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# INTRA-ORGANIZATIONAL TWO-MODE NETWORKS ANALYSIS OF A PUBLIC ORGANIZATION

**ABSTRACT**. The article focuses on the analysis of intra-organizational and two-mode networks of knowledge, resources and tasks. Each of these networks consists of a human and non-human actor in the terminology of the actor-network theory (ANT), or of only non-human actors. This type of research is rare in the theory of organization and management, even though the first article on meta-networks dates back to nearly two decades ago (Krackhardt & Carley, 1998). The article analyses the prominences and ties between particular network nodes (actors, knowledge, resources and tasks), assessing their effective use in an organization. The author selected a public organization operating in the university education sector, where saturation with communication, resource and knowledge-sharing are relatively high. The application of the network analysis provides a totally different perspective on an organization, taking into account the inter-relationship, which allows a holistic (complex) outlook on the analyzed object. Especially, as it measures particular nodes as related to one another, not as isolated variables, as in classical research, where observations are independent.

***JEL Classification:*** D85, L21, L86

***Keywords***: intra-organizational networks, two-mode networks, public organization, actor-network theory, actor, knowledge, resources, tasks.

## Introduction

The intra-organizational analysis of relationships and ties between (human and non-human) nodes is a relatively rare subject of interest among researchers specializing in organizations and management. Most scientists concentrate on inter-organizational relations (e.g., Carlsson, 2003; Harima, 2014; Hydle & Meland, 2016; Mentzas *et al.*, 2006; Ryan *et al.*, 2014; Wäsche, 2015), including one-mode social networks (e.g., Alguliyev *et al.*, 2015; Fang *et al.*, 2015; Hollenbeck & Jamieson, 2015; Zemaitaitiene *et al.*, 2016). Even when the research deals with two-mode networks, where relations are identified within the affiliation network, they still remain social networks (Field *et al.*, 2006; Rawlings & McFarland, 2011; Rodríguez *et al.*, 2011), which determine the ties between actors and a particular organization, location or events (Davis *et al.*, 2009).

In this research, networks have a two-mode nature and contain relations between an actor (human) and an actor (non-human): knowledge, resources and tasks. There are also relations only between non-human actors: between knowledge and a task and resources and a task. The analysis of this area is justified by the fact that an outlook on organizations, taking into account the interrelationship of ties between employees and knowledge, resources and tasks they use or perform in their work, provides a complex picture of how effectively an organization works from the perspective of the network of relations and ties. The unique networks analyzed here are: networks of knowledge (an employee utilizes knowledge), networks of resources (an employee uses resources, usually intangible ones, such as computer software) and networks of tasks (an employee performs a task). To calculate the workload generated by work, knowledge and resources it is necessary to determine the interdependencies between knowledge and tasks (what knowledge is essential to accomplish the task) and between resources and tasks (what are key resources for accomplishing the task). The input data in shape of a two-mode matrix was presented in *Table 1* below.

Taking the above into account, apart from research questions, the following research hypotheses were formulated:

H1: There is a relation between the knowledge network and the resource network.

H2: There is a relation between the knowledge network and the task network.

H3: There is a relation between the resource network and the task network.

The article fills the gap in research concerning two-mode networks in intra-organizational conditions, correlations existing between specific networks and effectiveness of using intangible resources in an organization. The theoretical context is provided by the resource approach and the actor-network theory which has not been yet widely used in theories of organization and management, particularly, however, on resource-based approach. The actor-network theory is a unique approach to joining people, artifacts, institutions and organizations, which allows to understand the complexity in which organizations function. As rightly observed by Czarniawska and Hernes (2005), many European and American scientists use ANT to examine various aspects of an organization, including technologies, organizational changes, procedures, virtual organization, strategy, power, market mechanisms, consumer behavior, public administration and knowledge management. However, there is a deficit of research which would combine ANT and the network approach. Usually, ANT is used is research on information systems (e.g., Doolin & Lowe, 2002; Tatnall, 2005; Walsham, 1997).

The article treats social relations, including the prominence of network nodes, as network results. Similarly to Law's approach (1992) it was assumed that ANT describes heterogeneous networks and an organization would not exist is it was only social. Intangible resources, such as knowledge, resources (structural capital), understood as IT infrastructure, and tasks create the complexity of the network and are of primary importance for social networks existing in an organization.

## 1. Literature review

In the actor-network theory (ANT), whose representatives include Bruno Latour, Michael Callon and John Law (see Law and Hassard, 1999), the community comprises both human and non-human factors. In ANT building networks and treating knowledge-creation processes through the prism of ties between heterogeneous actors is based on dynamic relations between people and non-human factors. Since an organization is perceived as the whole (socio-technical system), changes related to a particular actor (human and non-human) affect the whole network, its development, weakening and, in extreme cases, destruction. ANT, also known as sociology of translations, put special emphasis, compared to other network theories, agency of non-human factors. The actor or the actant (Latour, 1987) may be any animated object (human) or inanimate object (for example tangible and intangible resources), which are treated equally. This means that all socio-technical elements or an organization exert the same influence on shaping the organizational reality. This phenomenon, within ANT, is known as general symmetry (Callon, 1986).

The network is defined as a group of unspecified relations between individuals whose nature is unspecified, too (Callon, 1993, p. 263). The actor-network does not limit itself to social entities and covers *de facto* two concepts: sociogram (people) and technogram (things). In case of sociogram, the sociological analysis, such as the analysis of social networks, focuses on the set of alliances (Wasserman & Faust, 1994). Technogram, on the other hand, covers all technical elements, tailored to the place in order to combine people. Therefore it is not appropriate to examine these systems separately, since they are related to each other. Each change in the technogram usually consists in minimizing limitations in the sociogram and vice versa (Latour, 1987, pp. 138-139). The dependence between the sociogram and the technogram is visible, for example when the resource is not used by its anticipated user. One of the ways of reacting to such ill-adjustment is to change the resource which constitutes the basis for users' acceptance (changing the sociogram) or changing the user themselves. In order to understand the dynamics in one level of network it is necessary to examine its second part.

The analysis of the heterogeneity of the network may be the way to mapping the complexity and diversity of resources in organizations. Such socio-technical networks may become the foundation for future technological development. ANT also stipulates the explanation of why and how networks function by analyzing the network of influences (prominence) which shape social behavior. ANT assumes that each actor is equally important for the social network and that the social order is a result of the efficiently operating actor-network. This order may be violated as a result of removing a particular actor or actors. Such approach means that the level of details and precision in examining networks should be increased. According to Steen (2010), the necessity of combining social and technical elements encourages us to describe in detail specific mechanisms bonding networks together.

The contemporary outlook on an organization, through the prism of ownership and evaluation of the effectiveness of resource use is not sufficient. Certainly it is a static perspective. It should be supplemented with organizing, understood as a construction of the network of actions (Czarniawska, 2010). Therefore this research includes the network of tasks as immanent ties with human actors and resources, mostly intangible ones. In order to dynamize human and non-human actors, which in this research takes the shape of two-mode networks consisting of actors (human) and non-human (knowledge, resources, tasks), it is necessary to conduct an analysis of their ties and their practical use. We cannot analyze alienated human actors without tying them with knowledge and resources they use in specific tasks in the intra-organizational context.

The second theoretical approach is a popular approach based on resources (RBV) (Barney, 1991; Peteraf, 1993). In RBV resources occupy the central place, as can be seen in the works of Penrose (1959), who perceives human and material resources inextricably with services, as she calls them. Services are tasks taken up by humans towards the resources. Many authors ((Peppard & Rylander, 2001, p. 512) (Barney, 1991, p. 101) lists structures, processes, people, culture, information and knowledge, relations, assets, skills, organizational processes or enterprise attributes as resources. In RBV resources, especially intangible ones, contribute to achieving and maintaining productivity when they are combined or integrated (Barney, 1991). As in case of the company growth theory, in the approach (Penrose, 1995), where resources and activities of an organization are perceived as a fundamental part in value-creation. They do not exist independent of each other, and they are its part.

Both ANT and RBV are complementary to each other. Human resources (including, most of all, knowledge and skills), tools (in form of IT infrastructure, e.g. software) and tasks cooperate with each other in unlimited combinations, creating value for an organization.

## 2. Methodological approach

This research aims at examining interrelations between nodes, here human and non-human actors (terms usually used in the actor-network theory, see Alcadipani and Hassard, 2010). Actors (human) (A) are employees of an organization, whereas non-human actors comprise knowledge (K), resources (R) and Tasks (T), which they use and perform in their work. The identification of knowledge, resources and tasks was conducted during the interviews with the management staff in connection with key business processes of the organization. The knowledge number was in total K=24, the resources number R=26, whereas the task number was T=31. The main research questions are:

- How burdened with knowledge (K), resources (R) and tasks (T) are particular employees of the organization (A)?
- Which nodes in the knowledge network (AK), the resource network (AR) and the task network (AT) occupy a prominent position in the network and what consequences does this might bring for the organization?
- What knowledge and resources are the key ones in the task network (KT and RT networks)?
- Is there a correlation between defined networks of knowledge, resources and tasks?

The survey covered 82 employees of a public organization operating in the university education sector (N=82) out of 89 intended for the survey, which accounts for 93% of the respondents. We used an interview and a questionnaire consisting of over 10 questions with the Cronbach's alpha = .821. For the purpose of this article 5 questions in total were used: (1) What knowledge do you use in your work? (2) What resource do you use in your work? (3) What tasks do you perform in your work? (4) Is this knowledge necessary for the task? Is the resource necessary for the task? The questions were developed using a five point Likert scale, which was later dichotomized. We took into account strong relations (4 and 5), assigning to them the value of 1. The replies within points 1-3 on the scale were given the value of 0. Such dichotomized matrices were then used for calculations, applying measurements defined in *Table 1*. On the other hand, the matrices of relations between knowledge and tasks (KT) and resources and tasks (RT) were given the value of 1 only when particular knowledge or resource was vital for accomplishing a given task. We also used the Quadratic Assignment Procedure (QAP) method to analyze the network correlation and the Organizational Risk Analyzer (ORA) and UCINET software.

The choice of the survey as the research method is determined by the unique nature of each organization. On the basis of the survey it was possible to identify the basic elements (nodes) of the network, which constitute the basis for the survey questionnaire. These elements are knowledge and skills, resources (tools, mostly intangible ones) and tasks, which are unique for a specific organization and subordinated to business processes. On the other hand, the choice of the QAP method is a natural consequence of the network approach to the analysis of an organization. It is a tool which allows us to correlate whole networks, taking into account the fact that observations are interdependent.

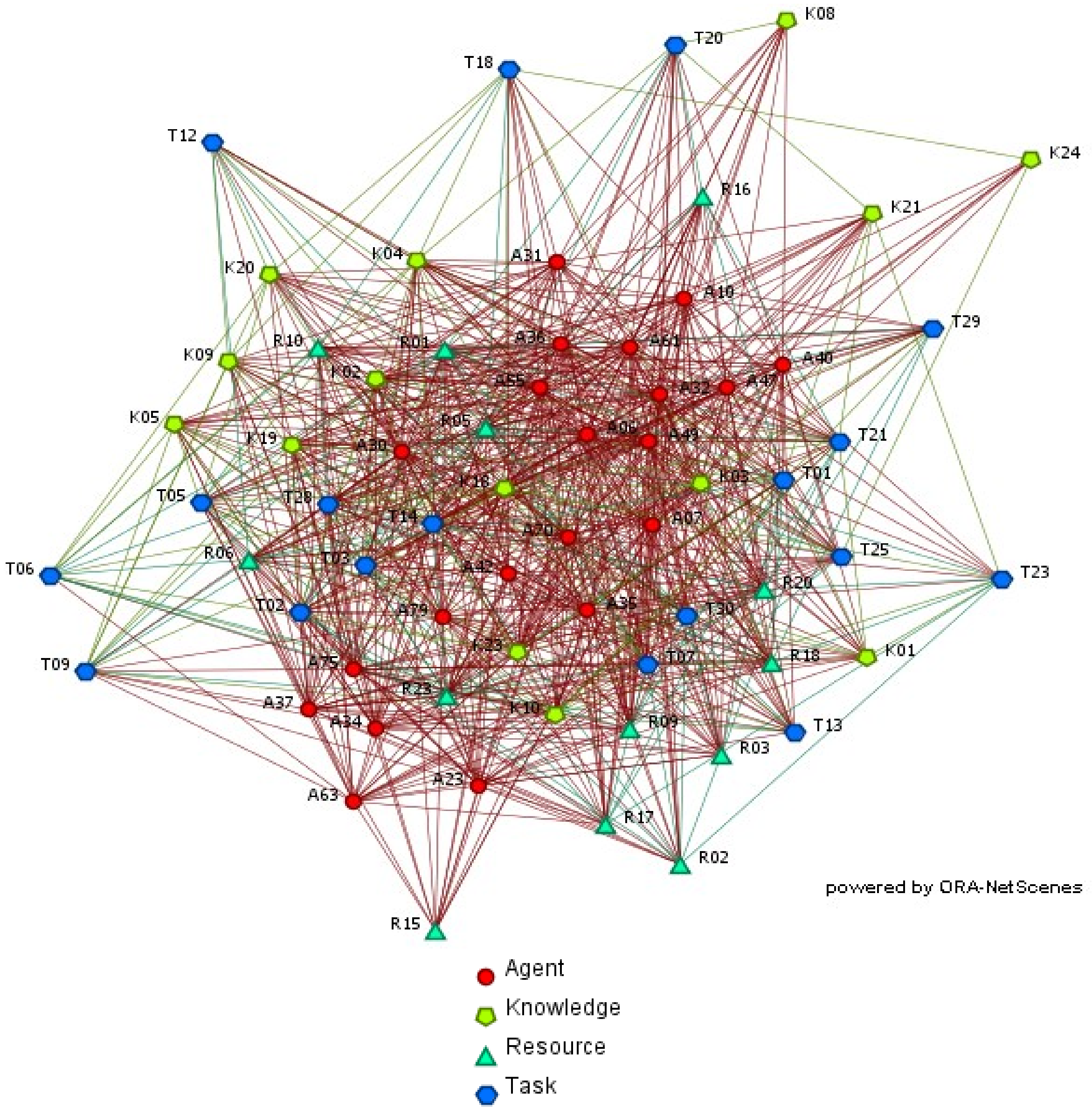
Table 1. Intra-organizational measurements used in the research

| Measure | Definition | Matrix |
|---|---|---|
| Actual workload | The knowledge and resources an agent uses to perform the tasks to which it is assigned. Individuals or organizations that are high in workload are those that are doing more complex tasks and have the resources and knowledge or expertise to do those tasks. Tasks are more complex if they require more expertise and/or more resources. | AK, AR, AT, KT, RT |
| Knowledge actual workload | The knowledge an agent uses to perform the tasks to which it is assigned to. | AK, AT, KT |
| Resource actual workload | The resources an agent uses to perform the tasks to which it is assigned to. | AR, AT, RT |
| Row degree centrality knowledge/actor | For any node, e.g. an actor or a knowledge, the out-links are the connections that the node of interest has to other nodes. | AK |
| Row degree centrality resource/actor | For any node, e.g. an actor or a resource, the out-links are the connections that the node of interest has to other nodes. | AR |
| Row degree centrality task/actor | For any node, e.g. an actor or a task, the out-links are the connections that the node of interest has to other nodes. | AT |
| Row degree centrality actor/knowledge | For any node, e.g. a knowledge or an actor, the out-links are the connections that the node of interest has to other nodes. | $AK^T$ |
| Row degree centrality task/knowledge | For any node, e.g. a knowledge or a task, the out-links are the connections that the node of interest has to other nodes. | KT |
| Row degree centrality actor/resource | For any node, e.g. a resource or an actor, the out-links are the connections that the node of interest has to other nodes. | $AR^T$ |
| Row degree centrality task/resource | For any node, e.g. a resource or a task, the out-links are the connections that the node of interest has to other nodes. | RT |
| Row degree centrality actor/task | For any node, e.g. a task or an actor, the out-links are the connections that the node of interest has to other nodes. | $AT^T$ |
| Row degree centrality knowledge/task | For any node, e.g. a task or a knowledge, the out-links are the connections that the node of interest has to other nodes. | $KT^T$ |
| Row degree centrality resource/task | For any node, e.g. a task or a resource, the out-links are the connections that the node of interest has to other nodes. | $RT^T$ |

T – denotes transposition of the matrix.

*Source*: developed on the basis of selected literature Bonacich, 1972; Carley, 2002; Carley and Yuqing, 2001; Freeman, 1978; Hirschman, 1945; Jiang *et al.*, 2012; Ujwary-Gil, 2017; Wasserman and Faust, 1994.

*Graph 1* presents a meta-network which illustrates all analyzed networks: AK, AR, AT, KT and RT.




Graph 1. Meta-network of a public organization
*Source*: own elaboration based on ORA-Net Scenes.

## 3. Conducting research and results

*Tables 2* and *3* present the results in the context of using knowledge and resources and accomplishing tasks by particular network actors and their actual workload, knowledge actual workload, and resource actual workload. The actual workload denotes here the knowledge and resources that an actor uses to perform tasks for which such knowledge and resources were intended. People with a high ratio perform more complex tasks and have the resources, knowledge and experience to accomplish such tasks. The tasks are more complicated if they require more knowledge and/or resources. The knowledge and resource actual workload determine the knowledge and resources used by an actor to perform tasks. *Table 2* shows that the most work loaded persons as far as the work performed by them and the knowledge and resources they use are concerned, are actors A06 and A36. They are followed by actors A61 and A32. Out of this four-person group of most prominent staff, three occupy some management positions. Their professional experience varies from 6 to over 20 years.

Table 2. Knowledge, resources and tasks performed by network actors

| Rank | Actual workload | | Knowledge actual workload | | Resource actual workload | |
|---|---|---|---|---|---|---|
| | Actor | Result | Actor | Result | Actor | Result |
| 1. | A36 | 0.610 | A36 | 0.640 | A06 | 0.572 |
| 2. | A06 | 0.552 | A06 | 0.535 | A36 | 0.572 |
| 3. | A61 | 0.524 | A61 | 0.515 | A32 | 0.566 |
| 4. | A32 | 0.493 | A55 | 0.460 | A61 | 0.535 |
| 5. | A79 | 0.443 | A79 | 0.460 | A75 | 0.478 |
| 6. | A42 | 0.426 | A32 | 0.435 | A70 | 0.434 |
| 7. | A70 | 0.421 | A42 | 0.425 | A42 | 0.428 |
| 8. | A75 | 0.421 | A30 | 0.410 | A79 | 0.421 |
| 9. | A55 | 0.409 | A70 | 0.410 | A35 | 0.415 |
| 10. | A63 | 0.387 | A63 | 0.390 | A49 | 0.409 |
| | Min: 0<br>Max: 0.610 | M: 0.239<br>SD: 0.135 | Min: 0<br>Max: 0.640 | M: 0.227<br>SD: 0.142 | Min: 0<br>Max: 0.572 | M: 0.254<br>SD: 0.135 |

Notes: Min: minimum value. Max: maximum value. M: mean. SD: standard deviation.
*Source*: own elaboration.

*Table 3* presents the actors best equipped in knowledge, resources and task completion. For each node, for example a person, knowledge, resources, tasks, the output ties denote the ties between the node and other nodes. In case of the following networks: application of knowledge (AK), application of resources (AR) and accomplishment of tasks (AT), the number of external ties a particular actor would have denotes the number of knowledge, resources or tasks tied to them. Persons or organizations rich in knowledge (resources or tasks) have more experts' knowledge (resources or tasks) or are related to more kinds of knowledge (resources, tasks) than others.

Table 3. Row centrality of knowledge, resources and tasks of network actors

| Rank | Row centrality knowledge/actor | | | Row centrality resource/actor | | | Row centrality task/actor | | |
|---|---|---|---|---|---|---|---|---|---|
| | Actor | Result | NR (K) | Actor | Result | NR (R) | Actor | Result | NR (T) |
| 1. | A55 | 0.917 | 22 | A79 | 1 | 26 | A06 | 0.677 | 21 |
| 2. | A36 | 0.875 | 21 | A42 | 0.846 | 22 | A36 | 0.645 | 20 |
| 3. | A10 | 0.833 | 20 | A23 | 0.808 | 21 | A61 | 0.613 | 19 |
| 4. | A30 | 0.792 | 19 | A75 | 0.769 | 20 | A32 | 0.581 | 18 |
| 5. | A79 | 0.792 | 19 | A30 | 0.731 | 19 | A42 | 0.516 | 16 |
| 6. | A34 | 0.750 | 18 | A63 | 0.731 | 19 | A31 | 0.484 | 15 |
| 7. | A37 | 0.750 | 18 | A70 | 0.731 | 19 | A40 | 0.484 | 15 |
| 8. | A32 | 0.708 | 17 | A07 | 0.692 | 18 | A47 | 0.484 | 15 |
| 9. | A61 | 0.708 | 17 | A34 | 0.692 | 18 | A49 | 0.484 | 15 |
| 10. | A70 | 0.708 | 17 | A35 | 0.692 | 18 | A75 | 0.484 | 15 |
| | Min: 0<br>Max: 0.917 | | M: 0.437<br>SD: 0.220 | Min: 0<br>Max: 1 | | M: 0.483<br>SD: 0.184 | Min: 0<br>Max: 0.677 | | M: 0.323<br>SD: 0.140 |

Notes: NR: non-scaled result; Min: minimum value; Max: maximum value; M: mean; SD: standard deviation; (K) – knowledge; (R) – resource; (T) – task.
*Source*: own elaboration.

The row centrality of knowledge locates actor A55 as a person equipped in nearly all types of knowledge (of 24 available), followed by actors A36, A10, A30 and A79 as far as knowledge and knowledge application are concerned. Then, there are actors who use 18 and 17 kinds of knowledge (A34, A37, A32, A61, A70). The ranking of actors applying resources looks different, with the top position occupied by A79, who uses all kinds of resources available in their work (R=26). The indicator of the row centrality of tasks points at actors A06, A36 and A61 as those most heavily actual workload. They perform approximately 20 (over 60%) of tasks out of their total number of 31. This group is led by respectively A55 and A36 actors (equipped in knowledge, followed by A79, A42 (equipped in resources) and A06 and A36 (equipped in tasks).

The centrality measures are the most popular measures in the organizational network analysis. Based on them we were able to determine the most central and influential person in the company as far as all possible interactions in a given network are concerned, who can play the role of a change leader, who can implement innovations, activate others to cooperate, pass the information and knowledge and to perform other activities related to allocation of resources and knowledge.

This does not mean we should focus only on prominent nodes of the network. Peripheral nodes, located at the outskirts of the network or those with low values of centrality measures, may be the source of additional specialist knowledge and their potential may not be fully utilized by the organization. Other ratios illustrate the knowledge and resource actual workload. They show that four persons, namely: A36, A06, A61 and A32, who use over 50% of knowledge and resources to accomplish tasks. This raises doubts as to whether knowledge and resources are optimally used by the organization and its employees. The “real” labor input corresponds to the number of skills which everyone can use to accomplish tasks to which they are assigned at a particular time. This ratio thus may be very effective in identifying employees who have been delegated tasks badly matched to their knowledge and access to resources.

In order to determine what knowledge, resources and tasks are of key importance in the network, we shall apply once again the indicators of the row degree centrality and their transpositions, as shown in *Table 1*. The row centrality (the number of the external ties) for knowledge, resources and tasks allowed us to identify the most important elements of the network as far as the number of indications is concerned. *Table 4* presents the results of the degree of centrality indicating the external ties with other nodes in the network, divided into knowledge, resources and tasks.

Table 4. The row degree centrality of knowledge, resources and tasks in the network

| Rank | Row centrality actor/knowledge | | | Row centrality task/knowledge | | | Row centrality actor/resource | | |
|---|---|---|---|---|---|---|---|---|---|
| | Knowledge | Result | NR (A) | Knowledge | Result | NR (T) | Resource | Result | NR (A) |
| 1. | K18 | 0.890 | 73 | K18 | 0.903 | 28 | R09 | 0.951 | 78 |
| 2. | K23 | 0.768 | 63 | K10 | 0.710 | 22 | R05 | 0.902 | 74 |
| 3. | K04 | 0.744 | 61 | K03 | 0.484 | 15 | R18 | 0.890 | 73 |
| 4. | K19 | 0.683 | 56 | K23 | 0.484 | 15 | R01 | 0.878 | 72 |
| 5. | K02 | 0.659 | 54 | K04 | 0.452 | 14 | R20 | 0.878 | 72 |
| 6. | K21 | 0.610 | 50 | K02 | 0.355 | 11 | R03 | 0.829 | 68 |
| 7. | K03 | 0.549 | 45 | K01 | 0.290 | 9 | R06 | 0.744 | 61 |
| 8. | K01 | 0.476 | 39 | K09 | 0.290 | 9 | R23 | 0.744 | 61 |
| 9. | K20 | 0.476 | 39 | K19 | 0.290 | 9 | R15 | 0.659 | 54 |
| 10. | K08 | 0.463 | 38 | K05 | 0.258 | 8 | R16 | 0.610 | 50 |
| | Min: 0.061<br>Max: 0.890 | M: 0.437<br>SD: 0.208 | | Min: 0.032<br>Max: 0.903 | M: 0.269<br>SD: 0.207 | | Min: 0.085<br>Max: 0.951 | M: 0.483<br>SD:0.289 | |

| Rank | Row centrality task/resource | | | Row centrality actor/task | | | Row centrality resource/task | | |
|---|---|---|---|---|---|---|---|---|---|
| | Resource | Result | NR (T) | Task | Result | NR (A) | Task | Result | NR (K) |
| 1. | R05 | 1 | 31 | T25 | 0.841 | 69 | T14 | 0.542 | 13 |
| 2. | R01 | 0.452 | 14 | T14 | 0.756 | 62 | T01 | 0.458 | 11 |
| 3. | R20 | 0.452 | 14 | T07 | 0.671 | 55 | T09 | 0.417 | 10 |
| 4. | R23 | 0.419 | 13 | T21 | 0.610 | 50 | T02 | 0.375 | 9 |
| 5. | R02 | 0.323 | 10 | T20 | 0.561 | 46 | T05 | 0.375 | 9 |
| 6. | R17 | 0.323 | 10 | T29 | 0.524 | 43 | T06 | 0.375 | 9 |
| 7. | R06 | 0.290 | 9 | T13 | 0.463 | 38 | T12 | 0.375 | 9 |
| 8. | R18 | 0.258 | 8 | T28 | 0.463 | 38 | T18 | 0.375 | 9 |
| 9. | R10 | 0.194 | 6 | T02 | 0.427 | 35 | T28 | 0.375 | 9 |
| 10. | R09 | 0.161 | 5 | T03 | 0.427 | 35 | T03 | 0.333 | 8 |
| | Min: 0.032 M: 0.197<br>Max: 1 SD: 0.208 | | | Min: 0.061 M: 0.323<br>Max: 0.841 SD: 0.213 | | | Min: 0.042 M: 0.269<br>Max: 0.542 SD: 0.113 | | |

| Rank | Row centrality resource/task | | |
|---|---|---|---|
| | Task | Result | UR (R) |
| 1. | T30 | 0.538 | 14 |
| 2. | T01 | 0.423 | 11 |
| 3. | T07 | 0.346 | 9 |
| 4. | T02 | 0.269 | 7 |
| 5. | T05 | 0.269 | 7 |
| 6. | T06 | 0.269 | 7 |
| 7. | T14 | 0.269 | 7 |
| 8. | T03 | 0.231 | 6 |
| 9. | T21 | 0.231 | 6 |
| 10. | T23 | 0.231 | 6 |
| | Min: 0.077 M: 0.197<br>Max: 0.538 SD: 0.100 | | |

Notes: NR: non-scaled result; Min: minimum value; Max: maximum value; M: mean; SD: standard deviation; (A) – actor; (K) – knowledge; (R) – resource; (T) – task.

*Source*: own elaboration.

The row centrality of the actor towards knowledge shows that as many as 73 people out of 82 (89%) use K18 knowledge. The further 90% of tasks apply K18 knowledge. On the other hand, for 90% of people in the organization resources R09, R05 and R18 are of key importance. Also the R05 resource is used in accomplishing all tasks. As far as task performance is concerned, 84% of employees perform task T25, 76% – task T14, approximately 60% - tasks T07 and T21. In performing task T14, knowledge is used in 54%, in task T01 – in 46% and in T09 – in 42%. The application of resources to perform tasks is on a much lower level, here T30 task uses 53% of available resources, while T01 – 42%.

The least important or the least used kinds of knowledge are K24 (18%), K16 (11%) and K13 (6%). On the other hand, such knowledge or skills may turn out to be specialist, since only a few people can apply them in their work. K17, K16, K08, K24, K22, K15, K07 are used only in a few tasks, or, to put it differently such knowledge is of key importance only in a few tasks. The least used resources are R25, R26 and R08, which are vital only for four tasks.

The tasks based on knowledge and resources without which it would be impossible to perform them differ in their significance in the analyzed organization. Tasks T10, T06 and

T27 are performed by the fewest employees. It is worth comparing which knowledge and resources are of key importance for particular tasks. Only 4% of knowledge is used in task T31, compared to 12% in tasks T25, T22, T20 and T15. In case of resources, the importance of tasks changes. To perform task T30 54% of resources are used, whereas for tasks T25, T19 and T15 – only 8%. Neither knowledge nor resources are fully utilized to perform tasks, less than half of identified knowledge and resources were assigned to tasks. This is confirmed by the density of networks KT and RT, which cover respectively 27% and 20% of all possible relations.

The research uses two-mode matrices of relations (AK, AR, AT, KT and RT). Only three of them (AK, AR, AT) were correlated using QAP having transformed a two-mode network into a single-mode one (AA) in which actors share knowledge (AA shared knowledge), resources (AA shared resources) and tasks (AA shared tasks). The results are presented in *Table 5* below:

Table 5. QAP correlation

| | | Average | SD | Min | Max | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | 1 | 2 | 3 |
| 1 | shared- knowledge | 0.0015 | 0.0979 | -0.3166 | 0.3657 | 1.000 | 0.616 | 0.678 |
| 2 | shared-resource | 0.0021 | 0.0912 | -0.3278 | 0.3192 | 0.616 | 1.000 | 0.622 |
| 3 | shared-task | 0.0014 | 0.0931 | -0.3334 | 0.3440 | 0.678 | 0.622 | 1.000 |

Legend: SD: standard deviation; Min: minimum value; Max: maximum value; QAP p-values 0.0002.
*Source*: own elaboration.

QAP calculates Pearson's correlation for given square matrices of the same size. The procedure is generally used for examining the relations between networks. One network is often observed while the other serves as a model or an expected network. This algorithm has two stages. In the first stage we calculate Pearson's correlation coefficient between corresponding cells of two matrices. In the second stage, we randomly permute lines and columns of one matrix and calculate correlations and other measures. The second stage is performed hundreds of time (in our case we use the default value of 5000) in order to calculate the proportion of time when the random measurement is higher or equal to the observed measurement calculated in the first stage. A low proportion (<0,05) indicates a strong relationship between matrices, and its random occurrence is very unlikely. Such procedure is repeated for each pair of matrices. In the analysis we used a default random value (16825) which activates random permutations. The results in *Table 5* indicate that the networks of knowledge, resources and tasks are strongly correlated with each other, which justifies their analysis in the way conducted in our research. The formulated hypotheses were confirmed in the high level of correlation. However, this is only the confirmation of the existing dependencies, not the causality between them or the influence of one network on another. In order to determine this we need to use another tool, namely MRQAP (Multiple Regression Quadratic Assignment Procedure).

## Conclusion

This article presents mostly the results of the networks of actors (A), knowledge (K), resources (R) and tasks (T) which occupy the first ten places in those networks calculated out of particular measures used in the analysis. Thus it indicates which actors, knowledge, resources and tasks have the biggest number of direct indications (ties) and their role seems to be prominent in the whole network (organization).

The actual workload (that is knowledge, resources and tasks), the knowledge actual workload alone and the resource actual workload indicate that the first ten people are workload with the above-mentioned areas on the 40% – 60% level, and standard deviation reaches the level of 0.135. There is a large disproportion between the mean value for the whole population, which was 23%, which indicates a relatively low workload, knowledge and resource workload placed on the employees. It is difficult to point out, however, whether this is a relatively low or high level, since there are no references to similar research available.

The top ten actors are staff who are most burdened with knowledge, resources and tasks. While the knowledge-burden indicator is generally positive, as it points at actors best equipped in knowledge and skills (these are the people who use most of these resources in their work), the task-burden indicator may point at people who are overloaded with work. Excessive load resulting from too many tasks performed lowers the staff productivity in the long term, making them less productive. Also resource-burden indicator has positive connotations, since it means that the staff use the resources available in the organization. It is the role of the management to optimally adjust workers to tasks and resources on the basis of the knowledge and skills they possess, while limiting the risk of overwork or ineffective use of resources.

The row centralities of actors (A) due to the knowledge and resources they use and the tasks they perform, demonstrate that on average, employees use 44% of the knowledge defined in the organization, 48% of the resources and perform 32% of the tasks in the analyzed organization. The maximum result is 98%, and it refers to the fact that A55 uses nearly all kinds of knowledge required in business processes, A79 uses 100% of resources and A06 performs 68% of the tasks in the organization's business processes. There are also actors who do not use any knowledge, resources or tasks (in the sense that their replies were given the value of 0 on a 5-point scale, which means such relations were not strong). On the other hand, average prominences for knowledge (K), resources (R) and tasks (T) are on a relatively low level. The average value for knowledge applied in performing tasks is 27%, it is slightly better utilized by actors (44%). The average values of using resources by actors are 48% and in tasks – 20%. The average centrality of tasks performed by actors was 32%, and as share in knowledge – 27%, and in resources – 20%.

The above results concerning the prominence and the effectiveness of using resources and performing tasks in the organization indicate some areas for improvement which should be taken care of by the management. First of all, the level of workload placed on employees needs to be diagnosed to check if it is on the optimal level. The identification of prominent network nodes is related to the risk of losing work efficiency and used resources in high fluctuation or absence of organizational experts.

The knowledge of which nodes are prominent is particular relation networks brings a number of consequences for an organization. Firstly, it indicates actors who can take the role of leaders in an organization due to their expert knowledge, to whom staff usually go if they need assistance. It indicates the workers who use the most resources, perform the biggest number of tasks, as potential coaches, trainers for the newly-employed staff. Central actors also possess unique knowledge for decision-makers as to what knowledge, skills, performed tasks are of key importance for the organization. This will allow to identify the risk related to staff mobility or access to resources in the event of losing them.

This research also enables us to identify the key knowledge, skills and resources used in tasks. Determining these three types of nodes was possible thanks to specified basic business processes, which were not presented here due to the different topic of the article. Nevertheless, focusing on key knowledge, resources and tasks allows us to characterize business processes taking into account their relation networks existing between these three types of nodes. The network presentation of the business process elements allows managers to identify the interactions, the inter-relationship between the nodes and within a particular business process. It is a much broader and more interactive perspective than when using traditional block systems, allowing us to identify clusters, cliques, emerging nodes, intermediary nodes and many other network phenomena.

The analysis of the interrelationship between ties or the influence of particular network nodes on one another offers a different perspective – a network perspective, which allows us to visualize the interdependencies between network elements, something which is not available in traditional statistical analysis, where observations are statistically independent. This cannot be stated when we formulate data in form of a matrix, therefore it was justified to use the QAP method, which deals well with the structural problem of auto-correlation in data. The application of QAP allowed us to correlate three networks: knowledge, resources and tasks. The results pointed at high dependence between these networks, thus confirming the research hypotheses. As far as the assumptions of the actor-network theory and the resource approach are concerned, with their perception of an organization through the prism of heterogeneous actors or resources, the analysis of selected networks indicated, to some minor extent, the complexity of an organization from the perspective of the network of relations and ties.

This analysis does not cover all configurations of particular network nodes, on the basis of which a more detailed analysis is possible. It is necessary to conduct wider research to formulate unambiguous conclusions. The article pointed at the measures, on the basis of which we can determine prominent network nodes that may affect the way other nodes function. This influence is determined by direct relations received by a given node (the number of incoming and outgoing indications). The role of such nodes in the network may assume various forms, from activating to blocking the flow of information, knowledge, resources or tasks. It is therefore necessary to conduct a more detailed analysis of particular nodes and their role in a given network.

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