INFORMATION AND KNOWLEDGE NETWORK ANALYSIS IN AN ORGANIZATION

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Abstract

The article presents a selected organization from the perspective of its network of relations and ties. The main networks to be analyzed are the information network and the knowledge network, which constitute core elements of every organization's operations. The article comprises theoretical considerations of information and knowledge as key intangible resources as well as information and knowledge networks. The research was based on a single case study in which the authors used the basic network measure, namely total degree centrality. Centralities are among the most popular measures which allow us to determine the prominences of network actors. Each network determines a different network of relations, such as: receiving and giving information and joint problem-solving, awareness of the knowledge and skills of other network actors as a necessary requirement for information and knowledge flow in an organization.

Keywords: *information network, knowledge network, organization, total degree centrality.*

1. Introduction

Information and knowledge networks are the key elements in every organization's operations. Information and knowledge flow determines communication between employees (actors) within an organization, and also the degree of using these resources. Both information and knowledge are key non-tangible elements, constituting a broadly understood intellectual capital of an organization. In a knowledge-based economy, organizations are becoming increasingly dependent on information and knowledge which they obtain, process in line with their own categories of perceiving the environment and use in order to achieve competitive edge. This competitive advantage is based on creating and proposing values for an organization and clients within a specific business model. Creating and/or proposing values takes place within the network of relations and ties. Information and knowledge become

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interdependent, located in the network of ties between actors. Information and knowledge networks thus becomes fundamental concept which allows us to assess the effectiveness of the flow and use of these resources in an organization.

An organization is gaining new significance. It is perceived through the prism of the relations, mostly between social actors, whose social structure affects many variables. Among them one can find giving and receiving advice among corporate creators (Brennecke & Rank, 2017), where supporting each other, joint problem-solving are important elements in creating innovations in an organization. The interest in intra-organizational network research has been growing (Figure 1). There are many authors who examine network structures and their influence on creating value (Tsai & Ghoshal, 1998); innovations and corporate results (Tsai, 2001); facilitating cooperation (Parker, Cross & Walsh, 2001), or creating knowledge (Cross, Parker, Prusak & Borgatti, 2001).

Figure 1. Intra-organizational network trends

Source: based on Google Ngram Viewer.

This article aims at examining how networks of information and knowledge are shaped in a public sector organization and whether they are correlated. The information and knowledge flow is closely tied to performing tasks and organizational work. The main research assumptions will be presented in the methodological part of the paper.

2. Information and knowledge networks in organization

Information and knowledge constitute the key non-tangible resources of an organization. These resources are more and more often presented in the context of their flows, which is associated with their more dynamic presentation. Information is a basic element of communication between people.

Information is generated on the basis of data which must be processed and contextualized to become information that can be passed or received from others via verbal or non-verbal communication (Lillrank, 2003). In everyday use, information affects individual and organizational decision-taking processes, whereas effectively managed and processed information facilitates building intellectual capital, a basis for innovations and growth (Buchanan & Gibb, 2007, p. 162).

Organizations are aware of the potential of information in building competitive advantage (Ismail & Yee-Yen, 2015). In the context of a resource, information, its creators, intermediaries and users are all perceived as separate and isolated elements. Thus information assumes a fragmentary form, not connected into the general flow of information and state of knowledge (Braman, 1989, p. 236). This approach to information, perceived as unrelated elements, dominated the atomistic perception of an organization. In the network approach pieces of information are tied to each other thanks to interpersonal relations of its actors. It is the subject of these relations, since their features include its ability to be passed on within the communication process (Barlow, 1994, p. 14). Information is an activity most often determined by the verbs such as: send, pass, receive, than by nouns. It is an activity taking place between people, even if it uses the services of such intermediary as tele-information structure. Therefore information is not an abstract thing but a relationship between two actors, so much greater emphasis is placed on the user (recipient, actor) of information. This relationship is always intentional, not random. It contains the actor's intentions, which, in the intra-organizational context, are goals, and in a broader context creating value and achieving competitive advantage. Information exchange is of key importance for the competitiveness of a particular organization and requires its free flow between members. Such flow should not be disturbed and it should be updated. However, providing broad access to information in organizations is still an exception rather than a rule (Li & Lin, 2006).

Information is primary to knowledge. The relationship between them is mutual (Choo, 1998). Knowledge is created and organized by a particular flow of information. Whereas information itself can be an activity, knowledge refers to human activity. According to Carlsson (2003) knowledge exists as a resource which can be transferred, re-combined and used in order to create the company value. On the other hand, it exists as a process, the knowledge flow, in which knowledge is created, passed, integrated and used, becoming key tasks in network management (Knight & Harland, 2005). This means such design of knowledge processes which will allow to achieve competitive advantage thanks to knowledge sharing and applying the existing knowledge to problem solving.

An ability of an organization to sharing knowledge among organization members is the key to achieve competitive advantage (Hansen, Mors & Lřvĺs, 2005; Ipe, 2003).

Two types of knowledge have gained wide acceptance, namely tacit and explicit knowledge (Collins, 2010). Explicit knowledge is codified, has formal nature (it is somehow formalized, written down in an organization), just like information. Tacit knowledge is personalized and based on experience. The significance of experience plays a vital role in understanding and in possibilities of applying tacit knowledge. Explicit knowledge may be understood and applied in a relatively simple way, without the need of adding experience. Tacit knowledge, on the other hand, cannot be formally passed on and requires experience in order to be understood. Therefore it is justified to perceive the tacit knowledge flow only as potential. Such exchange may be best presented as a network consisting of the knowledge of employees and their cooperation relatively to their task. The usefulness of information and knowledge occurs when a person can apply the information and knowledge while performing their tasks (Grant, 1996). Both information and knowledge are dynamic. This dynamics is connected with the perception of information and knowledge through the prism of relations and ties and their configuration, transformations related to knowledge transformation and practical use (in organizational tasks).

In this article information and knowledge networks (AA) are single-mode, though they may be double-mode – AK (for example actor (A) possesses and/or uses knowledge (K)). The determine how information and knowledge spread within an organization. The constitute of the same types of nodes, namely actors (A), that is organization employees, who contribute to information exchange, joint problem-solving or task division. In the AA information network actor i is related to actor j (AAij) if actor i passes and/or receives information related to professional work, and within the knowledge network (AA) he jointly solves problems or is aware of the knowledge and skills of actor j. Then the matrix cell between ij elements = 1. The knowledge network determines the relationships between people. It allows us to examine with whom a particular person discusses or solves complex problems related to professional work and whether employees are aware of the knowledge and skills possessed by others. The network predictions of information diffusion, especially the information concerning knowledge and activities of other actors, are a good indicator of group results (Carley, 2005). Knowledge is located in heads of various people and, if it is to be used effectively, we need to know who possesses this knowledge.

Understanding the information flow is an important element in transforming information into knowledge.

Describing the patterns of interactions between people and information within an organization we gain an opportunity of analyzing the flow of knowledge created on the basis of joint problem-solving and information exchange over the functional and organizational boundaries and where the increased knowledge flow will exert the biggest influence on general productivity or value creation.

From the perspective of coordinating the network of ties, the organizational integration based on informal social mechanisms increases joint problem-solving. The theory of information processing shows that member of an organization use directions from official and unofficial sources to give them their actual sense, since behaviors are mostly driven by joint interpretation of events and actions (Soda & Zaheer, 2012).

Popular techniques examining the network of information and knowledge are the analysis of social and organizational networks which can grasp the complexity of the network of information influence and knowledge flow much more effectively than traditional knowledge maps. By mapping relations, the networks of information and knowledge allow us to discover informal communication patterns and compare than with the existing formal structures in order to explain organizational phenomena. This analysis helps us determine whether an employee in a particular point of the network provides information and knowledge to other parts of the network. The employees positions defined as information and/or knowledge provider are associated with a high level of information and knowledge exchange.

3. Research questions and methodology

The research using the analysis of social and organizational network was conducted in an organization operating in the higher education sector. The choice of the case for our study was intentional, guided mainly by the accessibility criteria (Yin, 2011). The consent of the management is vital in such network research (Tsai & Ghoshal, 1998). The research was conducted at the turn of 2014 and 2015. There were 82 employees who participated in it, out of 89 we selected for the research, which accounts for 93% of the respondents. According to the assumptions of network research, the survey sample covered the whole population. We used a survey questionnaire which contained over ten questions, however, for the purpose of this article we only used four popular questions developed by Cross and Parker (2004) (see Table 1).

Table 1. Measurement of constructs

Organizational networks	Questions/statement	Scale	Acronym/ matrix
Information network	1.How often do you give the information closely related to work performed in the organization to this person?	1 – never 2 – at least once a quarter 3 – at least once a month 4 –at least once a week 5 – at least once a day	AA_give_info
	2. How often do you get the information closely related to work in the organization from this person?	1 – never 2 – at least once a quarter 3 – at least once a month 4 –at least once a week 5 – at least once a day	AA_get_info
Knowledge network	3. Which of these persons and how often do you contact to get help in solving complex problems related to performed work?	1 – never 2 – at least once a quarter 3 – at least once a month 4 –at least once a week 5 – at least once a day	AA_solve
	4. I am aware of the knowledge and skills possessed by this person. This does not mean I have the knowledge and skills, but I understand what skills and knowledge this person possesses.	1 – definitely not 2 – rather not 3 – it is difficult to say 4 – rather yes 5 – definitely yes	AA_understand_skills

The questions were developed using Likert's five-grade scale, which was then dichotomized. In the matrix concerning the information and knowledge network we took into consideration strong relations (4 and 5), attributing the value of 1 to them. The answers on the 1-2 grades were given the value of 0. Such matrix was then used for calculations using the centrality degree measures (Table 2).

Tabela 2. Total degree centrality

Metric	Description	Formula
Total degree centrality	The total-degree centrality of a node is the normalized sum of its in-degree and out-degree.	Let A be the input network with N nodes and maximum link value v Total-degree centrality for node i = (sum(A(i,:)) + sum(A(:,i)) – A(i,j)) / 2*V*(N-1)

Source: Altman, Carley & Reminga (2017, p.).

The basic tool for correlating the matrix is the Quadratic Assignment Procedure (QAP). QAP computes the Pearson correlation all pairs of a set of

equally sized square matrices, and assess the frequency of random measures as large as actually observed. The procedure is principally used to test the association between networks. Often, one network is an observed network while the other is a model or expected network. The algorithm proceeds in two steps. In the first step, it computes Pearson's correlation coefficient between corresponding cells of two data matrices. In the second step, it randomly permutes rows and columns (synchronously) of one matrix (the observed matrix, if the distinction is relevant) and recomputes the correlation and other measures. The second step is carried out hundreds of times in order to compute the proportion of times that a random measure is larger than or equal to the observed measure calculated in step 1. A low proportion (< 0.05) suggests a strong relationship between the matrices that is unlikely to have occurred by chance. This procedure is repeated for every pair of matrices. The larger the number of permutations, the better the estimates of standard error and significance (in our case it was 10,000). UCINET generates a different random number as default each time it is run. This number should be changed if the user wishes to repeat an analysis. The range is 1 to 32000 (in our research the random seed was 22041). The output consists of results for each pair of matrices and contains the following: the observed value i.e. the correlation between the two matrices; significance i.e. the proportion of randomly generated correlations that were as large (or small if they are negatively correlated) as the observed; the average, maximum, and minimum of all the generated values together with their standard deviation; the proportions as large and as small as the observed (Borgatti, Everett & Freeman, 2002).

Additionally, the scatter plot has been used to show the association between the total degree centrality of specified networks. A scatter plot uses Cartesian coordinates to display values for two variables. The data is displayed as a collection of points, each having one coordinate on the horizontal axis and one on the vertical axis. A scatter plot does not specify dependent or independent variables. Either type of variable can be plotted on either axis. Scatter plots represent the association (not causation) between two variables. A scatter plot can show various kinds of relationships, including positive (rising), negative (falling), and no relationship. If the pattern of dots slopes from lower left to upper right, it suggests a positive correlation between the variables being studied. If the pattern of dots slopes from upper left to lower right, it suggests a negative correlation. A line of best fit can be drawn in order to study the correlation between the variables. An equation for the line of best fit can be computed using the method of linear regression (Altman, Carley & Reminga, 2017, p. 568).

Referring to the introduction and the main goal of the article, the basic research problems consist in examining:

Is there a correlation between the information and knowledge networks in the examined organization?

Is there a correlation between total degree centrality of actors in the information and knowledge network?

4. Research results

Table 3 presents the results of correlations obtained thanks to associating four matrixes mentioned in Table 1. The results show relatively high correlation between information networks AA_give_info and AA_get_info, where r=.761, p<.0001, which confirms high dependence between these networks. An equally high correlation exists between the knowledge network (AA_solve) and the information network (AA_get_info and AA_give_info), where r is, respectively, r=.668, p<.0001 and r=.655, p<.0001. A slightly lower correlation is recorded by the information networks with the knowledge network AA_understand_skills. Here the correlation is r=.321, p<.0001; r=.333, p<.0001, or slightly more r=.340, p<.0001 for the knowledge network AA_solve.

Table 3. QAP correlation

		1	2	3	4
1	AA_get_info	1.000	0.761	0.668	0.321
2	AA_give_info	0.761	1.000	0.655	0.333
3	AA_solve	0.668	0.655	1.000	0.340
4	AA_understand_skills	0.321	0.333	0.340	1.000

Note: QAP p-values 0.0001.

The next Table 4 presents the position of actors in a particular network (the most important people from the perspective of prominence, occupied position in the network and their influence on the network and other members of an organization). We presented the results of the actors' prominence only from the top ten, due to the lack of space for a more in-depth analysis.

Central people in a given network are those who are related with many other people and who, thanks to their position, have access to their information, knowledge, ideas, thoughts, opinions. The degree of centrality allowed us to identify that most connected people in the network from the perspective of information and knowledge flow. A prominent place is occupied by actors: A79 (AA_give_info), A65 (AA_get_info), A61 (AA_solve), A55 (AA_understand_skills). These people can send the information quickly, share their knowledge and also control the flow of information and knowledge in an

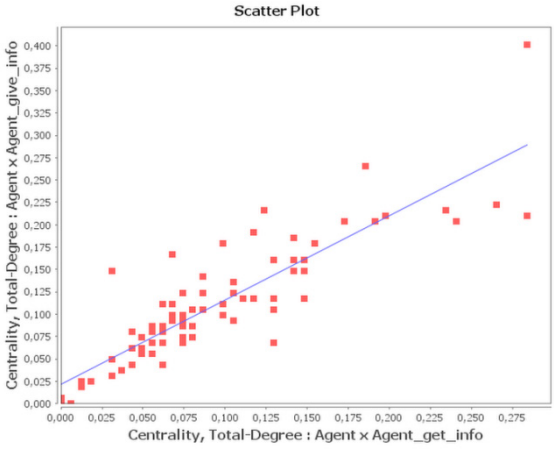
organization. Employee A79 in network AA_give_info has connections with 40% of actors in the network and is the most central figure in the network. Other values oscillate around 20%, except for network AA_understand_skills, where actor A55 has 83% of all connections in the network.

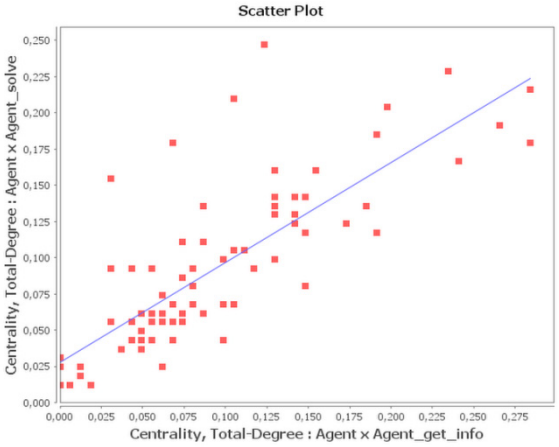
Tabela 4. Degree centrality of information and knowledge networks

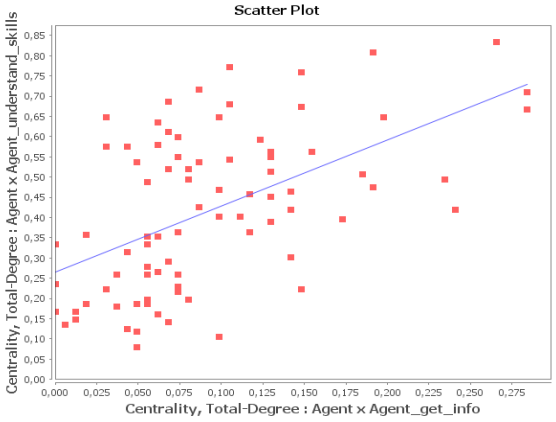
Network	**AA_give_info**		**AA_get_info**		**AA_solve**		**AA_understand_skills**	
Rank	Actor	Result	Actor	Result	Actor	Wynik	Actor	Wynik
1.	A79	0.401	A65	0.284	A61	0.247	A55	0.833
2.	A32	0.265	A79	0.284	A36	0.228	A14	0.809
3.	A55	0.222	A55	0.265	A79	0.216	A41	0.772
4.	A36	0.216	A72	0.241	A05	0.210	A06	0.759
5.	A61	0.216	A36	0.235	A40	0.204	A12	0.716
6.	A40	0.210	A40	0.198	A55	0.191	A79	0.710
7.	A65	0.210	A14	0.191	A14	0.185	A44	0.685
8.	A14	0.204	A17	0.191	A19	0.179	A05	0.679
9.	A17	0.204	A32	0.185	A65	0.179	A29	0.673
10.	A54	0.204	A54	0.173	A72	0.167	A65	0.667
	Min: 0 Max: 0.401 M: 0.109 SD: 0.068		Min: 0 Max: 0.284 M: 0.093 SD: 0.063		Min: 0.012 Max: 0.247 M: 0.092 SD: 0.055		Min: 0.080 Max: 0.833 M: 0.417 SD: 0.194	

Notes: Min: min value. Max: max value. M: mean. SD: standard devotion.

Figure 2 below present the total degree centrality of the information network nodes (AA_give_info; AA_get_info) and the knowledge Network nodes (AA_solve; AA_understand_skills) and the level of their correlation.




Scatter Plot
Centrality, Total-Degree : Agent x Agent_solve
Centrality, Total-Degree : Agent x Agent_get_info


Scatter Plot
Centrality, Total-Degree : Agent x Agent_understand_skills
Centrality, Total-Degree : Agent x Agent_get_info


Scatter Plot
Centrality, Total-Degree : Agent x Agent_solve
Centrality, Total-Degree : Agent x Agent_give_info

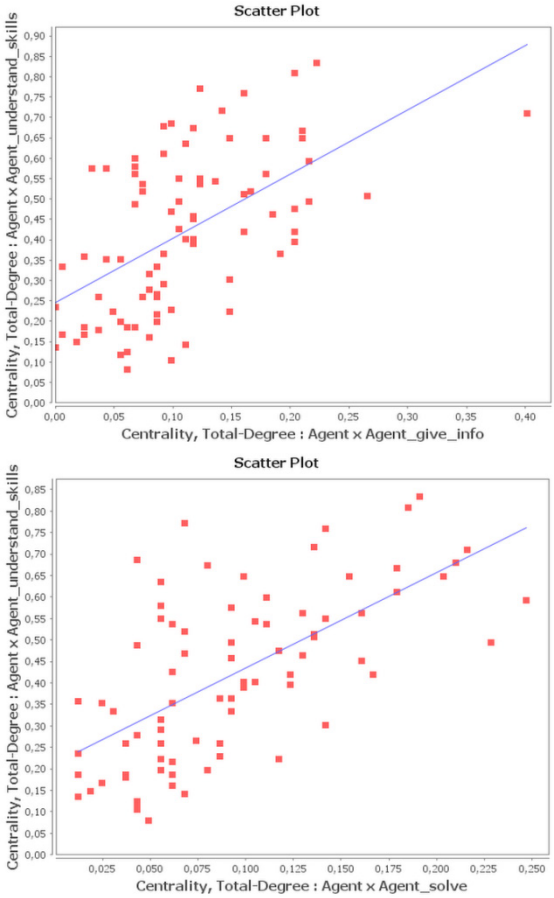


Figure 2. The scatter plots of total degree centralities of information and knowledge networks

Each square in the graph represents a particular node (employee of the organization). Nodes located in the upper corner of the dispersed graph show a high degree of centrality for the given persons. The inclination (M) of the line ranges from 0.630 to 2.225, which, in the latter case, means that the normalized centrality of the node AA_solve is approximately twice as big the normalized degree of centrality of the node AA_understand_skills. R2 of the linear regression ranges from 0.286 to 0.778, which means that between 28% and 77% of the centrality of a particular network node can be explained by the centrality of the node of another network. Correlation r determining the relations between the centrality degree of the nodes of particular information and knowledge networks ranges from r=.535 for the point graph covering x axis (AA_get_info) and y axis (AA_understand_skills) and r=.878 for the point graph covering x axis (AA_get_info) and y axis (AA_give_info).

5. Conclusions

Centrality measures are the most popular measures in the analysis of social and/or organizational networks. Based on them we could determine the most central and influential person in an organization, taking into account the number of all possible interactions in a given network. This person could play the role of a change leader, implement innovations, activate others to cooperate, organize information and knowledge flow and many other activities, related, inter alia, to allocation of resources and knowledge. This, obviously, does not mean that we should focus only on the prominent nodes in the network. Peripheral nodes, located on the peripheries of the network or possessing low values of centrality measures, may constitute a source of additional specialist knowledge and their potential is not fully used by the organization.

The research using QAP and scatter plot indicated that there is a high correlation between the information and knowledge networks. A slightly lower correlation was found between information networks and knowledge network (AA_understand_skills). In the examined organization the degree of networking strong relations (density) in the knowledge network AA_solve is relatively low and amounts to 9%. Although 41% of people are aware of the knowledge and skills of co-workers, this does not necessarily translate into joint problem-solving. Scatter plot was used for examining the relations between the degree of centrality of information and knowledge networks. The graphs have shown that prominent people in the information network also occupy prominent positions in the knowledge network. The centrality degree provides information on the most central actors in the information and knowledge network.The organization may use the potential of these people in managing the organization, especially when central people in the network are not necessarily and not always those who occupy management positions. Especially as the identification of the information and knowledge network concentrates mostly on informal relations in the organization. Prominent people in the network (organization) may run trainings, work as mentors for the newly-employed staff or be project leaders.

The research was had a primary and cross-sectional nature. It concentrated only on one measure – total degree centrality. In the future we can examine the relations between various measures of centrality. For example, we may check whether the actors who are the most influential ones due to their occupied (central) position in the network are also the people who most often work as intermediaries in passing (or blocking) information and knowledge in the network. An interesting aspect of this research would be to include the attributes such as years of service, age, occupied position in the organizational hierarchy, and even gender as the explanatory or controlling variables for particular networks of information and knowledge.

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