Knowledge Use and Problem-Solving Networks in an Intra-Organizational Context: Strong and Weak Ties Analysis

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Abstract: This article concerns the assessment of knowledge use and problem-solving networks in an IT organization in connection with strong and weak ties. The primary research question is as follows: Is knowledge use network associated with strong or weak problem-solving network relationships? The study was conducted in an IT company in 2017 with a population of 45 employees (there were 1980 observations per network and 5940 observations across all networks). An interview and questionnaire were used to identify the relationship matrices. In total, three matrices (variables) were determined. Also, methods of network statistics were used: quadratic assignment procedure (QAP) and multiple regression quadratic assignment procedure (MRQAP). The results show a low correlation (statistically significant) between knowledge use network and problem-solving strong and weak ties networks. Also, the regression model shows that the knowledge use network is influenced by strong and weak ties of problem-solving networks. The article refers to many limitations indicating the need for further, in-depth studies. The results may be useful for IT company managers, especially in the context of strengthening networks of relationships that have the most significant impact on the use of knowledge in a company.

Keywords: knowledge use network, problem-solving network, strong tie, weak tie, social network analysis, QAP, MRQAP, IT company.

1. Introduction

So far, many researchers have undertaken research into several knowledge networks in an organizational context. For instance, Helms et al. (2010) noted that knowledge sharing is an integral part of an employee's tasks because it is one of the mechanisms for learning and introducing innovation. Knowledge sharing usually takes place in informal networks of organizations through social interaction. The authors proposed using social network analysis to study knowledge-sharing relationships in organizations and identify potential barriers to knowledge sharing. In another study, Borgatti and Cross (2003) proposed a model of information seeking in which the probability of seeking information from another person is a function of knowing another's expertise that leads to seeking information; valuing another's expertise in relation to one's work that leads to seeking information, and access to another's thinking that leads to seeking information. In turn, Hsu and Tzeng (2010) attempted to understand the relational features of knowledge exchange. It was found that knowledge sellers provide knowledge only to those they know, and therefore the basic condition for knowledge exchange is the awareness of knowledge buyers. In both studies, the authors confirmed the positive relationship between information seeking and knowledge exchange to the awareness about other people's knowledge and skills understood as a potential for tacit knowledge flows.

In our research, we make the assumption similar to Abusweilem and Abualoush (2019) that the use of knowledge ensures effective achievement of the organization's goals. This requires the delegation of extensive powers and ensuring sufficient freedom of knowledge use for employees and its practical application in their work. Knowledge should be used to solve problems faced by the organization. This is one of the main goals of the knowledge management process, which becomes a response to identified problems in business activities and processes. Considering the above, our article aims to clarify social relations regarding the use of knowledge by applying quantitative social network analysis to examine social interactions between IT company employees and the impact of strong and weak ties of problem-solving networks on the knowledge use network. We want to go beyond the classic research on knowledge sharing among employees, which is certainly a space for the flow of tacit knowledge. However, there are few studies in which the use of knowledge is analyzed in the context of weak and strong ties on the example of tacit knowledge network, such as problem-solving.

Moreover, as soon as knowledge is disseminated, it is important that it is also used in business processes (Karagiannis et al., 2008). Hence, our research concerns knowledge used by employees but closely related to business processes of the examined organization. The use of knowledge is an activity aimed at applying knowledge in business processes resulting in higher commercial value for customers in the form of better products and services and competitive advantage (Dahiyat, 2015). In addition, effective use of knowledge also

results in new knowledge, new skills, new products and services, which translates into the development of human, relational and structural dimensions of intellectual capital (Ujwary-Gil, 2017). Social relationships are becoming a key subject of research in the context of the use of knowledge in an organization (Phelps et al., 2012).

A network approach to organization management, including knowledge management, in particular, remains a research area where interactions, connections, and interdependencies between employees' knowledge networks remain under-explored. The article uses network statistics (correlation and regression) to study the relationship between knowledge use network in an IT organization and tacit knowledge networks (problem-solving) broken down into strong and weak ties. The main research question is as follows:

RQ: Is knowledge use network associated with strong or weak problem-solving network relationships?

2. Literature background and hypothesis development

2.1. Knowledge use and problem-solving

Phelps et al. (2012) define a knowledge network as a set of nodes (people, departments) connected with each other by social relations that enable or limit the efforts of nodes to acquire, transfer and create knowledge. This knowledge network is the basis for the 'know-who' network and its hidden potential. The best-known research related to the strength of inter-faculty ties and their impact on knowledge transfer belongs to Hansen (1999). Nodes are also sources and recipients of information and knowledge. Intra-organizational research differs from interpersonal and inter-organizational research in that it focuses on relationships between members in an organization, such as a team or department, and on relationships between them in the same organization.

We define knowledge use as the ability of employees to use knowledge to solve problems and cope with tasks and challenges in the organization. The use of knowledge is one of the key stages of the knowledge management process. Linking the use of knowledge to problem-solving, decision making, and improving business performance in an organization, was noticed, among others, by Micic (2015). In the Tubigi and Alshawi (2015) study, managers chose the use of knowledge as the most influential process on organizational performance. Similarly, according to Xu et al. (2010), the use of knowledge focuses on conceptual and cognitive aspects of knowledge and deals with solving a specific problem. Another critical aspect of the knowledge management process in organizations is the application of knowledge or its re-use in decision-making processes related to business strategy, task performance, service provision, and organizational efficiency and effectiveness (Kim and Lee, 2010). The use of knowledge in an organization includes widely understood interventions, including incentives, aimed at increasing the use of knowledge to solve organizational problems (Backer, 1991) or increasing overall business performance (Dang and Le-Hoai, 2019). Knowledge brought and shared by organization members increases productivity and reduces production costs only when it is implemented and used.

Similarly, Alavi and Leidner (2001) noted that although the processes of creating, storing, searching for knowledge, and transfer of knowledge do not necessarily lead to increased organizational efficiency, the effective application of knowledge already does. Therefore, organizational performance often depends more on the ability to transform knowledge into effective operation and less on knowledge itself. The use of knowledge is defined here as in Chung and Galletta (2012) as the extent to which a person has included the object of knowledge in organizational tasks, including problem solving and decision making. This definition includes the use of knowledge to replicate existing practices as well as to solve new problems and generate new practices. In addition, the use of knowledge in this article is closely related to human knowledge resources (human view). The importance of knowledge utilization (physical view) or the application of knowledge (technological view) were omitted (c.f., Xu et al., 2010).

Mikovic et al. (2019) believed that the impact of social capital on the use of knowledge is not fully explored. The authors attempted to analyze the relationship between social capital and the use of knowledge and achieving social change in non-profit organizations, i.e. the assessment of the conditions embedded in the internal and external social relationships of the organization necessary to apply knowledge. The authors conducted a study on the correlation between social capital and the use of knowledge by linking dimensions and elements of social capital with key dimensions and elements of the use of knowledge at the inter-organizational and intra-organizational level. Social capital is an essential factor supporting knowledge

management initiatives, knowledge management processes, and results at the organizational level, but there are scarce arrangements regarding the impact of social capital on the use of knowledge.

In other studies, Zaim et al. (2019) showed that the use of knowledge has the strongest relationship with the efficiency of the knowledge management process and thus the organization's ability to use available knowledge resources. As the authors rightly point out, managers responsible for implementing knowledge management in organizations should explore ways to encourage employees to make better use of available individual and organizational knowledge.

2.2. Strong and weak ties

Tie strength is defined as the combination of time, emotional intensity, intimacy, and mutual services characterizing a tie (Granovetter, 1973). In general, it ranges from strong to weak ties based on closeness of relationships and frequency of interactions (Hansen, 1999; Levin and Cross, 2004). Weak and strong ties were the subject of Granovetter's classic studies (1973), who concluded that weak ties were more likely as a source of unique and useful information in opposition to strong ties. Weaker ties are a path along which new information or new insights may appear more often compared to stronger ties. In other, equally well-known studies, strong and weak ties are compared in terms of their contribution to the flow of information on the professional activity of people in intra-organizational social networks (Friedkin, 1982). Strong ties are more important than weak ties in promoting the flow of information on organizational activities. Weak ties are more important than strong ties in promoting the flow of information on non-organizational activities. The strength of weak ties in promoting information flows is not in their individual performance but in their numbers. So, as Friedkin (1982) concluded, producing the highest probabilities of information flow involves a combination of both weak and strong ties.

Rogers (1995) showed that weak ties spread ideas. Studies of weak ties have also shown that they are useful in disseminating non-redundant information (Levin and Cross, 2004) and technical advice (Constant et al., 1996). In addition, Levin and Cross, 2004 investigated the effect of binding strength (structural variable) and trust (relational variable) on obtaining useful knowledge. Knowledge was seen as applicable when it had positive project results. Employees worked on projects relying on colleagues to get information to help solve problems and coordinate work. Weak ties were more important than strong ties in obtaining useful knowledge.

Krackhardt et al. (2003) suggested that strong ties were more important to the individual than weak ones, because they were social ties that became available and helped in solving problems. In the context of project-based work, weak ties help information seekers find useful information and accelerate projects when knowledge is not complex (Hansen, 1999). When the tie strength is high, the knowledge seeker and their strong ties share both knowledge and established communication channels (Hansen, 1999), leading to better problem solving (Uzzi, 1996). Relational studies show strong interpersonal ties, characterized, among others, by high frequency of communication as more effective than weak ties in strengthening knowledge transfer and learning (e.g., Levin and Cross, 2004). Research also shows that tie strength improves specific types of knowledge transfer, learning, and the individual's ability to benefit from working with a variety of partners. Increasing the strength of relationships between team members helps them effectively search for useful knowledge and improve group problem solving (De Montjoye et al., 2014).

Zhang et al. (2015) argue that strong social ties, mutual trust, and a shared vision facilitate the integration of knowledge and its use in teams. Similarly, Thomas and Paul (2019) believe that communication is a means to build trust and strong social ties. However, this requires linking the knowledge used with the organization's business processes, as is the case in our research. Thanks to this, we know what knowledge employees of the organization have, what tasks they use it for, and finally what is the knowledge gap and tasks in the organization. Especially that knowledge that the employee does not use or does not share is not of great importance for the organization.

In our research, taking into account the above studies, we assume that the use of knowledge is associated with problem solving in an intra-organizational context. Thus, the proposed hypotheses broken down into strong and weak tie in the problem solving networks are as follows:

H1a: The extent to which actor i uses shared knowledge with actor j is positively associated with the degree to which actor i solves problems with actor j through a strong tie.

H1b: The extent to which actor i uses shared knowledge with actor j is positively associated with the degree to which actor i solves problems with actor j through a weak tie.

3. Methodology – a network approach

We used a diverse research approach, combining qualitative, quantitative, and network research in understanding the knowledge networks in an intra-organizational context. First, based on an interview with the director of the studied IT organization, we identified business processes that became the framework for identifying the knowledge nodes, resources and tasks included in the survey questionnaire. In order to identify nodes of knowledge, an interview was conducted with a director (manager), who usually has the most extensive knowledge of how the organization functions (Tsai & Ghoshal, 1998). In our research, the tacit knowledge network is a network of joint problem solving by employees in an organization understood as a dyadic relation. Tacit knowledge is personal and embodied (Polanyi, 1966), which makes codification and dissemination very difficult. If the actor is not associated with a specific domain of action, then tacit knowledge becomes almost impossible. Hence, associating employees with the knowledge they possess and use; their access and use of resources as well as skills and real performance of tasks in business processes (c.f., Ujwary-Gil, 2019). Tacit knowledge is rooted in the actor's activities and is revealed through organizational tasks.

However, for the purposes of this article, we will focus only on knowledge nodes, the other (resources, tasks) are not presented here (more in Ujwary-Gil, 2020). In total, we identified 47 knowledge nodes. 45 employees took part in the survey, which is 98% of the population of the surveyed organization. Then, we defined a one-mode knowledge network, i.e. problem-solving, based on the question: How often do you communicate with this person for assistance in solving work-related problems? (Cronbach's alpha = 0.883). The scale of response was: 3) - at least once a day; 2) at least once a week; 1 - at least once a month; 0 - never. We divided the answers into strong relations (3-2), creating the matrix: AA.PS.strong and weak relations (1-0), creating the matrix: AA.PS.weak. The division of ties into strong and weak is based on the frequency of interaction similar to Granovetter (1973). The two-mode matrix of relations was the connection of social actors (A) with knowledge nodes (K) based on the question: I use this knowledge or skill in my work (Cronbach's alpha = 0.870) and Likert scale: 5 - definitely yes and 1 - definitely no. The two-mode matrix - AKij was created. Then we binarized the matrix cells assigning a value of 1 when the responses were on a scale of 5-4 and a value of 0 when they were about 3-1. In order to correlate and regress all matrices, one had to fold on a bimodal matrix to form a one-mode knowledge use matrix (AA.KU.shared).

To correlate and regress the matrices in the network approach, we used commonly used tools, such as quadratic assignment procedure (QAP) and multiple regression quadratic assignment procedure (MRQAP) (c.f., Ujwary-Gil, 2020). The dependent variable is the knowledge use matrix (AA.KU.shared); independent variables are problem-solving matrices divided into strong (AA.PS.strong) and weak (AA.PS.weak) ties.

4. Results and discussion

To illustrate the network in the organization under study, we present visualizations of problem-solving networks broken down into strong and weak ties measured by the frequency of interactions. In a network with strong ties, the density of relationships was 0.17, and the number of links was 341 (Figure 1). In turn, in networks with weak ties, the network density was 0.25, and the number of links was 508 (Figure 2). Here, the density metric is the ratio of the number of links versus the maximum possible links for a network. Actor A10, as the only one, remains excluded from this kind of relationship in the organization. Visualization of knowledge use networks is quite different due to the folding operation, where at the intersection of rows and columns of the matrix, we have the number of knowledge nodes that the actors (organization employees) share with each other (Figure 3).

To correlate entire matrices, we used QAP (Table 1) and calculated statistical relationships using Pearson's r and p-value. As suggested by Borgatti et al. (2018), we used a large number of permutations (10,000, with a random seed of 8510) to stabilize the p-value. The order of nodes changes randomly, but not the network structure. The generated distribution allows the calculation of the statistical significance of a given variable. We conducted data analysis using UCINET 6 (Borgatti et al., 2002). To test the hypotheses, we subjected the dependent variable matrix to MRQAP regression on independent variable matrices (10,000). It is not possible to calculate degrees of freedom, statistical power, effect size in QAP as in standard OLS regression. R2 values may be smaller than p values at .01, which means that 1% of permutation has a higher correlation than observed (Gibbons, 2004).

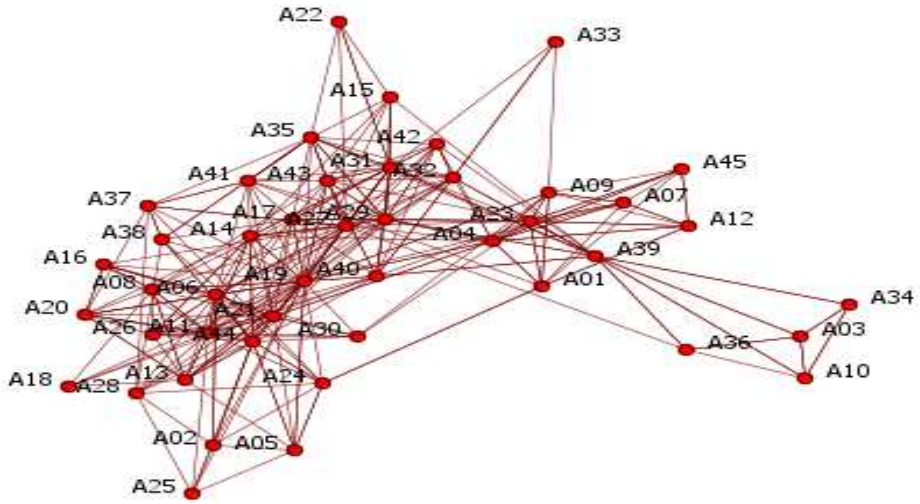

Figure 1: Problem-solving network – strong ties

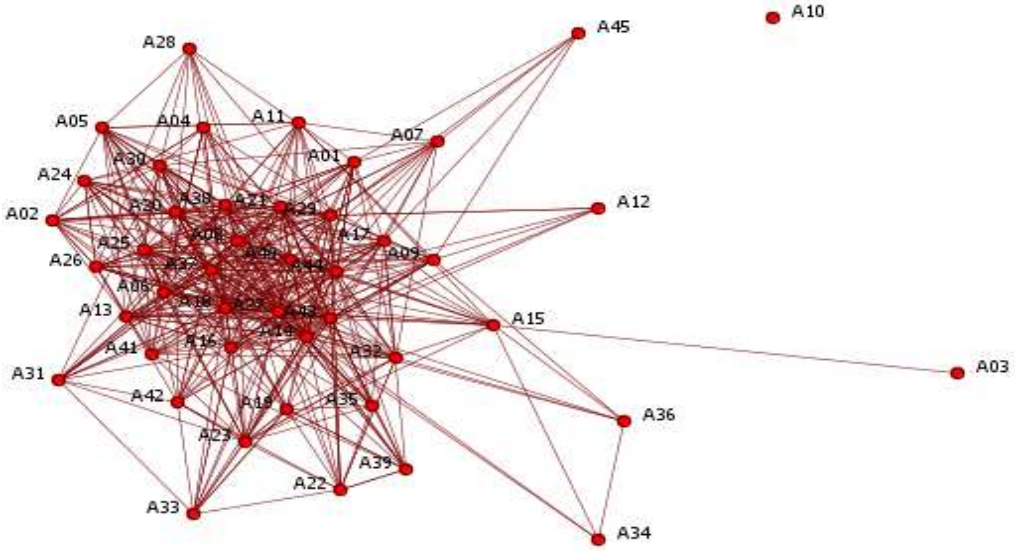

Figure 2: Problem-solving network – weak ties

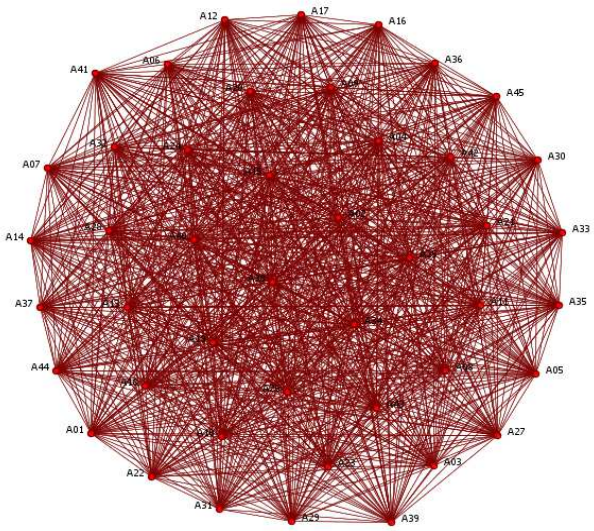

Figure 3: Knowledge use network

Table 1: Correlation and regression results

	Correlation				Regression		
				Std Dev	Independent variables	Dependent variable	Std Err
QAP Correlation	1.	2.	3.			1. AA.KU.shared	
1. AA.KU.shared	1.000			0.0503	2. AA.PS.strong	0.25350 (p=0.00010)	0.93033
2. AA.PS.strong	0.203	1.000		0.0605	3. AA.PS.weak	0.18777 (p=0.00350)	0.92044
3. AA.PS.weak	0.120	-0.268	1.000	0.0326	Adj R^2	0.07307	
					Model fit	0.00010	
QAP P-values	1.	2.	3.				
1. AA.KU.shared	0.000						
2. AA.PS.strong	0.000	0.000					
3. AA.PS.weak	0.026	0.000	0.000				

Surprisingly, we find that all networks are low-correlated, but statistically significant, despite the expected relationship between knowledge use and problem-solving. Correlations between any two networks have a distribution with a standard deviation of 0.03-0.06. The number of observations was 1.980 diads in each matrix (N * [N - 1]), the total number of observations in all three matrices was 5.940 diads. Standardized coefficients, along with the p-value, were obtained as a result of 10,000 permutations. MRQAP determines which predictive (explanatory) relationships are relevant to predicting knowledge-based behavior. From the perspective of standardized coefficients, the dependent variable is important in relation to solving work-related problems.

To test hypotheses, we have created one model that contains two independent variables and explains 7.3% variance in the dependent variable (Adj. R2 = 0.073, p <.001), suggesting that the solving problem with strong ties (AA.PS.strong) and the problem solving network with weak ties (AA.PS.weak) are not the main conditions for knowledge use (AA.KU.shared), although there is great potential for further exploration here. H1a hypothesis has been confirmed (β = .253, p <.001) and indicates a link between the use of knowledge by actors and joint problem-solving in the organization based on strong ties. The H1b hypothesis (β = .0.187, p <.01) was also confirmed, pointing to the relationship between the use of knowledge by actors and joint problem-solving in the organization based on weak ties.

Probably (according to the author's knowledge), these are the first empirical studies that allowed to measure the relationship between the use of knowledge, understood as one of the knowledge management processes, and strong and weak ties in the network of organizational problem solving. The results emphasize the importance of strong ties in the use of knowledge in the organization's activities (c.f., Friedkin, 1982); in access to others and help in solving problems (c.f., Krackhardt et al., 2003); in using knowledge to solve problems (c.f., De Montjoye et al., 2014); in the integration of knowledge and its use by employees (c.f., Zhang et al., 2015). In turn, the impact of weak ties in the network of problem solving can affect the use of new knowledge in the organization's activities by combining the knowledge possessed by the employees of the organization, especially with those with whom we do not have frequent contact, which can be a source of new knowledge (c.f., Rogers, 1995; Levin and Cross, 2004). We can assume that the use of knowledge requires a combination of both weak and strong ties (c.f., Friedkin, 1982).

In general, the results of hypotheses emphasize the statistically significant impact of problem-solving networks broken down into weak and strong ties on variances in the use of knowledge and skills. Even if the statistical generalization is not possible, the important analytical (theoretical) generalization is that these networks create alternative pathways to constructing knowledge networks in the organization. The results show that social networks are a source of social inequality in the organization. This means that changing and balancing inequalities is within the scope of organizational (human) actors who are the basis of all the relationships mentioned.

5. Limitations, implications, and direction for further research

The study has a number of limitations due to various organizational restrictions. The study was conducted in a small organization with a population of 45 people, which may affect the size of e.g. standard error. However, the number of observations is measured differently than in classical social studies. Here, all observations are dependent on each other, and the problem of variable autocorrelation is included in the network statistics methods used (QAP, MRQAP).

The survey questions that were used in researching the network of knowledge use and problem solving require further, detailed analysis, possibly also reformulation, which would increase the explanatory power of the adopted model. We have limited independent variables to two networks of relationships related to solving work-related problems. The impact of other relationship networks (e.g., information networks, trust networks, conflict networks) on the use of knowledge in an intra-organizational context needs to be tested. We subjected network variables to correlation and regression, but an additional advantage could be the inclusion of attribute variables (e.g., age, experience/tenure, location in the company, or position/status) in the research model to exclude other explanations.

The division into strong and weak ties based on the frequency of interactions may not be sufficient to draw clear conclusions. Auxiliary networks of relationships defining the closeness of relationships or emotional involvement (affective behavior) of actors are necessary. In addition, the research is cross-sectional, which hinders the direction of inference and impact of individual variables, as well as cause-effect relationships. Research does not lead to the formulation of generalizations. To make this possible, research needs to be replicated to more organizations.

The findings contribute to the literature on knowledge management, its strategy and processes, where knowledge use and problem solving play a crucial role. Current literature recognizes the potential of networks to study and understand the complexity of knowledge management, interactions of its processes that are interdependent with each other. The theoretical background presented in the paper aims at defining a knowledge use and problem solving from the perspective of network and investigating their association empirically. The network approach enables one to define knowledge use and problem solving as a network of interrelated actors (employees) that affect each other in unilateral or mutual relations. The theoretical implications can be associated with methods used in assessing the knowledge use and with the network analysis itself. The study presented in the paper uses network analysis to analyze knowledge use and problem solving of an IT organization and to provide information to managers highlighting the strong ties within the problem solving network that influence the knowledge use process in the organization. The practical implications of the method used to study knowledge use are expressed in the benefits of using network analysis that allows one to look at company knowledge from a different perspective. The value of knowledge can be expressed in the organization's ability to use it and develop those that have the most significant impact on problem solving in the organization.

Further research should focus on linking one-mode and two-mode matrices, detailing the interrelationships between human actors and resources and tasks in the organization, including network effectiveness indicators (organization)—besides, the inclusion of other variables and their validation. The added value would certainly be longitudinal studies, which would allow determining the structure of network dynamics and cause-effect relationships.

6. Conclusion

Our research aimed to operationalize the knowledge use in an intra-organizational context and to link the use of knowledge with problem-solving in accordance with research assumptions, which were repeatedly presented in the literature on the subject (see Literature background). The results of the research are promising and constitute an interesting direction for further exploration. We have established, however, with the research limitations outlined that there is a statistically significant relationship between the use of knowledge and problem-solving in the organization with an emphasis on strong and weak ties. These are probably one of the first studies of this type related to the operationalization of the use of knowledge in the network approach, understood as one of the key knowledge management processes.

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