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THE IMPACT OF KNOWLEDGE MANAGEMENT ON THE ECONOMIC INDICATORS OF THE COMPANIES

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Abstract

This paper analyzes the impact of knowledge management on the organizational performance of companies measured through previously defined economic indicators. Knowledge management in the company is observed through the factors that make up a knowledge management system, namely: business processes, people (employees), and information technology, while the same has been done for economic indicators through indicators of liquidity, indebtedness, activity, economic efficiency, and profitability. Knowledge management as a variable is described by ordinal data, while the business indicator variable is described by quantitative, real data. Research shows that most large companies have built-in elements of knowledge management, some medium-sized companies are involved in this process, and most small companies have not developed management strategies in which knowledge management exists as an important factor. The research also proves that there is a positive correlation between knowledge management and economic indicators, i.e., in other words, the research shows that knowledge management has a positive impact on reducing indebtedness and increasing liquidity, activity, economic efficiency, and profitability.

Keywords: *knowledge management, organizational performance, economic indicators, revenue, profit, profitability ratio, economy ratio*

JEL Classification: *L2, M1, O30*

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1. Introductory considerations

Knowledge is today the most important resource through which companies gain a competitive advantage. Therefore, knowledge management in organizations has become imperative for their development and achieving the predefined organizational goals. In addition, the need for knowledge management is emphasized by its exponential growth in the environment of the organization, as well as the necessity of its contribution to the overall knowledge. The total human

knowledge created until the year 1900 has doubled by 1950, after which the doubling time was shortened to five to eight years (Jakupović and Grandov 2014). The specificity of knowledge as an organization's resource is certainly the fact that it is not consumed by use, and its economic value directly depends on the time of its appearance and is most valuable when it is inaccessible to others. Managing knowledge means ensuring access to knowledge, followed by its collection, storage, modification, transfer, and implication. A systematic and comprehensive approach to knowledge management has positive and immediate effects on organizational performance.

Knowledge management is becoming one of the main tasks of modern management, a factor in increasing its effectiveness. The most important thing to achieve is that the knowledge management in the company cannot be copied because it guarantees a long-term advantage and a better market position. The development of knowledge management in an organization is not an end in itself but has clear economic reasons that are manifested in increasing organizational performance. Organizational performance depends most on human resources and technology, the environment, and the knowledge management system. There should be a single goal of introducing and developing a knowledge management system in a company, and that is increasing organizational performance and business results. Therefore, the modern manager needs to see the connection between the knowledge management system and organizational performance and constantly ask himself the question: Can we increase the business results of the organization by further development of the knowledge management system?

There are numerous literary sources that investigate the connection between knowledge management and organizational performance (Acosta-Prado, Navarrete and Tafur-Mendoza 2021). Effective knowledge management enables cooperation between individuals and organizations, and they can quickly incorporate knowledge into their technologies and thus produce new products (Miković et al. 2020). Knowledge drives product and process innovation, and such dynamic results in improved organizational performance. In the process of knowledge management, the critical activities are the acquisition, storage, distribution (sharing) and application of knowledge. In researching the relationship between knowledge management and organizational performance, researchers most often use the structural equation model (Namdarian, Sajedinejad and Bahannesteh 2021), regression (Saied 2021) or based on interviews (qualitative approach) describe the connection between knowledge management and organizational performance.

In the paper, cluster analysis (algorithm k-means clustering) is used in hypothesis testing. The established null hypotheses claim that companies with better knowledge management and better organizational performance measured by coefficients of profitability, liquidity, economy, indebtedness and activity are in the same cluster and vice versa. Cluster analysis is important but not sufficient. Therefore, the paper also uses the method of multi-attribute decision-making to determine the position of the enterprise cluster for the organizational performance variable in relation to the ideal cluster. An Excel spreadsheet was used to store respondents' answers about the dimensions of knowledge management (processes, people, and information technology) and balance sheet end income statement of companies, while software packages of the programming language R were used to determine the optimal number of clusters, Cronbach's alpha test, multiattribute decision-making. R language showed excellent development and application research power.

2. Theoretical framework

Knowledge management systems (KMS) were classified (Centobelli, Cerchione and Esposito 2017) into two categories: knowledge management practices and knowledge management tools. Knowledge management practices support the organizational process of knowledge management, whereas knowledge management tools are IT-based solutions that support knowledge management practices. Based on data collected from a comprehensive survey of 223 businesses from various European countries and industries (Alexandru et al. 2019), they identified three clusters: companies exhibiting a relatively "unconscious" attention to knowledge management and implementing knowledge management practices without particular awareness, companies adopting a more conscious approach and employing a substantial number of knowledge management practices and companies with a marginal propensity towards knowledge management. In study (Song and Zhao 2019) examined the synergistic effects of three knowledge management strategy orientations on firm performance: external and internal, explicit and tacit and exploratory and exploitative. The authors present a framework for analyzing the synergistic effects of knowledge management strategy and organizational structure. In order to evaluate the framework, they surveyed 345 Chinese firms that had implemented a knowledge

management strategy. In one study (Centobelli, Cerchione and Esposito 2019) proposed a 3D fuzzy logic methodology for assessing the effectiveness and effectiveness of KMS adopted by small and medium-sized enterprises (SME). The analysis revealed a wide variety of behaviors associated with the nature of knowledge and KMS used. Four types of behavior were identified: the efficient and effective SME, the effective but inefficient SME, the efficient but ineffective SME and the inefficient and ineffective SME. Study about relationship between knowledge management orientation (KMO), its dimensions, competitive intensity and innovativeness of SME (Kmieciak and Michna 2018) employs survey data from 120 Polish SME and the method of partial least squares. The findings reveal a positive and statistically significant correlation between KMO and the innovativeness of SME. Each of these factors is significant, but individually insufficient to have a direct effect on innovativeness. The only way they can improve is if they come together and form KMO. Sourcing and leveraging knowledge from an external network is only half the battle for companies seeking greater success. A company's knowledge management orientation may facilitate knowledge acquisition, sharing, and transfer. Knowledge management significantly mediates the effects of external embeddedness on the firm's ambidexterity, according to data collected of 119 Italian SME in the ceramic tile industry (Dezi et al. 2021). Some authors conducted expert interviews to determine the barriers, practices, methodologies and technologies for knowledge management in start-ups. Based on the theoretical study (Oliva and Kotabe 2019), desk research and expert interviews, quantitative research was conducted with the top Sao Paulo start-up co-working spaces. In research (Zerbino et al. 2018) examine knowledge management from an interdisciplinary perspective, focusing on the barriers to knowledge management in a supply chain context.

The study about the relationship between knowledge management processes (KMP) and business performance (Dzenopoljac et al. 2018) surveyed 500 private and public sector employees in Kuwait and found that KMP have a positive impact on the perception of business performance and improve innovation performance. Holistic integrated knowledge management model was used in an Indian scenario (Payal, Ahmed and Debnath 2019) with success and found that a well-designed knowledge management strategy had a significant positive correlation with organizational performance. An organization's cultivation of knowledge management enablers had a positive effect on the knowledge management process and it mediated the association between the knowledge management strategy and organization's performance. Organizations must priorities knowledge management and decision making (Abubakar et al. 2019). In their study propose a relationship framework between knowledge management enabling factors (collaboration, T-shaped skills, learning and IT-support) and organizational performance. The relationship between knowledge creation and organization performance is moderated by intuitive and logical decision-making styles. Some authors (Soto-Acosta and Cegarra-Navarro 2016) highlight the potential of new information and communication technologies for knowledge management in organizations by presenting a variety of perspectives and approaches for the role of new information and communication technologies in knowledge management and by measuring the impact and diffusion of new information and communication technologies for knowledge management in organizations. The development of a company's competitive advantage is relying on knowledge management and dynamic capabilities. However, understanding of the effect of knowledge management on firm performance remains limited. Study (Santoro et al. 2019) examines the connection between knowledge management orientation, dynamic capabilities and ambidextrous entrepreneurial intensity. Using a dataset consisting of 181 Italian firms, this study examines whether and how this relationship affects the overall performance of firms. In one research (Zand et al. 2018) investigate how customer knowledge management enhances organizational performance. Based on process-oriented approach, infrastructures enhance customer knowledge management capabilities through customer knowledge management processes and consequently improve firm performance. Evaluation of the research framework is conducted via a questionnaire distributed to 51 software companies in Iran. The findings also indicate that customer knowledge management processes and customer knowledge management capabilities serve as mediators between customer knowledge management and organizational performance. It implies that organizations with enhanced customer knowledge management process capabilities enjoy superior organizational performance. Some authors (Muthuveloo, Shanmugam and Teoh 2017) determine whether organizations have tacit knowledge management strategies that have a tangible and intangible impact on organizational performance. They conclude that tacit knowledge has a significant impact on the performance of an organization. Only socialization and internalization, out of the four dimensions of socialization, internalization, externalization and combination, contribute to the significant effects of tacit knowledge

management on organizational performance. 200 individuals from five commercial companies surveyed to determine the impact of knowledge management on organizational performance (Namdarian and Sajedinejad 2020). The results demonstrate a direct relationship between knowledge management indices and organizational performance, indicating a positive and significant relationship between knowledge management and organizational performance dimensions such as financial performance, product quality, staff performance, innovation and customer satisfaction.

The productivity of knowledge workers is crucial not only for organizational innovation and competitiveness but also for sustainable development. In the context of knowledge-intensive firms, the implementation of knowledge management is likely to increase knowledge worker productivity. Data from 336 knowledge workers at five mobile network operator companies in Pakistan (Kianto et al. 2018) indicate that knowledge creation and knowledge utilization impact productivity positively and statistically significantly. Knowledge management could be a way to foster job satisfaction and investigate how it can increase the job satisfaction of individual employees. One study (Kianto et al. 2016) present a model of the relationships between five facets of knowledge management (knowledge acquisition, knowledge sharing, knowledge creation, knowledge codification, and knowledge retention) and job satisfaction in a Finnish municipal organization. They conclude that the presence of KMP in the workplace is significantly associated with high levels of job satisfaction. Particularly intra-organizational knowledge sharing appears to be a key KMP that increases employee job satisfaction across the board. Intriguingly, significant knowledge-based job satisfaction boosters vary according to job characteristics. KMP lead to sustainable competitive advantage (Mahdi, Nassar and Almsafir 2018). The introduction of structural equation modelling assisted in determining the deductive relationship between the study variables. This study surveyed 525 academic leaders in various roles from 44 private Iraqi universities. In a public university setting (Adeinat and Abdulfatah 2019), an organization's culture primarily influences the knowledge creation process, followed by knowledge exchange. Utilizing the organizational culture assessment instrument and structural equation modelling, the study determined the culture type and assessed the underlying relationships between knowledge management process and culture.

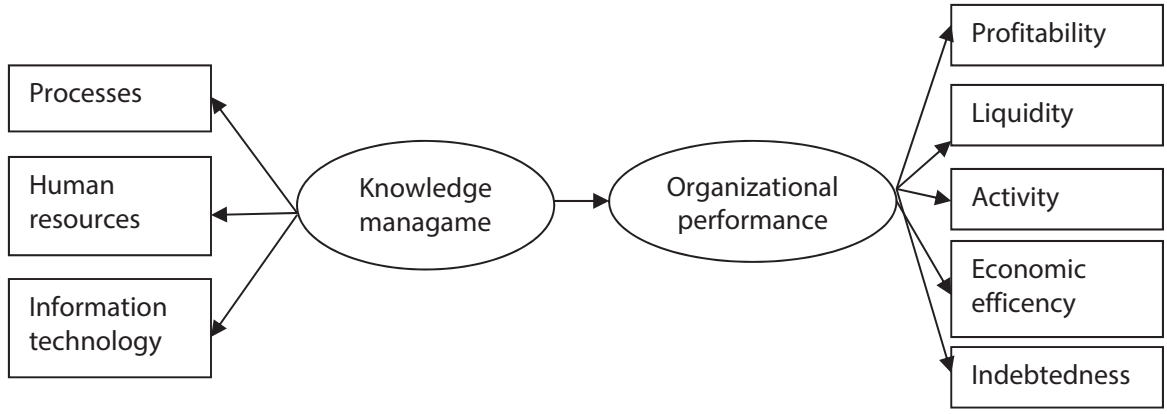
A special research task of investigating the impact of knowledge management on organizational performance is to define an algorithm applicable to any organizational system. Of course, the theoretical research framework defines a sufficiently abstract, general and applicable sequence of steps in generating concrete experimental results of the impact of knowledge management on organizational performance in small, medium and large companies, companies in different industries or some other criterion of their classification. The research framework is invariant in relation to the size of the organization, its organizational structure, core activity or some other classification criterion. The first step is to determine the determinants of knowledge management, which consist of processes, human resources and information technology. Then the indicators of organizational performance are determined: profitability, activity, liquidity, indebtedness and economic efficiency. The third step in the research framework is cluster analysis. It is twofold. The first allows the formation of a certain number of clusters for objects of analysis (enterprises) based on the value of organizational performance indicators. The second cluster analysis identifies the maturity of knowledge management based on respondents' responses in the survey questionnaire on the factors that determine its quality. Finally, in the construction of the conceptual model, a contingency table is formed, the columns of which are clusters based on the values of organizational performance indicators, and the rows are the "maturity" of knowledge management. The research framework has three parts: input variables (independent variables), output variables (dependent variables), and the environment, which consists of different methods of transforming inputs into outputs, as well as theoretical knowledge and hypotheses about the relationships between independent and dependent variables. Theories are always a systematic representation of a phenomenon that shows relationships (relationships) between variables using a set of interrelated constructs (variables), definitions and assumptions. The following figure clearly shows the conceptual framework of research into the impact of knowledge management on organizational performance.

Research on the impact of knowledge management on organizational performance focuses on the three most important factors for assessing the maturity of an organization in knowledge management:

a) Human resources,
b) Organization of business processes and
c) Information technology.

The second research variable in the conceptual framework is organizational performance. They need to be measured and are shown by several key groups of performance indicators: liquidity, indebtedness (leverage ratios), activity, economic efficiency and profitability (Markić 2016).

Figure 1. Conceptual framework with research variables



Source: made by authors

3. Research methodology

The research tests the following hypotheses:

H1: Companies in Bosnia and Herzegovina (BiH) that have established procedures and knowledge management systems generate significantly higher revenues and profits per employee.

H2: Companies in BiH that have established procedures and knowledge management systems have a significantly higher profitability ratio.

H3: Companies in BiH that have established procedures and knowledge management systems have a significantly higher coefficient of economic efficiency

In the study of the impact of knowledge management on organizational performance, a subset of possible hypotheses was selected and they were verified based on data from the survey questionnaire and the balance sheet of companies in BiH.

3.1. Data

After defining the conceptual framework of the research, goals and hypotheses, data collection on organizational performance and maturity of knowledge management in companies in BiH follows. Data collection is always a complex and demanding part of research. The data are structured in research dynamics so that they correspond with the set hypotheses. The paper will present a part of the research and obtain results from the doctoral dissertation of one of the co-authors.

The questionnaire was distributed to 352 companies of various sizes with regard to the number of employees, income, and business assets (according to the classification of the Agency for Statistics of BiH). The answers came from 1019 respondents, managers at different levels, employed in 124 companies in BiH for the observed period of the year 2018 and 2019. After that, the data were collected from current and publicly available analyzes of income and balance sheets to calculate business indicators for the observed 124 companies in BiH for the observed period of the year 2018 and 2019. The research covers companies with headquarters in five cantons of the Federation of BiH: Herzegovina-Neretva Canton, Herzegbosnian Canton, Posavina Canton, West Herzegovina Canton and Central Bosnian Canton. The first step of this research, which will be presented in abbreviated form due to limited space, is the selection of variables that identify maturity knowledge management in companies. The second step is to select variables that identify business indicators. The third step of the research process is the selection of clustering methods and finding the optimal number of clusters that identify the impact of knowledge management on the business indicators of the analyzed companies. The fourth step is to assign the company to a particular cluster, the cluster from which it is least distant in terms of human resources, processes, and the quality of information technology.

The survey questionnaire contains two groups of questions. The first refers to the socio-demographic characteristics of the respondents and is dominated by the nominal scale. The second group of questions is related to knowledge management using the Likert scale with five degrees. Business indicator data are quantitative data. These are real numbers that reflect

Table 1. Transformation of the survey questionnaire into a two-dimensional data set

		Human resources(V1)					Processes (V2)					Information technology (IT-V3)				
Num. examinee	ID. Comp.	V11	V12	V13	V14	V15	V21	V22	V23	V24	V25	V31	V32	V33	V34	V35
1	1	2	2	3	5	5	2	2	3	1	2	1	1	5	2	5
2	1	2	4	1	2	4	5	3	3	3	4	1	1	5	4	4
3	1	4	4	3	2	3	2	4	4	2	1	3	4	1	2	3
....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
1016	124	4	4	2	2	2	5	3	3	2	4	3	4	5	4	4
1017	124	4	5	5	4	5	5	5	2	1	3	4	1	2	4	3
1018	124	2	3	2	1	3	3	4	2	5	1	3	3	4	3	4
1019	124	1	2	4	5	3	3	4	2	5	1	1	4	3	2	4

Source: made by authors

liquidity, indebtedness, business activity, economic efficiency, and profitability. They are calculated based on the balance sheets and income statements of the companies in which the respondents of the survey questionnaire are employed. The research uses the programming R language, its available functions, and software packages. In the data analysis, the internal consistency of the questions in the questionnaire is tested using Cronbach's alpha reliability coefficient. The obtained value of alpha is 0.84 which can be accepted as the confidence limit (Cronbach's alpha <0.5 is unacceptable). In other words, the internal questions in the survey questionnaire are consistent. A two-dimensional data model was formed from the respondents' answers to the survey questionnaire.

Numerical values in the table above reflect the awareness of the importance of knowledge management (V11), the intensity (strength) of employee cooperation in creating and implementing new knowledge (V12), the development of rewards and recognition for new ideas and their application in business (V13), communication and intensity of information exchange between employees on business processes in the company (V14) and systematic encouragement and stimulation of employees to learn by the organization (V15). If the average value is 5 then the organization has a strong awareness (element of organizational culture) about the importance of knowledge management, has a developed system of rewards and recognition for new ideas (innovations) and their application (inventiveness), has intensive communication and rapid dissemination of information among employees in various business functions and functional areas on the manner of execution of business processes (speed, quality, weaknesses, new solutions) and systematic encouragement and stimulation of employees to learn and improve in solving tasks in the workplace. An average value of 1 means that there is no awareness of the importance of knowledge, no incentive for employees to learn or value employee ideas, and the exchange of information among employees about business process operations is very rare. The second variable indicating the attitude of management towards knowledge management is the processes in the organization. The importance of process organization and ways of their execution for knowledge management derives from the strength of process integration (procurement process, sales, and production process) (V21) or integration of business functions (marketing, finance, and human resource management) (V22). Knowledge management is incorporated into every business function (V23). Knowledge management is part of the defined organizational strategy, i.e., the document on company strategy also contains a part on knowledge management (V24). The data generated by the business processes of the organization is continuously analyzed and these analyzes are used to create new knowledge about the market (customers, suppliers, products, and services) (V25). A value of 5 (data refers to the company and its processes) means that top management is strategically committed to analyzing the operations of each business process, their optimization, and integration into a system that results in the best quality products and services. If the value of process data for a particular company is 1 then knowledge management is not part of every business function, processes are not optimized, and management does not analyze key processes continuously. Knowledge management is not part of the defined organizational strategy, i.e.,

the document on company strategy does not contain a part on knowledge management. The third variable of the attitude of management towards knowledge management refers to the implemented information technology. Information technology is a combination of two technologies: unlimited data transmission technologies (communication technology) and data processing technologies (computer technology). Sometimes one can find works in literary sources that equate knowledge management with the quality of information systems in the organization. Such partial approaches to knowledge management neglect its broader, organizational, cultural, and social context. It is almost impossible to use all the potential of information technology within the organization. Those companies whose value of information technology data 5 means developed network infrastructure (V31), built and implemented decision support system at the strategic and tactical level of management (V32), developed business applications for management and document exchange (V33), systematic collection knowledge and development of own knowledge base (V34) and successfully integrated various technologies (V35). The value of data 1 in the information technology column refers to companies without a developed network infrastructure. Their information systems only record data generated by the operational level of management (transaction information system), and they do not have developed collaboration systems or built their own knowledge base. After clarifying the meaning of each data, the next step is to create a two-dimensional table with data for each company on the factors of each knowledge management system, i.e., people, processes, and information technology. The survey questionnaire also contains questions related to the respondents and with a similar procedure, this group of questions is transformed into the following table.

The third table is not the result of the answers from the survey questionnaire. Its data is filled by calculating the value of organizational performance indicators.

Table 3 shows the two-dimensional data structure with the performance indicator values of all companies, the size of the company and the number of respondents who answered the questions in the questionnaire.

3.2. Hypothesis testing

Testing of set hypotheses begins with the k-means clustering algorithm. The clustering of companies according to the answers of the respondents will be

Table 2. Transformation of the socio-demographic part of the survey questionnaire into a two-dimensional data set

I	II	III	IV	V	VI	VII	VIII	IX
1	1	M	21 – 30	High school and college	Complex jobs of the profession	1501-2000	HNC	Quality of human resources
1	2	F	41 – 50	High school and college	Complex jobs of the profession	1501-2000	HNC	Top management and its organizational skills
....	....	....	....	....	....	....	....	....
124	1019	M	31 – 40	High school	Complex jobs of the profession	1001-1500	HNC	Information technology

Source: made by authors

Table 3. Business indicators of the company

ID company	Number of Respondents	Size of the company	P1 liquidity	P2 indebtedness	P3 Activity	P4 Economic efficiency	P5 profitability
113	28	Big	0.43	0.65	3.37	1.04	0.09
117	27	Big	0.52	0.96	8	1.15	0.07
....	....	....	....	....	....	....	....
102	4	Big	0.45	0.79	7.37	1.06	0.06
62	3	Big	0.55	0.3	5.46	1.17	0.04

Source: made by authors

Table 4. Mean values of respondents' responses for the variables of people, processes and information technology

Company	Human resources	Processes	Information technology
1	4.14	4.17	4.14
2	4.94	5.00	4.90
3	4.94	4.93	4.87
.....	.....	.....	.....
123	4.93	4.89	4.85
124	4.40	4.40	4.20

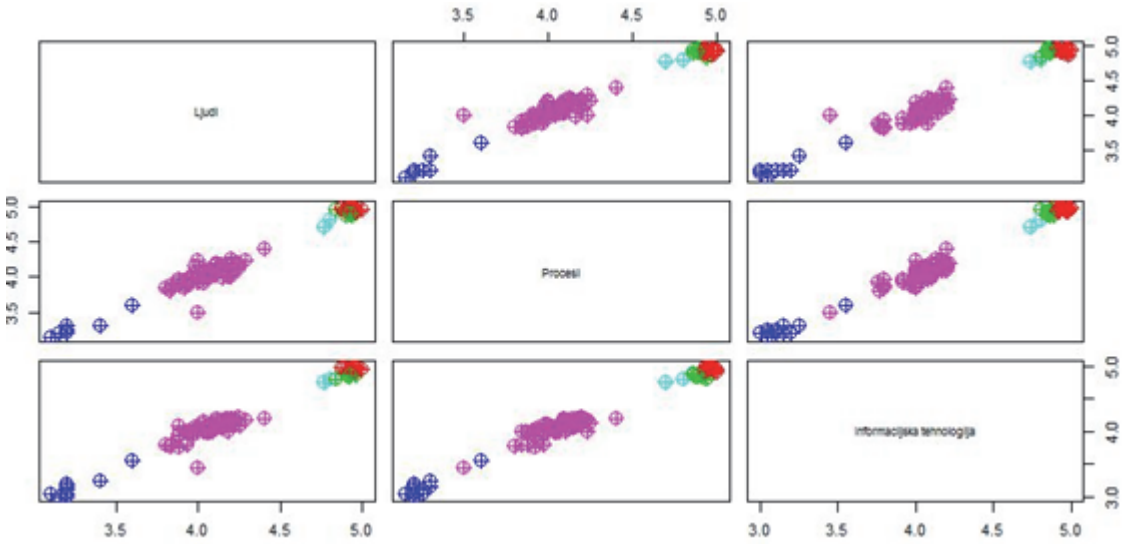
Source: made by authors

based on the average values of their answers about the organization's strategy according to the knowledge of human resources and the need for their development and improvement. After clarifying the meaning of each data, the next step is to create a two-dimensional table with data for each company on the factors of each knowledge management system, i.e., people, processes, and information technology.

In the next step, companies can be organized into several clusters. The goal of clustering is to divide a given set of data into clusters so that the distance between cluster elements is the smallest (cluster elements are companies) and the distance between clusters is the largest. Each cluster has common features that can be analyzed based on values in the center, the mean of the cluster (centroid). Therefore, the cluster represents the same level of company maturity in knowledge management with respect to research variables: people, processes, and information technology. A cluster is a set determined with these three variables and their values at the center of the cluster. Cluster center (center - cluster representative) are the average values of respondents' answers about the same company for the three variables. Of course, the question arises whether it is possible to determine the optimal number of clusters for a given data set? The answer is yes, but before determining the optimal number of clusters for the data set, companies will first be clustered into five clusters (124 companies). The partitive clustering algorithm k-means was applied. It was shown that the minimum and maximum values of all three variables do not differ from each other, that the attributes are equal and that the data do not need to be standardized before clustering.

The next step is to ask a logical, but at the same time very complex and challenging question: is five clusters the optimal number given the data obtained?

Graph 1. Visualization of five clusters and assigning companies to clusters (color indicates cluster)



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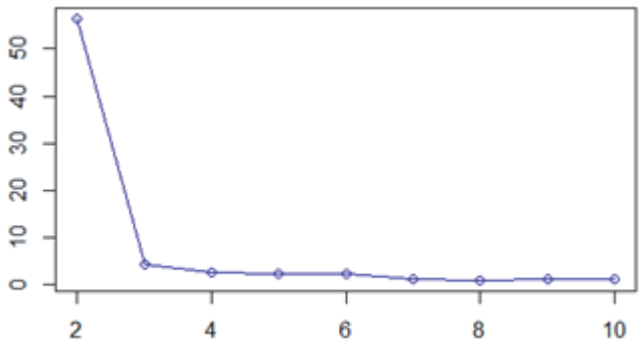
Graph 2. The optimal number of clusters



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The analysis of Graph 2 shows two "elbows", one more pronounced for three clusters and the other for six clusters. The sum of the deviations of observations within a cluster decreases rapidly if the number of clusters is greater than 3. The optimal number of clusters for the observed data for people, processes, and information technology is three.

The clustering results further show that the whole set, 124 companies are grouped so that the first cluster comprises 13, the second 32 and the third 79 companies.

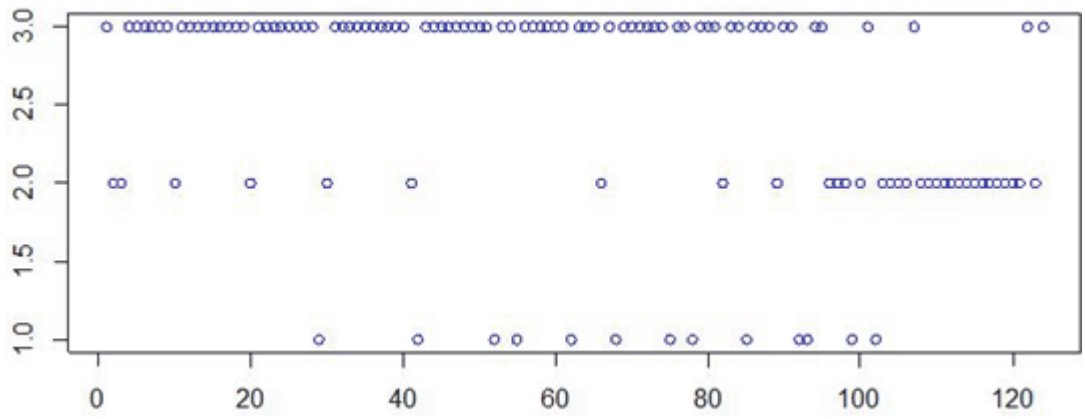
The highest values of centroids (centers) are in the second cluster, then in the third, and the lowest is in the first cluster. The next step is to visually assign each company to one of the cluster.

Table 5. Cluster centers for people, processes and information technology

Cluster	Human resources	Processes	Information technology	Number of companies
CKM1	3.234615	3.250000	3.126923	13
CKM2	4.925625	4.918750	4.896562	39
CKM3	4.047848	4.028987	4.027468	79

Source: made by authors

Graph 3. Assigning each company to one cluster



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The basic characteristics of the cluster can be briefly described:

a) CKM1 - contains companies whose level of knowledge management is initial. Knowledge management is not part of the organization's strategy and knowledge of its importance is not a strategic commitment of managing structures. Managing structures are indifferent to knowledge management.
b) CKM2 - consists of companies that have incorporated knowledge management into the organizational strategy. Knowledge management is fully integrated into the organization and it is constantly being improved and perfected.
c) CKM3 - consists of companies whose management is aware of the importance of knowledge. They intend to manage organizational knowledge but do not yet know how to do so. They are at the very beginning of the provision of resources and basic infrastructure for knowledge management.

After clustering companies with regard to the maturity of knowledge management in the optimal number of clusters, a new, logical research step follows, and that is clustering companies in the optimal number of clusters with regard to their business indicators. Namely, it is to be expected that companies with better liquidity, economic efficiency, profitability, faster business activities, and lower indebtedness belong to a cluster with a developed culture of knowledge management where it is integrated into the organizational strategy.

The analysis of Graph 4 shows the optimal number of clusters for business indicators. After the fourth cluster, the sum of the squares of the deviation from the center for all clusters is acceptable (an "elbow" is visible).

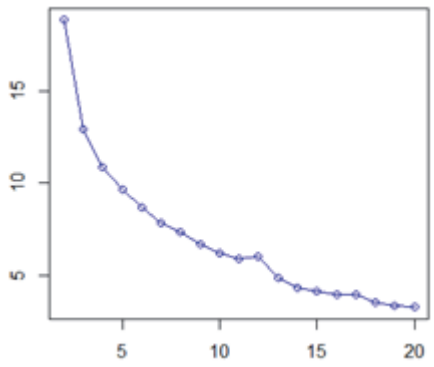
In the next step, the clusters are ranked in several iterations by first calculating the sum of each column in Table 6, then dividing each value in the table by that sum, and finally obtaining a normalized table of business indicator cluster centers.

Based on the value of business indicators, the cluster whose center for liquidity, asset turnover, economy, and gross margin is larger, and for indebtedness is less acceptable. It is this fact that allows the creation of an ideal cluster in the table below.

Since such a cluster does not exist, the next step is to find the distance of each cluster from the ideal by calculating the Euclidean distance of each cluster from the ideal.

The smallest distance from the ideal cluster is Cluster 4, then Cluster 3, Cluster 2 and finally Cluster 1. The next step in R language is to calculate the

Graph 4. The optimal number of clusters for business indicators of the company



Source: made by authors

Table 6. Center of clusters of business indicators of the company

Cluster	Size	P1_liquidity	P2_indebt	P3_activity	P4_economic efficiency	P5_profitability
1	10	0.7043776	0.7072468	0.7356769	1.795216	0.16433222
2	53	0.6418788	0.6573327	1.3741435	2.058225	0.11332419
3	29	0.6255537	0.6740149	1.3934919	1.505423	0.11090897
4	32	0.3967904	0.3028339	0.6257571	1.403931	0.08382869

Source: made by authors

Table 7. Normalized table of centers of clusters of business indicators of the company

P1_liquidity	P2_indebt	P3_activity	P4_economic efficiency	P5_profitability
0.297381344	0.302057851	0.178170147	0.265454742	0.347871048
0.270994961	0.280740051	0.332797385	0.304345319	0.239893337
0.264102663	0.287864847	0.337483284	0.222603672	0.234780614
0.167521032	0.129337251	0.151549184	0.207596268	0.177455001

Source: made by authors

Table 8. Ideal cluster

P1_liquidity	P2_indebt	P3_Activity	P4_Economic efficiency	P5_profitability
0.297381344	0.129337251	0.337483284	0.304345319	0.347871048

Source: made by authors

Table 9. Cluster order with respect to the distance from the ideal cluster

Distance from ideal cluster	Cluster ordinal number
3.246	Cluster 1
3.004	Cluster 2
2.103	Cluster 3
1.184	Cluster 4

Source: made by authors

Table 10. Matrix of frequencies of knowledge management clusters and business indicators of companies

	CKM1	CKM2	CKM3
COP1	f(1.1)	f(1.2)	f(1.3)
COP2	f(2.1)	f(2.2)	f(2.3)
COP3	f(3.1)	f(3.2)	f(3.3)
COP4	f(4.1)	f(4.2)	f(4.3)

Source: made by authors

elements of a matrix containing frequencies (number of occurrences of the same) of companies in clusters.

The next step is to further develop the matrix in Table 10 based on the respective clusters and the companies associated with those clusters. The algorithm for calculating company frequencies in clusters: CKM1, CKM2, CKM3 (knowledge management clusters) and clusters: COP1, COP2, COP3, COP4 (business indicator clusters) includes a selection of vectors representing clusters, determination of vector cross-sections (12 cross-sections in total), for each cross-section calculation of the number of members (companies) and based on that filling in the frequency table or contingency table.

The rows of the contingency table show the frequency (number of occurrences) of company clusters of the business indicators cluster in the knowledge management cluster. Thus, the cluster of companies that have the best strategies for managing people's knowledge, processes, and information technology (such are 32 such companies) is completely located in the cluster of companies that have the best business indicators (such are 79 companies).

Table 11. Contingency table

	CKM1	**CKM2**	CKM3	Row sum
COP1	f(1.1)=9	f(1.2)=0	f(1.3)=1	1
COP2	f(2.1)=3	f(2.2)=0	f(2.3)= 50	53
COP3	f(3.1)=1	f(3.2)=0	f(3.3)= 28	28
COP4	f(4.1)=0	**f(4.2)=32**	f(4.3)=0	79
Column sum	13	32	79	144

Source: made by authors

4. Analysis of research results

H1 hypothesis testing was based on collected data on revenues, expenditures, profits and the number of employees for the observed companies. The first step required calculating the average revenue of the knowledge management cluster.

Table 12 shows the order of average revenues of clusters CKM1, CKM2 and CKM3. The best cluster (CKM2) has the highest average income, followed by the CKM3 cluster and the CKM1 cluster. Looking only at the average income, a significantly higher average income per employee in the best cluster is visible. In addition to income, it is necessary to observe the average profit per employee of the company in knowledge management clusters, which was done in the second step.

Table 12. The average revenue of knowledge management clusters

Knowledge Management Cluster	Average income
CKM1	1 717 067.00
CKM2	173 890 396.00
CKM3	4 724 173.00

Source: made by authors

Table 13. Average profit per employee of the knowledge management cluster

Knowledge Management Cluster	Average profit per employee
CKM1	7 712.70
CKM2	19 418.60
CKM3	4 167.70

Source: made by authors

The companies in the best knowledge management cluster (CKM2) have the highest profit per employee, followed by the first and third clusters. Profit per employee reflects the established procedures and the quality of the knowledge management system. Therefore, hypothesis H1 can be accepted.

H2 hypothesis testing was based on the collected data on company profitability (measured by gross profit margin) with respect to three defined knowledge management quality clusters. Average business indicators for knowledge management clusters were calculated with special emphasis on the average profitability of companies in clusters CKM1, CKM2 and CKM3.

The results of the average profitability of the cluster do not show that the profitability of the cluster (measured by the gross profit margin) with the best knowledge management system is the highest. Namely, the average profitability for the best cluster is: CKM2 = 0.08383, for the cluster CKM1 = 0.16230 and for the cluster CKM3 = 0.11017. Therefore, hypothesis H2 cannot be accepted. However, it must be emphasized that a mathematical comparison of profitability only can lead to incomplete conclusions. Profitability is only one of the business indicators whose denominator is sales revenues, and sales revenues for companies in cluster 2 (CKM2) are the highest, so the absolute values of profit are higher (due to the law of the tendency of falling profit margin). Mathematically it cannot be accepted but economically yes. Therefore, the second step required the calculation of the standard gross margin deviation in knowledge management clusters.

Table 14. Knowledge management clusters and business indicators

Cluster	P1_liquidity	P2_indebt	P3_activity	P4_economic efficiency	P5_profitability
1	0.713826	0.935756	0.646328	1.755395	0.14565
2	0.364584	0.328658	0.567792	1.519671	0.078519
2	0.348301	0.185251	0.798742	1.289226	0.064309
3	0.730834	0.683801	1.265685	1.966166	0.064693
...	.....	.....	.....	.....	.....
2	0.383607	0.023122	0.751982	1.376588	0.092646
3	0.83596	0.533693	1.404574	1.985951	0.168717

Source: made by authors

Table 15. Values of average profitability for each of the clusters

Cluster	Average profitability of the cluster
CKM1	0.16230
CKM2	0.08383
CKM3	0.11017

Source: made by authors

Table 16. The standard deviation of gross margin in knowledge management clusters

Cluster	Standard deviation of gross margins
CKM1	0.03892028
CKM2	0.01471849
CKM3	0.03560589

Source: made by authors

The average square deviation of the gross margin in the best knowledge management cluster (CK2) is almost three times less than the remaining two clusters. The values are closer to the average, their dispersion around the mean value is significantly lower, i.e., the gross margin instability is lower in the cluster with the best knowledge management. This fact confirms the quality of the CKM2 cluster because the profitability is stable and it does not oscillate around the mean value as in the two worse clusters CKM1 and CKM3.

Hypothesis testing H3 is a comparison of the maturity of the knowledge management system and economic efficiency indicators. The first step in testing the H3 hypothesis was to calculate average economic efficiency coefficients for the three knowledge management clusters. Based on the value of the economic efficiency ratio for companies in a particular knowledge management cluster, the cluster economic efficiency ratio is calculated.

Comparing the coefficients of economic efficiency of the knowledge management cluster, it can be seen that the highest coefficient of economic efficiency is in the cluster of small companies, which are dominant in the cluster CKM1, and the lowest coefficient of economic efficiency in the cluster CKM2, where large companies are dominant. Therefore, the analysis shows that hypothesis H3 is not accepted.

Table 17. Cluster of economic efficiency coefficient

Knowledge Management Cluster	Economic efficiency of the cluster
CKM1	1.990067
CKM2	1.40393
CKM3	1.833221

Source: made by authors

Such a result of the coefficient of economic efficiency in individual clusters has a simple explanation, and it arises from the absolute size of expenditures. Namely, in the CKM2 cluster, there are large companies whose average expenses are in absolute amount and several hundred times higher than the expenses of companies in the third and first clusters. Therefore, the value of the coefficient of economic efficiency is lower for companies with higher expenses.

5. Concluding remarks

The impact of knowledge management on organizational performance measured through previously defined economic indicators explores the relationships between complex variables that include other variables and their values. The decomposition of the research task enabled the formation of clear ideas about knowledge management and organizational performance. The research confirms the well-known scientific research fact that the foundations of research are found in digits, numbers, in the "enormous power" hidden in them. Therefore, it was very important to find the right ways to release the trapped, hidden power in numbers using research methods. Research methods from the collected data of the questionnaire (for knowledge management in the company) and balance sheet and income statement (for the organizational performance of the company) release power, the power of data transforming them into the knowledge of the relationship between knowledge management and organizational performance. The research shows all the complexity of the concept of knowledge. It has different shapes, complexity and clarity of presentation. Tacit, explicit, declarative, procedural, technological, managerial, and other knowledge exist in the company. Knowledge management as a process of acquiring, creating, adapting, storing, and using knowledge is often a missing process in companies. Research shows that only large companies have built-in elements of knowledge management, medium-sized companies are involved in this process, and small companies have not developed management strategies in which there is knowledge management. Research shows that there is a strong positive association between knowledge management and organizational performance as measured by relevant economic indicators. Knowledge management has a positive and powerful impact on reducing

indebtedness, increasing liquidity, activity, economic efficiency, and profitability. Still, it is proving to be a missing process in SMEs. The research concentrates on generating knowledge from data and information generated by the business process of the company. The research focuses on two sources of structured data: databases and data warehouses. In addition to aggregated process data, the data warehouse also stores data from external sources such as customer, market, and supply chain data. Knowledge management for decision-making at different management levels can, by applying appropriate data mining methods, generate information and knowledge at the right time (before making decisions). The prerequisite for generating such knowledge is the existence of communication infrastructure (intranet, extranet), the building of information systems to support decision-making, but also human resources that know the information needs of different management levels in the company. Therefore, a new task is opened and set for the strategic level of management, and that is the design, construction, and implementation of a knowledge management system for each company. Companies that recognize the knowledge management system will be able to manage business processes and direct them towards the accepted vision.

For knowledge management, it is especially important to build a culture of distribution and exchange of knowledge, acceptance, i.e., not rejecting new ideas and stimulating their implementation. It is a culture in which all employees contribute to the realization of the vision and set goals of the company. Preparing an appropriate organizational culture is a complex task and often a serious problem and obstacle to knowledge management and improving organizational performance in the company. It requires the support of employees at all levels to realize all phases of knowledge management, improve processes and establish connections between employees, exchange knowledge, and embed the benefits of knowledge exchange and use in strengthening the organizational performance of the company.

The results of the research suggest the setting within the organizational structure of departments or sectors in large and medium-sized companies that would continuously and systematically improve the knowledge management system. The Knowledge Management Department would constantly collect information on the state of human resources, their motivation, incentives for innovation, awards for new ideas and process improvement, the development of lifelong learning programs, and communication among employees. The knowledge management department would collect information from all business functions (accounting, finance, marketing, human resources, production), and deliver the processed information in the form of proposed decisions to the highest, strategic level of management. Also, one such knowledge management department would certainly collect information on how to execute business processes (procurement, sales, distribution (logistics), document movements, etc.), which would allow managers to obtain information on processes that slow down business and then to propose measures to optimize business processes.

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