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Towards integration of business process management and knowledge management. IT systems' perspective

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ABSTRACT
The processes of globalisation, the ongoing threat of the COVID-19 epidemic, the continuing war in Ukraine, and constantly emerging new technological solutions require organisations to adapt to changes constantly. Meanwhile, implemented business process management (BPM) often fails to integrate processes and knowledge resources. The awareness of the IT systems' role in management processes is still lacking. These premises influenced the implementation of the main research goal to identify the approach of Polish private and public enterprises and various industries to the BPM integration with knowledge management (MK) in the context of using new information technologies. The presented research results justify the usefulness of building relationships between the process and knowledge resources under dynamically changing conditions using IT systems. The diagnostic survey results confirmed the key importance of developing such BPM and MK elements as evidence-based decisions, strategic goals, measurement systems, databases, digital innovations, and IT use for data processing. The presented material can support managers of various organisation types in decision-making processes by fully understanding the IT systems' role and potential in process and knowledge management. Also, the article's implications are a source of guidelines, helping organisations to implement management systems based on modern technologies. The value of the publication is a wide range of respondents: 107 large, medium, small, and micro-enterprises operating in Poland. The article's research results also concern economic activities such as production, logistics, transport, banking, insurance, IT, telecommunications/media, public administration, healthcare/pharmaceuticals, consulting, energy, and construction.

KEY WORDS
business process management, knowledge management, knowledge resources, digital innovations, information technologies

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Introduction

The relationship between process management and knowledge resources in the context of emerging digital innovations is currently the subject of intense debate in academia and business (Langley, 2007; Christiansson & van Looy, 2017; Helbin & Van Looy, 2021). Meanwhile, according to many authors, this concept has recently focused primarily on the control and optimisation of processes rather than occurring and potential disruptions (Zakrzewska-Bielawska & Staniec, 2020; OMG, 2008; Lombarts et al., 2009;

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Badakhshan et al., 2019; BPM, 2020; BPM, 2021b). Until 2020, relatively little attention was paid by researchers and practitioners to the IT systems' importance for the integration of process and knowledge management, including the integration with business stakeholders (the environment), which is key in building relational capital (Gupta, Iyer & Aronson, 2000; Pant et al., 2011; Sanchez et al., 2011; Hove, von Rosing & Storms, 2015; Brajer-Marczak, 2016; Pereira, Barbosa & Duarte, 2020; Sobolewska & Bitkowska, 2020; Szelagowski & Lupeikiene, 2020; Grisold et al., 2021; Gzik, 2020). A dynamic change in this context occurred with the outbreak of the COVID-19 pandemic, which re-evaluated many of the strategies and systems used so far. For two years, a significant increase has been observed in the interest in IT systems that could effectively support management processes and communication with customers (Adam, Hofbauer & Stehling, 2021; Mahdi & Nassar, 2021; Keser Aschenberger et al., 2022; Toralles et al., 2021). The technological area in management is increasingly seen as a source of potential competitive advantage in virtually every sector and industry (AlShathry, 2016; Muntean, 2018; Muntu et al., 2021; El Ghalbzouri & El Bouhdidi, 2022; Mohamad, Jayakrishnan & Yusof, 2022, Polančič, Orban, 2023; Zakrzewska-Bielawska & Staniec, 2020). The geopolitical and socio-economic situation was greatly complicated by the war in Ukraine, which had been going on for several months and became another strong impulse for enterprises to verify the used and implemented strategies and solutions, including those relating to new information technologies. Many companies were forced to quickly redesign their current practices, including those related to activities within broken supply chains (Anderson, Müllern, Danilovic, 2023; Mbah & Wasum, 2022).

A literature review shows that large companies are less able to respond to disruptions (including digital) and adapt their BPM practices or knowledge management to disruptive technologies due to inertia, lack of incentives, or lack of faith in the effectiveness of new technologies (Hill & Rothaermel, 2003). The exception is enterprises with robotic process automation, which, as part of process and knowledge management, use the latest digital technologies more exploratorily (Dumas et al., 2013, 2018; Gross et al., 2020; Mendling, Pentland & Recker, 2020; Grisold et al., 2021). These premises encourage the scientific community to advocate for the need to extend the scope of BPM from process and operation control to greater emphasis on exploration and radical innovation, including the implementation of information technologies (Benner & Tushman, 2002; Bitkowska, 2018; BPM, 2021b; BPM, 2021a; Helbin & Van Looy, 2021; Zuhaira & Ahmad, 2021; Sitnikov et al., 2022).

Based on these premises, while considering the contemporary, difficult-to-predict social and economic challenges, the main research goal was to identify the approach of Polish private and public enterprises and various industries to the BPM integration with knowledge management (MK) in the context of the new IT use. The empirical research conducted in 2020 concerned such economic activities as production, logistics, banking, insurance, IT, telecommunications, public administration, health care, consulting, energy, and construction. The diagnostic survey confirmed the key importance of such elements as decisions, strategic goals, measurement systems, databases, digital innovations, and the use of information technology for data processing for the development of process and knowledge management.

1. Theoretical background

1.1. Determinants of business process management

According to Harmon, the BPM aims to improve managers' thinking and management of their organisations. Its manifestations, in particular Six Sigma, business process reengineering or business process management, are the basic impulse to change the mindset of managers and employee attitudes towards the organisation's continuous development (Harmon, 2010; Harmon, 2020).

The research described in the literature presents numerous factors that determine the implementation and functioning effectiveness of business process management in organisations. The most frequently mentioned elements are:

- aware process owners — having the appropriate knowledge resources,
- involvement of top management,
- appropriate communication,
- linking process goals with personal goals,
- high level of innovation in the organisation,
- follow-up of reported corrective and improvement actions,
- friendly and accessible process documentation,
- the process complexity,
- linking process goals with strategic goals,

- tool support.

Among the many methods and systems supporting the development of organisations that implement the concepts of process-managed organisations, the most frequently mentioned are TQM, ERP, CRM, SCM, BPR, BPI, ABC, BSC, TBM, JiT, LO, PERT, CPM, the concept of Kaizen continuous improvement, card systems Kanban, Benchmarking, E-business and many more (Kaplan & Norton, 2001; Bitkowska, 2017a; Detyna & Detyna, 2017; Badakhshan et al., 2019; Battisti et al., 2020; Sobolewska & Bitkowska, 2020; Espírito Santo et al., 2022; Gómez, Salazar & Vargas, 2022).

All these methods and tools require using appropriately collected and processed knowledge resources — data and indicators, based on which decisions are made. Meanwhile, knowledge resources must be reliable and up-to-date to fulfil their role in the organisation's improvement processes.

Recognising that knowledge is the most important strategic resource of an organisation implies the contemporary development of systems supporting the creation and application of knowledge (Moreno, Cavazotte & Lapa, 2015; Bitkowska, 2020; Criado-García, Calvo-Mora & Martelo-Landroguez, 2020). Meanwhile, the identification, acquisition, presentation, and documentation of knowledge are not independent tasks but internal elements of the processes implemented. Therefore, the starting point for managing knowledge resources in an organisation is understanding and accurately defining them. Previous research shows that creating knowledge management process models in organisations has a positive effect on generating innovation, stimulating the creativity of employees, and supporting internal communication (Anna, 2014; Bitkowska, 2017b, 2020; Kulesza & Rakowska, 2018; Sobolewska & Bitkowska, 2020).

1.2. Integration determinants for business process and knowledge management

The primary objectives of process management include, inter alia, standardisation and integration of the organisation's activities, which should potentially facilitate the prediction of ongoing processes, e.g., production, service provision, environmental changeability, etc. (Team, 2010; Bitkowska, 2017a; Sobolewska & Bitkowska, 2020; Bracci, Gobbo & Papi, 2022; Harymawan et al., 2022; Ispas & Mironeasa, 2022; Lopes et al., 2022; Silvestre, Fonseca & Morioka, 2022). Meanwhile, integration within process management and knowledge management should be manifested, e.g., in the pursuit of:

- improving access to services or products,
- appropriate quality of services/products in line with customer expectations,
- efficient use of resources,
- improving the flow efficiency of material streams,
- elimination of unnecessary or ineffective processes,
- shortening the duration of selected processes,
- improving the efficiency and effectiveness of IT systems,
- high flexibility of processes according to the needs of customers and other stakeholder groups,
- cost rationalisation (Detyna, 2016; Pereira, Barbosa & Duarte, 2020; Harymawan et al., 2022).

However, the growing complexity of processes carried out in companies limits the possibilities of their control by individual employees. One way of solving emerging problems may be to use various forms of teamwork, which gives a greater possibility:

- to deal with a wider range of problems beyond the scope of individual employees,
- to use various experiences, skills, predispositions, and knowledge,
- to solve problems characterised by complexity and a wider range of impact, usually concerning many organisational structures at the same time,
- to positively impact the motivation and satisfaction of employees,
- to easier implement recommendations resulting from the team's work compared to the implementation of individual ideas (Detyna, Detyna & Dudek-Kajewska, 2016; Bilas & Adeeb, 2017; Detyna, 2018; Chromjakova, Trentesaux & Kwarteng, 2021; Kir & Erdogan, 2021; Marín-González & Pérez-González, 2021; Tubis & Werbińska-Wojciechowska, 2021).

In light of scientific research, teamwork features are a key element in improving processes (including management) and creating the basis for constructing methods supporting the increase in employee engagement. However, their adequate motivation, ensuring the suitable group work, requires the management's involvement. The manager's role is primarily to create conditions for team problem-solving, creating a sense of acceptance and responsibility for decisions made (Govender & Parumasur, 2010; Bilas & Adeeb, 2017; Riyanto, Endri & Herlisha, 2021). Business specialists believe that process management effectiveness depends on management support (Baumgartner, 2011; Muntean, 2018; Schwartz et al., 2020; Adam, Hofbauer & Stehling, 2021). The main problems include competition from other process groups (teams) within the organisation, conflicts and quarrels over process solutions, and the lack of focus on process management. It also indicates the need for an integrated approach, in which the IT department works closely not only with business analysts, Six Sigma or Lean groups but also with individual process groups (Harmon, 2020). The main obstacles to the implementation and functioning of BPM and KM practices include the use of several techniques to analyse business processes. In the "BPTrends State of Business Process Management — 2020 Report", the most frequently indicated challenges related to the exploration of enterprise processes were financial aspects, including budgeting (46 %), the lack of know-how (55 %) and the lack of management support (45 %). These findings revealed gaps to be filled for organisations to strengthen the efficiency of processes with the possibility of exploring them and implementing innovative solutions (Harmon, 2021).

In this context, it should be clearly emphasised that for process and knowledge management to be effective and perceptible by customers and employees, managers need to concentrate on the processes. It is necessary to integrate equipment, including IT tools, activities, knowledge, employees, cooperating companies, etc.

1.3. IT systems for the integration of business process management and knowledge management

In the context of the article's subject, interesting data has been published based on the BPM Pulse study, actively involving over 450 organisations in April–May 2021 (BPM, 2021a). The conclusions of the report are as follows:

- According to the organisations surveyed, BPM applications are very effective in automating routine tasks, i.e., budgeting, planning, and forecasting, consolidation, and reporting. Businesses need measurement, analysis, and visibility in a wide range of management tasks, and many non-finance users are ready to deploy BPM applications in their workplaces (BPM, 2017);
- Vendors of business process management software increasingly recognise the importance of Artificial Intelligence (AI) capabilities in their products. Most software vendors currently have some AI-based features or are in the process of developing them. At the same time, only a few respondents perceive artificial intelligence as a strategic, crucial element in the management system. Financial services companies seem most interested (BPM, 2018).

Researchers and business practitioners are inspired by the comparisons and summaries of survey results published in cyclical BPTrends reports. The BPTrends 2021 report summarises the results for 2006, 2010, 2012, 2014, 2016, 2018, and 2020. This review demonstrates how BPM practitioners have changed the perception of business process management and knowledge issues as an organisation's resource over the last 16 years (Harmon, 2020). One hundred twenty-nine respondents actively participated in the survey, with the largest group of companies from Europe (36 %), followed by North America (29 %), Central and South America (15 %), Africa and the Middle East (12 %), and Eastern South Asia (5 %). Organisations from China, Japan, Korea, Australia and New Zealand accounted for 4 %. Respondents mentioned tools, including IT software used by the organisation to manage knowledge resources and model processes. There are two types of BPM solutions: those used to build diagrams (e.g., Visio) and those used to define processes, i.e., store models in a database. According to Harmon, the use of process modelling tools has not changed practically over the last two years. In 2017, 58 % of respondents used BPM software for process modelling. In 2019, the percentage was higher (70 %). This increase is assessed as rather small, considering that IT solutions for BPM have been on the market for over 20 years, and in recent years, there has been a significant evolution with the addition of countless new technologies and modules. The study group saw increased use of formal BPM tools for process modelling, e.g., AuraPortal, Bizagi, IBM Blueworks Live, Signavio, Pega BPM, and Software AG ARIS. Meanwhile, a large number of users still rely on tools that simply perform the function of defining process diagrams (i.e., Microsoft Visio, Lucidchart, and even Microsoft PowerPoint), which do not support business process management in its broader scope, considering additional functionalities (in the field of design and modelling processes, implementation and execution). Currently, organisations still have difficulties understanding, evaluating, and choosing the right software for their business. The market offers intelligent applications for business process management (iBPMS), business software for process automation (BPA —

Business Process Automation), and a tool for the automation of robotic processes (Robotic Process Automation — RPA). This choice makes it increasingly difficult for organisations to adopt the best solution (Harmon, 2020).

2. Materials and methods

The data source published in this article is a survey conducted in 2020 among 107 organisations operating in Poland. They were territorial enterprises: international (48 %), national (39 %), regional (6 %) and local (6 %), Fig. 1. The dominant group of respondents was private companies with mixed Polish and foreign capital (36 %), then, private companies with Polish capital only (31 %), State Treasury companies (18 %), and private companies with foreign capital only (11 %), Fig. 2. The research sample is represented by large (55 %), medium-sized enterprises (22 %), small (19 %), and micro-enterprises employing up to nine employees (4 %), Fig. 3. The organisations surveyed included enterprises operating in various industries: production (18 %), logistics (11 %), banking (11 %), IT (8 %), telecommunications/media (7 %), public administration (7 %), insurance (6 %), healthcare/pharmaceuticals (6 %), transport (5 %), consultancy (4 %), energy (1 %), construction (1 %) and others (15 % in total). The structure of the industries represented by the surveyed organisations is presented in Fig. 4.

In statistical research, it is often necessary to establish the relationship between two features, X and Y, both of which (or at least one) are qualitative. In such a situation, multi-way tables (contingency tables) are built with a specified number of rows and columns, including numbers of individual variants of features. The chi-square test of independence was used to assess the dependence of the variables studied in this publication. The study of interdependence is justified only when there are stochastic or at least correlational relationships between the variables. The study of stochastic independence based on the equality of conditional means and conditional variances is possible only in the case of measurable features. However, in statistical research, the necessity is also encountered to assess the stochastic independence of immeasurable features. In such cases, the chi-square test of independence enables the verification of the variable independence (Rubin & Levin, 2013).

The nonparametric null hypothesis states that the n-element random sample comes from a general population with stochastic independence of the random variables X and Y. The wording of both hypotheses is as follows:

H_0: X and Y features are independent,

H_1: the features of X and Y are interdependent.

The chi-square statistic is used to verify H0 with stochastic independence of variables (Sobczyk, 2022). The value of this statistic depends on three factors:

- the strength of the relationship between the investigated features: the greater the differences between the empirical and theoretical numbers, the greater the value of the chi-square statistic, and thus, the greater the strength of the relationship,
- the sample size, which, according to the test requirements, should be large,
- the level of detail of data grouping; it is required that the empirical counts in each field of the independence table be at least eight and at least not below five.

The literature assumes that if the analysis of the multi-way table shows a relationship between the two considered features (verified by, e.g., the chi-square test of independence), then its strength should be determined. The literature on the subject provides many measures of the relationship strength between two features expressed on nominal scales (Rubin & Levin, 2013; Sobczyk, 2022). One of these is Pearson's contingency coefficient C, used in this publication. It can be used with multi-way tables of any size (the minimum number of fields is four) and any form (rectangular or square). Theoretically, Pearson's contingency coefficient can take values from 0 (features are independent) to 1 (when the number of fields in the table increases to infinity). Determining the maximum values of the C_{max} contingency coefficient for square and rectangular tables has been described in detail in the statistical literature (Sobczyk, 2022). Considering this value, the adjusted value of the contingency coefficient is often determined as a relative measure based on the relationship:

$$C^* = \frac{C}{C_{\max}} \tag{1}$$

In addition, for the purpose of this article, one of the modern statistical modelling methods — Partial Least Squares (PLS) — was used. Modelling in economics or management and quality sciences, or, more broadly, social sciences, refers to the creation, disclo-

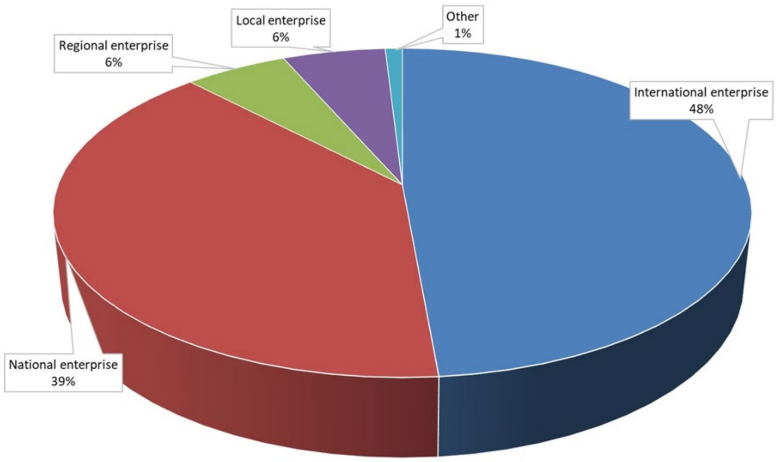

Fig. 1. Territorial scope of the activity conducted by the surveyed organisations

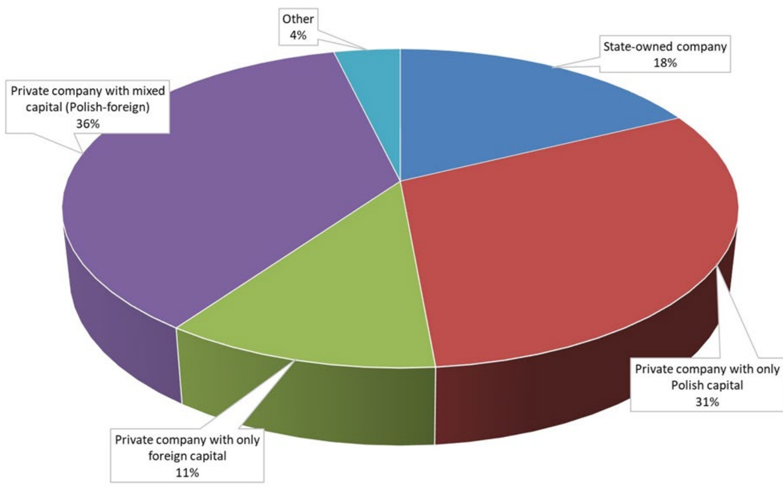

Fig. 2. Form of ownership of the surveyed organisations

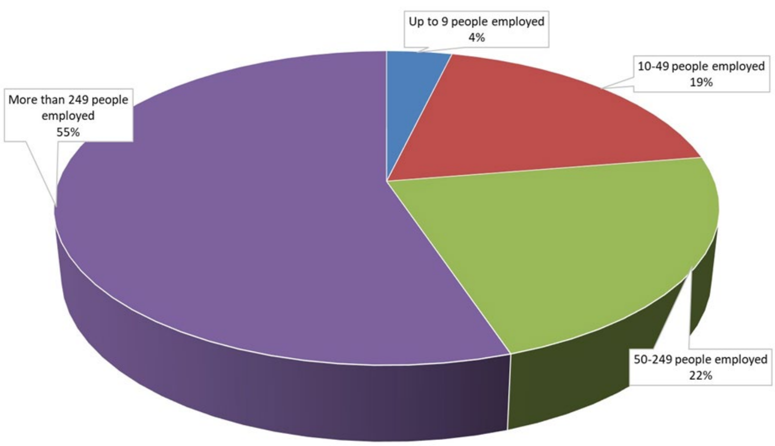

Fig. 3. Size of the surveyed organisations by the number of employees

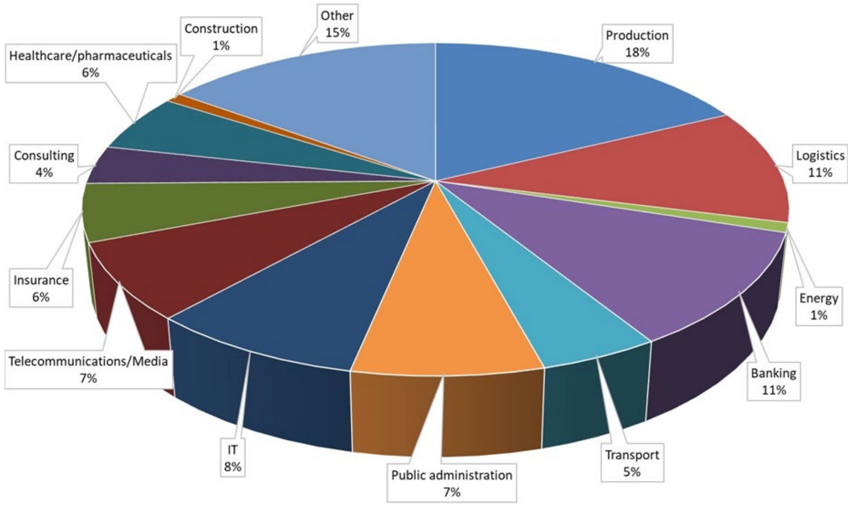

Fig. 4. Industries represented by the surveyed organisations

sure, and verification of relationship structures between the investigated elements. A given model illustrates the relational relationships, usually cause-and-effect relationships of the impact nature, occurring between the concepts or factors that are the research subject. Auch a relationship assumes that existing influencing factors (explanatory, independent, causal variables) impact the behaviour of some effect factors (dependent and effect variables). It is also possible for these factors to influence each other. In social sciences, these factors are often abstract and relate to concepts that are directly immeasurable (e.g., customer value, satisfaction, loyalty, experience, attractiveness, etc.).

The model simplifies the image of these relations: in essence, it assumes the omission of some reality's fragment, usually elements with a smaller scale of influence, less significant or unknowable. The model is a reflection of the theory, hypotheses or assumptions adopted by the researcher and is subject to empirical verification; therefore, it requires appropriate research and results analysis using appropriate methods (Biesok & Wyród-Wróbel, 2016).

The PLS-DA method was described for the first time in the late 1980s as a method aiming to find and visualise the maximum covariance between the input data and the predefined information related to belonging to a given class. This is the same as in the case of PCA. This is done by a linear transformation of the input data to a new orthogonal coordinate system, the so-called latent components (LC). The first LC reflects the maximum variability between classes (Sjöström, Wold & Söderström, 1986; Ståhle & Wold, 1987).

The quality of the PLS-DA model is determined by three parameters:

- the sum of squares of the data X, explained by the hidden components extracted,
- the sum of squares of data Y, explained by the hidden components extracted,
- the predictive ability of the model, defined by the sum of squares of the prediction error for all the extracted components.

As in the case of PCA, the number of identifiable hidden components depends on the order of the X matrix (bold – designation of a vector, matrix); however, this time, the selection of an appropriate number is crucial for ensuring the correct functioning of the model. The significance of the input variables in case factor loadings and weight plots is usually assessed visually: the further a given variable is from the centre of the action, the more significant it is. Such an assessment largely depends on the operator's experience and knowledge of the nature of the analysed data. In addition, the PLS-DA model allows the significance of input variables (variable importance — VIP) to be determined based on the absolute value of weights for a given variable, multiplied by the R2Y value for a given hidden component, which allows for the visual method's verification. It is assumed that the value of VIP> 1 allows for the recognition of a given variable as significant in the projection of the Y matrix. All the methods of statistical analysis presented above were performed using the TIBCO Statistica v. 13.3 statistical package.

3. Results

The methods used for the analyses — the chi-square test and Pearson's contingency coefficient C — also allowed linking the business process management activities in companies with their storage and use of knowledge resources. The statistical connection of business process management with the storage and use of knowledge resources in analysed organisations is presented in Table 1. The maximum value of the contingency coefficient for the investigated variables, in this case, is C_{max} (2x2) = 0.707. Considering this value, it can be stated that in most cases, the strength of connections is moderate, and in some cases, it is relatively high (C*> 0.5).

The greatest strength of connections was noted between the process simulation areas in the surveyed organisations and the process risks registered by them (C* = 0.625) and the use of so-called other process documents (C* = 0.520). A relatively high degree of association was also noted between process modelling and the storage of knowledge resources in the form of process models and their subsequent versions (C* = 0.605). A comparatively high rate was obtained by examining the strength of the relationship between the risk assessment in processes and the recording of these risks (C* = 0.549).

Tab. 1. Statistical connection of process management with the storage and use of knowledge resources in the surveyed organisations (C_{max} (2x2) = 0.707)

Process activities	Knowledge resources	Significant dependencies, chi-square test, p<0.05	
		p-value	contingency coefficient *C**
Identification of processes in the company	Process models and their successive versions	0.00126	0.412
	Results from process audits	0.00213	0.400
	KPI performance indicators assigned to appropriate processes	0.02017	0.304
	Procedures and instructions assigned to processes	0.00028	0.464
	Risk registers of process	0.00013	0.472
Modelling of processes in the company	Process models and their successive versions	0.00000	0.605
	Database of good trial practices	0.02331	0.303
	KPI performance indicators assigned to appropriate processes	0.00008	0.499
	Procedures and instructions assigned to processes	0.00778	0.351
Optimisation of processes in the company	KPI performance indicators assigned to appropriate processes	0.00791	0.335
Simulation of processes in the company	Process models and their successive versions	0.03738	0.279
	Results from process audits	0.00992	0.337
	Database of good trial practices	0.03928	0.276
	KPI performance indicators assigned to appropriate processes	0.00064	0.443
	Procedures and instructions assigned to processes	0.00218	0.396
	Other documents from the processes	0.00004	0.520
	Risk registers of process	0.00000	0.625
Improving processes in the company	Database of good trial practices	0.01096	0.330
	Other documents from the processes	0.00426	0.373
	Risk registers of process	0.00021	0.454
Controlling processes in the company	Process models and their successive versions	0.02662	0.293
	KPI performance indicators assigned to appropriate processes	0.00041	0.443
	Risk registers of process	0.02021	0.304
Risk assessment in processes	Other documents from the processes	0.00643	0.362
	Risk registers of process	0.00001	0.549

One of the key tasks in modelling PLS relationships is the selection of variables (predictors). A dedicated module was used in the Statistica v. 13.3 program, i.e., Selection of Variables from the area of Data Mining Analyses. Of all the variables resulting from the respondents' answers, the selected were statistically related to the so-called effect factors, differently explained, or caused (significance level $p < 0.05$ for the chi-square test). The lower the p-value, the smaller the error of the first type made when rejecting the null hypothesis (H0) about the independence of the variables (the hypothesis was rejected more strongly). The analysis considers three effect factors:

- quality of process implementation,
- optimisation of key performance indicators (KPIs), costs and process time,
- customer satisfaction.

A specific ranking of the so-called influencing factors (explanatory, causal) that are statistically significantly related to the quality of process implementation is presented in Table 2 and Fig. 5. The most strongly related variables in this context are the use of IT systems for process modelling, the use of IT systems for process optimisation, and the use of IT systems for process identification.

Table 5 and Fig. 6 present the factor selection results for influencing the optimisation of KPIs, costs and process time. The most closely related variables in this context are KPI performance indicators assigned to the respective processes, the use of KPIs and the implementation of IT tools supporting business process management.

Tab. 2. Results of the selection of variables in the PLS analysis concerning the quality improvement of process implementation in the surveyed organisations

Variable	Best predictors for categorical dependent var: Increasing the quality of process implementation	
	Chi-square	p-value
Use of IT systems for process modelling	47.81	0.000003
Use of IT systems for process optimisation	36.86	0.000236
Use of IT systems to identify processes	33.56	0.000792
Use of IT systems for process improvement	28.47	0.004722
Implementation of risk management in processes	12.25	0.006580
Process models and their successive versions	11.43	0.009615
Implementation of IT tools supporting process management	8.25	0.041205
Employee training in process management/process improvement	7.95	0.047006

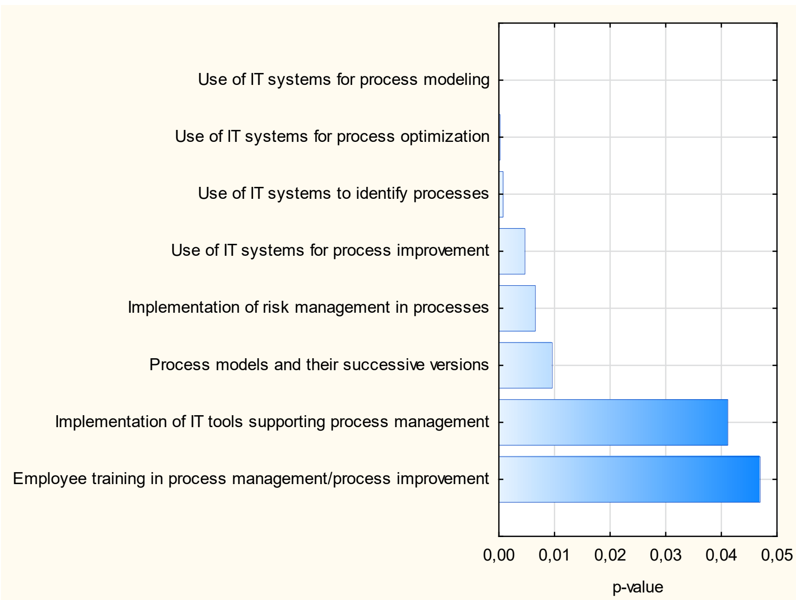

Fig. 5. Results of the selection of variables in the PLS analysis concerning the quality improvement of process implementation in the surveyed organisations

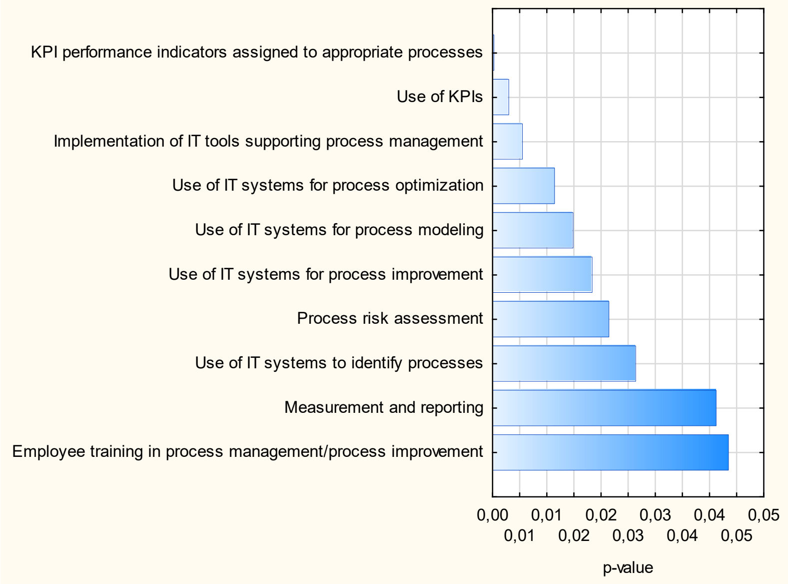

Fig. 6. Results of the variable selection in the PLS analysis regarding the optimisation of KPI, costs and time of processes in the analysed organisations

Tab. 3. Results of the variable selection in the PLS analysis regarding the optimisation of KPI, costs and time of processes in the analysed organisations

Variable	Best predictors for categorical dependent var: Optimisation of KPIs, costs and processes time	
	Chi-square	p-value
KPI performance indicators assigned to appropriate processes	21.32	0.000274
Use of KPIs	16.01	0.003005
Implementation of IT tools supporting process management	14.63	0.005530
Use of IT systems for process optimisation	31.55	0.011446
Use of IT systems for process modelling	30.66	0.014868
Use of IT systems for process improvement	29.93	0.018380
Process risk assessment	11.50	0.021474
Use of IT systems to identify processes	28.65	0.026416
Measurement and reporting	9.95	0.041249
Employee training in process management/process improvement	9.82	0.043531

Tab. 4. Results of the variable selection in the PLS analysis regarding the increase in customer satisfaction in the surveyed organisations

Variable	Best predictors for categorical dependent var: Increase in customer satisfaction	
	Chi-square	p-value
Use of IT systems for process monitoring	37.28	0.000201
Implementation of IT tools supporting process management	13.43	0.003796
Use of IT systems for process modelling	28.80	0.004213
Use of IT systems to identify processes	27.25	0.007116
Simulation of processes in the company	11.33	0.010058
Use of Cloud Computing	10.22	0.016788
Implementation of risk management in processes	9.33	0.025209
Procedures and instructions assigned to processes	9.20	0.026712
Employee training in process management/process improvement	8.69	0.033744

Tab. 5. Results of the PLS analysis for the dependent variable: improvement of the quality of the implemented processes

Variable	Variable importance Number of components is 2	
	VIP	Importance
Use of IT systems for process modelling {To a very large extent, for all processes}	2.191 t1	1
Use of IT systems to identify processes {To a very large extent, for all processes}	1.392 t1	2
Use of IT systems for process optimisation {To a very large extent, for all processes}	1.352 t1	3
Use of IT systems for process improvement {To a very large extent, for all processes}	1.317 t1	4
Process models and their successive versions {Yes}	1.257 t1, t2	6
Process models and their successive versions {No}	1.257 t1, t2	6
Use of IT systems to identify processes {To a small extent for single processes}	1.242 t2	7
Implementation of risk management in processes {Yes}	1.217 t2	9
Implementation of risk management in processes {No}	1.217 t2	9
Use of IT systems for process modelling {To a small extent for single processes}	1.213 t1	10
Use of IT systems for process improvement {To a small extent for single processes}	1.019 t2	11

Tab. 6. Results of the PLS analysis for the dependent variable: optimisation of KPI, costs and process time

Variable	Variable importance Number of components is 2	
	VIP	Importance
Use of IT systems for process optimisation {To a very large extent, for all processes}	1.512 t2	1
KPI performance indicators assigned to appropriate processes {Yes}	1.452 t1	3
KPI performance indicators assigned to appropriate processes {No}	1.452 t1	3
Use of IT systems to identify processes {To a very large extent, for all processes}	1.409 t2	4
Use of KPIs {Yes}	1.328 t1	6
Use of KPIs {No}	1.328 t1	6
Use of IT systems for process modelling {To a very large extent, for all processes}	1.302 t2	7
Use of IT systems for process improvement {To a very large extent, for all processes}	1.190 t2	8
Process risk assessment {Yes}	1.138 t1, t3	10
Process risk assessment {No}	1.138 t1, t3	10
Implementation of IT tools supporting process management {Yes}	1.103 t1	12
Implementation of IT tools supporting process management {No}	1.103 t1	12
Measurement and reporting {Yes}	1.042 t1, t3	14
Measurement and reporting {No}	1.042 t1, t3	14
Use of IT systems for process improvement {To a large extent}	1.006 t2	15

The variable selection results for the PLS analysis regarding the third effect factor — increasing customer satisfaction in the organisations surveyed — are shown in Table 6 and Fig. 7. The best predictors for this factor include the use of IT systems for process monitoring, the implementation of IT tools supporting business process management, the use of IT systems for modelling processes, and using them to identify processes.

The results of the PLS analysis concerning individual effect factors are presented in Tables 2–7 and Figs. 8–10. Tables 2–7 present only those variables for which the VIP coefficient (i.e., the importance of the variable) has values greater than 1. The higher the VIP value, the greater the importance of a given variable. Table 7 presents a list of variables according to their strength of influence on the quality of processes implemented in companies.

A cause-and-effect model was built in the computer package Statistica v. 13.3. (PCA Analysis module, PLS) only for previously selected variables (predictors), which, based on the chi-square independence test, showed a statistical relationship with the dependent variable under investigation (improve-

Tab. 7. Results of the PLS analysis for the dependent variable: increased customer satisfaction

Variable	Variable importance Number of components is 2	
	VIP	Importance
Use of IT systems for process monitoring {To a very large extent, for all processes}	1.372 t1	1
Use of IT systems to identify processes {In a medium range, the main processes}	1.337 t2	2
Use of IT systems for process modelling {To a small extent for single processes}	1.277 t3	3
Implementation of IT tools supporting process management {Yes}	1.169 t1	5
Implementation of IT tools supporting process management {No}	1.169 t1	5
Use of IT systems to identify processes {To a very large extent, for all processes}	1.100 t2	6
Simulation of processes in the company {Yes}	1.073 t1	8
Simulation of processes in the company {No}	1.073 t1	8
Procedures and instructions assigned to processes {Yes}	1.058 t2	10
Procedures and instructions assigned to processes {No}	1.058 t2	10
Cloud Computing Usage {Yes}	1.038 t2, t3	12
Cloud Computing Usage {No}	1.038 t2, t3	12
Implementation of risk management in processes {Yes}	1.021 t2	14
Implementation of risk management in processes {No}	1.021 t2	14

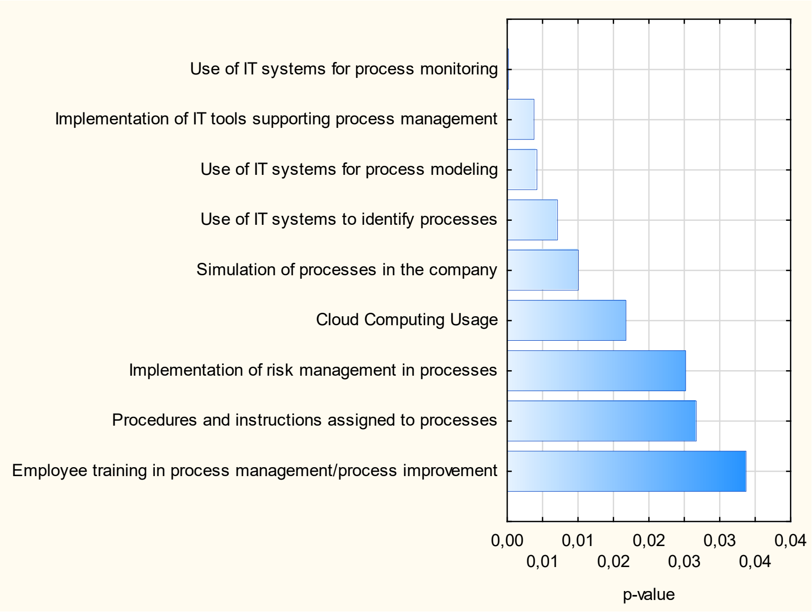

Fig. 7. Results of the variable selection in the PLS analysis regarding the increase in customer satisfaction in the surveyed organisations

ment of the quality of implementation processes). In this case, during the PLS analysis on the basis of the input variables, two principal components (t1, t2) were determined, which are related to the weight of the investigated explanatory variables (responses from the questionnaires in the left column of Table 5). The main first component (t1) plays a more important role as it is related to the use of IT systems in business process management. Such factors as the use of IT systems for process modelling, identification, optimisation, and improvement have the most substantial influence on process quality improvement.

An attractive graphical presentation of the studied factor dependence and the variable improving the quality of process implementation is a biplot (here, specifically a bagplot or in other words bag graph), which shows how the responses regarding the process quality correlate with answers to the questions concerning the selected variables (Fig. 8). It is visible that the improvement of the quality of process implemen-

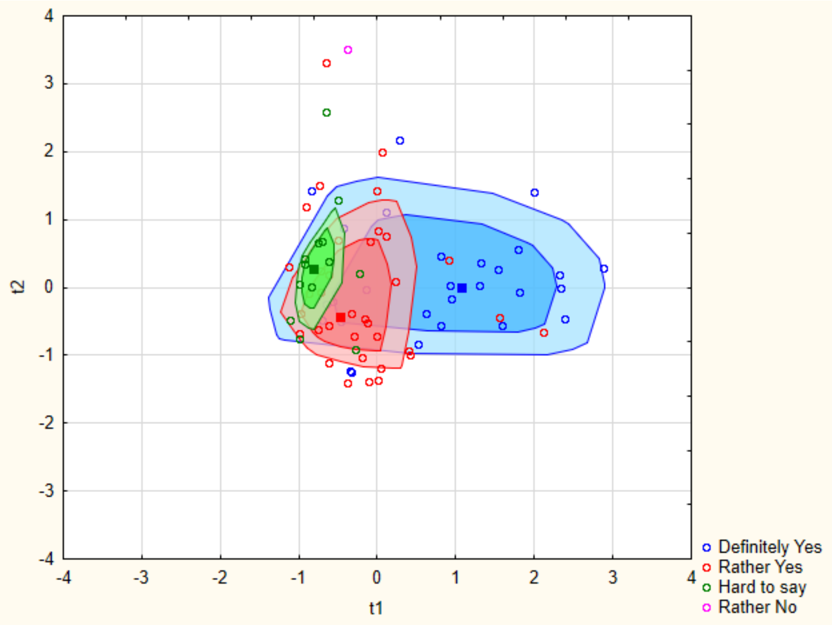

Fig. 8. Standardised biplot (t1 vs. t2): increasing the quality of process implementation

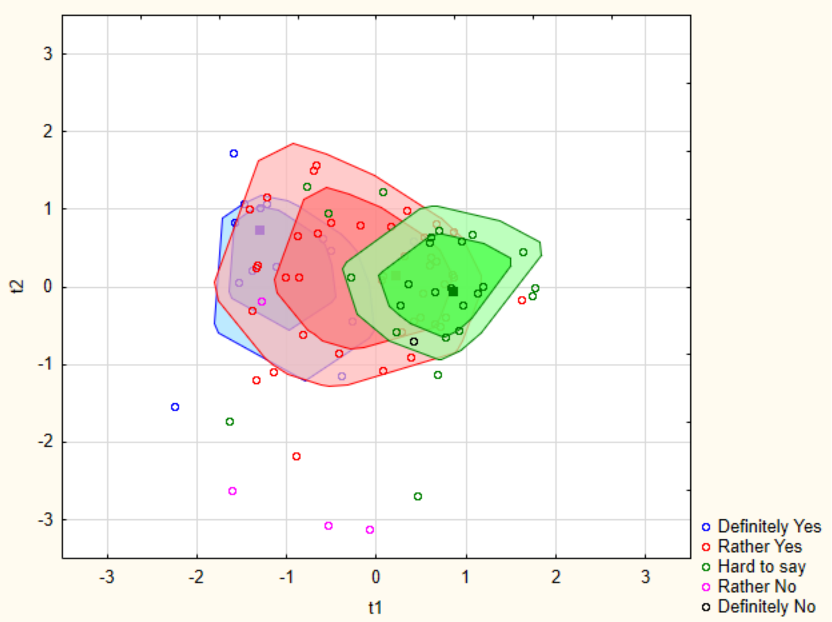

Fig. 9. Standardised biplot (t1 vs. t2): optimisation of KPIs, costs and processes time

tation (Definitely Yes) proceeds along the first principal component (t1, horizontal axis), which is related to the responses most strongly associated with this variable (Table 5), i.e., with very strong use of IT systems for modelling, identification, optimisation, and process improvement. This group of respondents is represented the strongest in the chart (Fig. 8) (blue bag). The answer of the respondents, "Hard to say", is visible in the green "bag", i.e., slightly to the right along the t1 component and slightly in the positive direction for the t2 part (the group of respondents is relatively small). This applies to companies that use IT systems to a lesser extent to identify processes (including individual), their modelling, and improvement. These companies can store knowledge resources about process models and their subsequent versions, and initiatives are planned for the implementation of risk management in processes (t2 component). Single points indicate the answer "Rather No", and the absence of the answer "Definitely No" is noticeable.

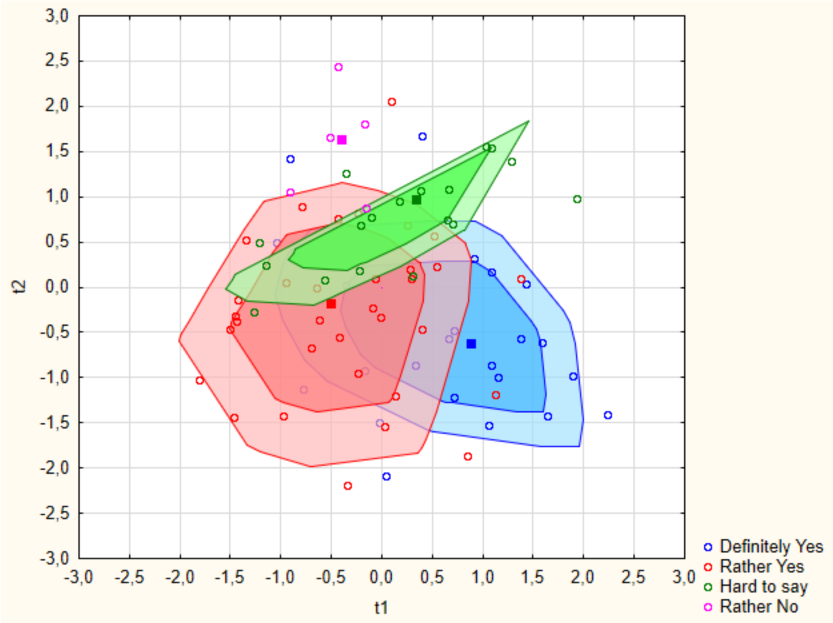

Fig. 10. Standardised biplot (t1 vs. t2): increasing the level of customer satisfaction

The results of the PLS analysis for the dependent variable KPI, cost and process time optimisation are presented in Table 6 and Fig. 9. The variables that have the strongest impact on the improvement of KPIs are use of IT systems to optimise processes, assigned KPIs to relevant processes and use of IT systems for process identification (very much for all processes). The bag graph (Fig. 9) does not show a clear correlation of observations with the main components. A large number of responses are concentrated in the central part of the graph, which may indicate a variation in the value of the predictors in relation to KPI optimisation, costs, and process execution time. Many predictors have a higher weight assigned to the principal component t2, even the most important value, "Use of IT systems for process optimisation {To a very large extent, for all processes}". However, two predictors directly related to KPI optimisation, namely, KPI performance indicators assigned to appropriate processes and use of KPIs, are assigned to the main component t1, which explains a much larger part of the dependent variable's variance. In addition, the chart shows that the largest part is taken up by "Rather Yes" responses and a relatively extensive set of "Hard to say" responses. This indicates that the respondents are less determined with regard to the optimisation of KPIs, costs and process time in relation to the previously described dependent variable.

PLS results for the dependent variable increasing the level of customer satisfaction are presented in Table 7 and Fig. 10. The causal variables that have the strongest impact on customer satisfaction are the use of IT systems for process monitoring, identification, modelling, and implementation of IT tools supporting business process management. A large proportion of respondents using IT tools indicate an increase in the level of customer satisfaction (Fig. 10, blue and red areas). It is not without significance, however, that there is quite a large group of undecided respondents who answered "Hard to say" (green area in Fig. 10), mainly those who use IT tools to a small or medium extent for individual processes. Single respondents (responding "Rather No") do not observe an increase in the level of customer satisfaction (although not definitely, because there were no such answers) using knowledge management methods and IT tools for business process management indicated here.

4. Discussion, implications and concluding remarks

4.1. Theory contributions

Comparing the research results with literature reports on the subject confirmed the significant connections between the use of IT systems, the level of business process management development and knowledge management, and the quality of processes implemented in companies, their effectiveness, and the level of customer satisfaction.

The research found that the knowledge resources stored by respondents most often include the results of process audits, databases of good process practices, KPI performance indicators assigned to appropriate processes, procedures and instructions assigned to processes, and other documents from processes or process risk registers. Statistically, the strongest links between the storage and use of knowledge resources by companies and a given industry concern the IT and banking sectors.

The greatest strength of connections between business process management practices and the methods of storing and using knowledge resources was noted between simulating processes in organisations and the process risks registered by them. A relatively high degree of association was noted between process modelling and storing knowledge resources in the form of process models and their subsequent versions. A comparatively high rate was obtained by examining the strength of the relationship between risk assessment in processes and recording these risks.

The research methodology allowed the authors to identify influencing (causal) factors statistically significantly related to the quality of processes, their effectiveness, and the level of customer satisfaction, which is the essence of the study. Thus, process implementation quality is most strongly influenced by such variables as the use of IT systems for modelling, optimisation, and identification of processes. In turn, the optimisation of KPIs, costs and process time is most influenced by variables in the form of KPI performance indicators assigned to appropriate processes, the use of these indicators, and the implementation of IT tools supporting business process management.

The strongest predictors influencing the increase of customer satisfaction in the surveyed organisations include the use of IT systems to identify, model, and monitor processes and the implementation of IT tools supporting business process management.

4.2. Implications for practice

The value of the presented research results has cognitive and utilitarian aspects. The presented material can support the decision-making processes of managers of various organisation types in fully understanding the IT systems' role and potential in process management. The implications shown in the article are also a source of guidelines that help organisations implement management systems based on modern technologies. The practical value of the publication is a wide range of respondents, i.e., 107 large, medium, small and micro-enterprises operating in Poland. In the literature on the subject, the dominant industries described in the context of using IT systems in BPM or knowledge management are finance, insurance, banking, trade, and logistics. The research results concern banking, insurance and logistics, production, IT, telecommunications/media, public administration, health care/pharmaceuticals, transport, consulting, energy, and construction.

The research results confirmed that IT systems and knowledge management processes are strongly integrated into enterprise management processes. Noticed by the management, these implications may result in appropriate and correct decisions regarding proper planning, organisation, monitoring, and improvement of management processes at every stage of the company's operations. It will be beneficial for companies to raise employee awareness of the IT systems' role and their personal commitment to the effectiveness and efficiency of the knowledge management system or BPM functioning in the organisation.

Proper identification of key knowledge management processes and the relationships between them, as well as the appropriate use of evidence-based information, experience, and competences of employees, are the conditions for the effective building (strengthening) of intellectual capital. This capital is unique for each organisation and is often not fully used as a source of competitive advantage. This publication may improve the awareness of the management staff and process owners responsible for specific tasks (projects).

4.3. Limitations and future research directions

The limitations of the presented research results refer to the adopted methodology, which was based on a diagnostic survey conducted using the proprietary questionnaire form. Despite its considerable diversity and relatively large number, the group of respondents is not a representative sample as it does not reflect the structure of enterprises operating in Poland. Manufacturing companies represented the largest group of respondents (18 %). Despite being broadly represented in the context of industries, not all sectors were represented.

Bearing in mind the specificity of each enterprise, it would be advisable to plan future research dedicated to specific sectors (industries), including the division into the private and public sectors. Contemporary geopolitical, socio-economic, and technological challenges do not only concern the private sphere. The rapidly changing expectations of customers also apply to public services that are often overlooked in research work (education, science, culture, local governments, etc.). Research dedicated to individual groups of organisations could significantly contribute to their development, including the acceleration of improvement activities with the use of new information technologies.

The literature review and the obtained empirical research results regarding the role of IT systems in integrating business process management and knowledge management indicate numerous directions of possible further research in this field. In this context, further research is particularly recommended by the authors:

- improvement of BPM systems and knowledge management,
- improvement of IT methods and tools used in process management and knowledge management,
- concepts, methods, and IT tools for the integration of knowledge management and BPM,
- models of integrated management systems in enterprises of various sectors and industries,
- research on the specificity of BPM and knowledge management in the public sector,
- new concepts and solutions in the field of sharing dedicated databases, as well as software for various types of organisations,
- tools for monitoring the effectiveness, efficiency and capacity of systems and processes in enterprises and within the created networks of enterprises,
- tools for monitoring management processes, main and auxiliary organisations,
- the role of IT systems in the development of process maturity of enterprises,
- creating new models of knowledge management maturity,
- research in the field of creating models of process maturity dedicated to cooperating organisations (networks, consortia, etc.),
- research on the effectiveness of IT systems used in companies,
- research on organisational structures, their flexibility and ability to achieve the set goals, including in the BMP context, knowledge management and the introduction of innovative management and organisational solutions,
- analyses and proposals regarding the usability of IT tools in the field of cooperation between enterprises and their clients,
- proposals for streamlining and increasing the efficiency of systems monitoring organisational and management processes.

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