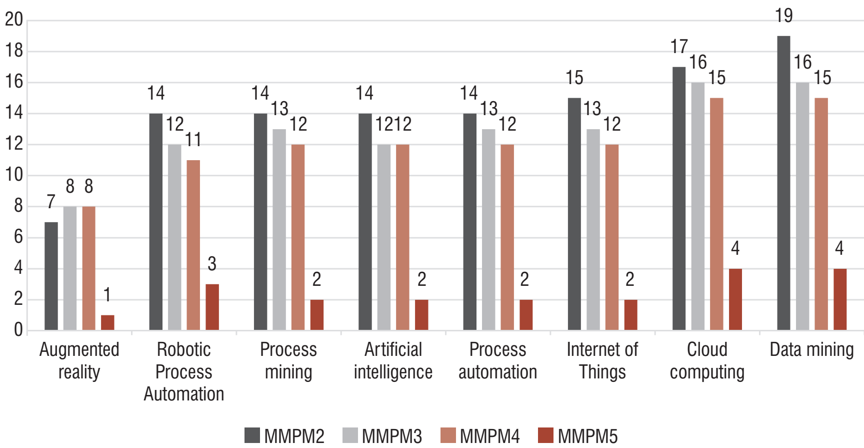


Source: Own elaboration based on a study carried out in 2020-2021.

of entities, the respondents conducting service-oriented activity primarily declared the use of data mining (26), cloud computing (24) and Internet of Things (23).

To recapitulate, the assessments of the organizations' process maturity and the degree of ICT technology implementation have been collated. Figure 6 shows the share of the technologies under examination in organizations classified at maturity levels 2, 3, 4 and 5.

Figure 6
The ICT technology used, in process maturity distribution



Note: MMPM n = the abbreviation indicates process maturity level according to MMPM model, where n signifies the level within the range <2;5>.

Source: Own elaboration based on the study carried out in 2020–2021.

As a result, using LOGIT estimation (univariate models), an attempt was made to identify the relationship between the declared selected technology implementation and the levels of process maturity in the entities surveyed. It has been established that artificial intelligence (AI) implementation statistically impacts the third level of maturity, according to the MMPM model (for $p < 0.05$), while robotic process automation (RPA) and cloud computing (CC) technologies impact the fourth level of maturity (for $p < 0.05$). The results indicate that AI implementation statistically supports the achievement of a system focused on implementing process solutions within the sphere of business process measurement. RPA and CC, in turn, can support the achievement of level four, i.e., a state in which management decisions are made on the basis of measurements of identified and formalized processes. It should be emphasized here that similarly to other studies of this kind which attempted to assess the level of process maturity of organizations in Poland, the vast majority of the entities surveyed indicate the lowest levels of maturity (usually the first and the second levels). The limitations in the context of maturity score compilation are related to the authors' use of various maturity models and sample selection techniques.

5. Conclusions

Based on the assumptions of the MMPM model, the vast majority of the organizations surveyed were classified as process-wise immature organizations. These organizations were classified at level 1 of process maturity according to the MMPM model, i.e., as those in which process identification and formalization was not confirmed (see: Sliż, 2018).

Out of the identified ICT technologies, data mining, IoT, AI, process automation, and process mining were the ones most frequently used in the examined group of 48 large organizations. As a result of LOGIT estimation using univariate models, a statistical relationship was identified between artificial intelligence (AI) technology implementation and the achievement of level 3 maturity as well as between robotic process automation (RPA) and cloud computing (CC) technology implementation and the achievement of level 4 process maturity (based on the MMPM model). Hence, it is concluded that the ICT technology application in the smart world era allows enterprise development in qualitative terms and, at the same time, enables the challenges of the global digital revolution to be met.

The results presented in this article are subject to research burden and limitations, similarly to any such study. The burden of the presented empirical investigation results primarily arises from the applied technique of non-probabilistic research sample selection. This means that the research conclusions concern the examined group of organizations and cannot be extended to the entire population of large organizations in Poland. From the perspective of research limitations, it is necessary to stress that the study examines the ICT technologies that primarily support the exploitation (activities implemented in the exploitation processes focused on increasing efficiency, productivity and quality of products and/or services in core business) and exploitative BPM (activities implemented in the exploratory processes focused on innovation and R&D activities) layers of an organization. This means that within the ongoing discourse in the English-language literature describing the integration of process management concepts and methods with the ambidexterity approach, it is important to identify the technologies supporting exploitative and exploratory activities as well as those that can be identified as a potential to support management activities in the achievement of balance between exploitation and exploration.

The research limitations outlined should serve as directions of further research extending the obtained results by the identification of ICT technologies that support exploitative and exploratory BPM, but above all, by the search for technological solutions supporting activities aimed at balancing exploitative and exploratory activities in process management, taking the ways of achieving organizational ambidexterity in terms of structure, context, sequence and leadership into account. Moreover, it should be emphasized that the aim of the authors is to extend the research to an international scale in order to compare future results in selected sectors of the economy in different countries. In addition, in the authors' opinion, it is worth focusing future research activities on seeking for a relationship between the implementation of selected ICT technologies in basic processes and the level of process evaluation parameters e.g., time of process implementation, process implementation costs, or the level of external or internal customer satisfaction. This type of research will enable the authors to verify whether the implementation of the ICT technology has a positive effect on the results generated in the processes.

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