How Do Social Networks Affect Organizational Knowledge Utilization?

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Abstract

In this paper we focus on the question how interpersonal network structures affect the degree of organization wide knowledge utilization. Coordinating the balance between knowledge utilization and knowledge generation is important for organizations (cf. March, 1991). Organizational structures that coordinate this balance can be characterized by people (knowledge carriers), resources (knowledge), and tasks (knowledge users and producers) and the set of relationships linking them (Carley & Krackhardt, 1999). As we define knowledge utilization as the extend to which tasks transfer useful or required knowledge to subsequent tasks, we can measure knowledge utilization in terms of these relationships. Especially, task assignment (relations between tasks and people) plays an important role in this measure of knowledge utilization. In this paper we empirically study the effect of different social network measures (relationships among people) on task assignment. With the empirical parameters we find we show through simulations how network characteristics affect the degree of knowledge utilization within the organization as a whole.

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Key Words: Knowledge utilization, explorative and exploitative learning, network structure.

Support: Generous support for this project was provided by CASOS. To work on this project the first author gratefully received financial support from the Erasmus University Rotterdam, dept. Of Organization and Marketing, under supervision of Prof. Philip Hans Franses.

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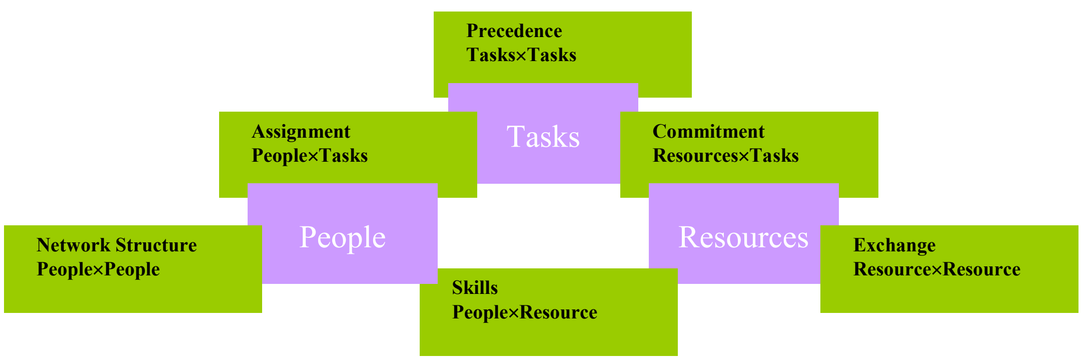
In this paper we focus on the question how interpersonal network structures affect the degree of organization wide knowledge utilization. Coordinating the balance between knowledge utilization and knowledge generation is important for organizations (cf. March, 1991). Organizational structures that coordinate this balance can be characterized by people (knowledge carriers), resources (knowledge), and tasks (knowledge users and producers) and the set of relationships linking them (Carley & Krackhardt, 1999). As we define knowledge utilization as the extend to which tasks transfer useful or required knowledge to subsequent tasks, we can measure knowledge utilization in terms of these relationships. Especially, task assignment (relations between tasks and people) plays an important role in this measure of knowledge utilization. In this paper we empirically study the effect of different social network measures (relationships among people) on task assignment. With the empirical parameters we find we show through simulations how network characteristics affect the degree of knowledge utilization within the organization as a whole.

First, we will discuss knowledge utilization as a PCANSX based measure of intra-organizational dependencies. Explicating the dependencies on which knowledge utilization depends provides a theoretical basis for the study of knowledge utilization management, i.e. coordination between knowledge utilization and knowledge generation. Second, we discuss the relationship between knowledge utilization and interpersonal network structures. Especially, we stress the effect of network structure on task-assignment and estimate the size of this effect with empirical data. Third, we discuss the link between network level characteristics and knowledge utilization and explore these effects with simulations based on earlier estimated empirical relations.

PCANSX: Organizational Dependencies and Knowledge Utilization

We use the PCANSX model [Carley & Krackhardt, 1999] to identify intra-organizational dependencies that need to be coordinated to achieve specific levels of knowledge utilization. The PCANSX model represents 6 types of organizational dependencies as a set of matrices that reflect the dependencies between people, resources, and tasks. These 6 matrices are: **p**recedence (Task x Task), **c**ommitment (Resources x Tasks), **a**ssignments (People x Tasks), **n**etworks (People x People), **s**kills (People x Resources), and e**x**changeability of substitutes (Resources x Resources) (see figure 1).



Here it is important to mention that each of these generic matrices can be further specified in terms of descriptive ('reality' based) matrices and normative matrices ('normative' based). Below we indicate normative matrices with the superscript *.

The degree of knowledge utilization depents on whether knowledge that was acquired earlier can be reused. For example, the execution of a task ideally would require an individual bearing the knowledge on how to accomplish that task. However, an individual assigned to that task might have no or partial knolwedge on the execution of this task. In this case there would be no or only partial knowledge utilization. The degree of knowledge utilization thus is a function of the dependency of tasks on the assignment of individuals with appropiate knowledge.

The Omega Measure of Knowledge Utilization

To determine the level of knowledge utilization in an organization we have to determine to what degree tasks reuse knowledge. In the framework of dependencies this requires that we establish information on a number of dependency matrices.

First: the assignment matrix reflects what tasks an individual is assigned to, hence these matrices reflect that some type of knowledge (the knowledge of the specific individual) is assigned to a task. We refer to this dependency matrix as *A*.

Second: whether an individual that applies knowledge also reuses knowledge in that task is dependent on the specific knowledge resources required to perform the tasks. This information is reflected in C^*.

Third: whether an individual's knowledge is reused on a task is dependent on the precedence of tasks. Only, knowledge that has been used in prior tasks is reused. The temporal sequence of tasks is reflected in matrix *P*.

Fourth: we should consider that knowledge can degenerate if it is not sufficiently updated. The question is whether there is knowledge reuse, when that knowledge has been idle for a longer period. The answer (of course) depends on the type of knowledge that is being considered. The period before degeneration is reflected in *q*.

Fifth: Since, we want to determine an organizational level of knowledge utilization we need to aggregate over individuals. As not everybody may reuse relatively the same amounts of knowledge at one point in time, we should consider a specific period over which we evaluate knowledge utilization. This period we call the utilization base and is denoted by δ.

In developing our measure we make three pivotal assumptions. The first is that the matrices we are considering are dichotomous. So, we only consider the information on whether an event did or did not happen. For example, we only consider the information that task *t* did proceed task *k*, and not the time span between the two tasks. Also, we only look at whether an individual was assigned to a certain task, not for how long. Obviously, we can relax these assumptions later.

The second assumption is that knowledge is transferred between tasks through individuals. Thus only when individual *A* is assigned to task *t* as well as task *k* is it possible that knowledge that was used and/or produced in task *t* is reused in task *k*. This assumption neglects, for example, the role of information databases and social networks, that allow knowledge of non-assigned individuals to be reused on a task. As we discuss later this assumption is easily relaxed.

The third assumption is that the matrix C^* has a dual interpretation. On the one hand it is a normative indication of knowledge that is required to perform some task. However, it also indicates what type of knowledge is enhanced or developed in the execution of tasks. In that sense we assume that individuals inherit some of the knowledge resources that are normatively associated with a task. To see the limits of this assumption consider the following example.

> The task we consider is riding a bike. The C^* associated with this task includes on the resource dimension a bike, basic bike riding skills and for example knowledge of traffic rules. Could our assumption three possibly hold? It all depends on the resources we look at. With regard to the resource "bike" it doesn't. Requiring a bike does not produce a bike. However, given the presence of a bike executing the skill of bike riding does produce the skill of bike riding, even if the eventual skill was not present. With regard to the traffic rules the assumption is less clear. On the one hand does riding a bike, not guarantee the production of knowledge of traffic rules. When you ride your bike in the country side you probably won't learn much detail about traffic rules. After a while you probably have experienced that you should drive on either the left or right side of the road (dependent on the country you are at). In areas with larger population densities, you probably learn more rules and you learn them faster.

Now, let us present the formal measure of knowledge utilization and subsequently give the rational behind it.

$$\Omega\ (q,\delta) = \frac{1((P^{'} \bullet AA^{'})C^{*})_{q} \bullet C_{\delta}^{*})\ 1}{1(C_{\delta}^{*})\ 1} \qquad \text{Eq. 1}$$

The minimal condition for knowledge to be reused is that an individual is at least assigned to two subsequent tasks that require similar knowledge. When we multiply matrix *A* with it's transpose *A'* we get a task by task matrix that reflects whether tasks share individuals. To get an temporal ordering in this *AA'* matrix we multiply it element wise with *P'*. This is the transpose of the precedence matrix, hence the product reflects the subset of *AA'* that received knowledge from prior tasks. The question is what knowledge was transferred and whether this knowledge was useful. Therefore we first multiply $P' \bullet AA'$ with C^{*}. This matrix reflects what knowledge that was required and hence developed or enhanced during the execution of tasks. Finally, an element wise comparison between the transferred knowledge and the knowledge a task requires, determines whether tasks contribute to the exploitation or exploration of knowledge.

Interpersonal Networks and Coordination of Task Assignments

The central question in this paper is: what are the effects of network structures on knowledge utilization. Now, there are different ways to link omega with network structures. For example, we could enhance omega into

$$\Omega_{N}(q,\delta) = \frac{1((P^{'} \bullet ANA^{'})C^{*})_{q} \bullet C_{\delta}^{*})\ 1}{1(C_{\delta}^{*})\ 1} \qquad \text{Eq. 2}$$

This omega measure indicates the indirect transfer of knowledge between tasks when *N* is the matrix that contains information transfer relationships. Of course, many variations on this measure are possible, by taking all kinds of linear transformations of *N*. However, here we take a different approach by focussing on how *N* affects *A*, i.e. we look how network structure affects task-assignment. In the paper we explore many models that reflect effects of interpersonal network structures on task-assignment. In this abstract we only discuss the model that has greatest explanatory power.

The Task Assignment Process

We model the task assignment process as follows. As the need to execute a task becomes apparent a unobserved coordination mechanism selects a task-leader. This task-leader is responsible for attracting people (task members) to perform the task. We propose that the social structural context affects to a great extend the selection a task leader makes.

Using empirical data from a large European consulting firm we estimate a theoretically specified task assignment (logit) model. This model includes 3 measures on the social structural context (i.e. network structure) and 2 measures on the degree of relative similarity between individuals in the social system. Here, we summarize our findings:

1. Information requests from a task leader to a potential task member has a **positive** effect on the probability of assignment of that potential task member.
2. Information requests from a potential task member to a task leader has a **no** effect on the probability of assignment of that potential task member.
3. The degree to which a task leader constraints (see Burt, 1992) a potential team member has a **positive** effect on the probability of assignment of that potential task member.
4. Relative number of mutual previous tasks a task leader and potential task member share has **no** significant effect on the probability of assignment of that potential task member.
5. Relative similar knowledge (cf. Carley, 1991) between a task leader and a potential task member has a **negative** effect on the probability of assignment of that potential task member .

Finding 1 and 5 suggest that task leaders in this context search for task members that can complement their knowledge. They do this in all possible ways, through their direct network contacts, but apparently also in other ways based on relative dissimilarities. These other ways could be roaming indirect network contacts, utilizing other types of direct relationships, or for example using databases. From interviews held within the company the former two were perceived to occur more frequent.

Network Level Characteristics and the Degree of Knowledge Utilization

Given this model of the task assignment process, we can now study how network level characteristics of a network could affect omega, i.e. knowledge utilization. Based on suggestions from the literature on explorative and exploitative learning (e.g. March & Levinthal, 1993) and literature on loose and tight coupling (e.g. Weick 1979) we look at 6 different network level characteristics.

1. Common deferent (Krackhardt, 1994), which is associated with an organization's potential for internal conflicts.
2. Sparseness (Krackhardt, 1994), curvilinear effect on the effectiveness of an organization.
3. Hierarchy (Krackhardt, 1994), which indicates to what degree informal organizations are dominated by status.
4. Reachability (Krackhardt, 1994), is related with the ease with which organizations can deal with and implement change.
5. Constraint (Burt, 1992) measures the degree to which individuals in an organization on average lack the opportunity to broker others within that organization.

First, we find that hierarchy negatively affects omega. Secondly, the results show that constraint has a positive effect on omega. Despite the fact that task assignment process incorporates a positive effect of relational constraint the latter is not a spurious finding. Remember that we look at the effect of structure on knowledge utilization. The task assignment process intrinsically says nothing about knowledge utilization, it only transfers the effect of structure to utilization.

The question to ask now is: "how do hierarchy and constraint affect our model of the task-assignment process such that we can explain these results". Much hierarchy suggest that there are a few knowledge "champions" within the organization. Many individuals request information from those champions, while those individuals won't ask each other information. Those "champions" are more likely to be assigned to tasks than others. Hence, the knowledge champions will serve on many different tasks, which reduces knowledge utilization.

High constraint implies that there are dense groups within the organization. As those within these groups constrain each other it is most likely that they will be co-assigned to similar tasks. Now if we assume that task leaders are assigned to similar tasks, we see that knowledge utilization becomes more likely than knowledge development.

References

[Burt, 1992] Burt, R.S., *Structural Holes, The Social Structure of Competition*. Cambridge, Massachusetts: Harvard University Press.

[Carley, 1991] Carley, K., 1991. "A Theory of Group Stability", *American Sociological Review*, 5-6, p.331—354.

[Carley & Krackhardt, 1999] Carley, K. M. & D. Krackhardt, 1999, "A Typology for C^2 Measures." *In Proceedings of the 1999 International Symposium on Command and Control Research and Technology*. June, Newport,RI.

[Krackhardt, 1994] Krackhardt, 1994. "Graph Theoretical Dimensions of Informal Organizations". *In Computational Organization Theory.* Eds. K.M. Carley & M.J. Prietula. Lawrence Erlbaum Ass.: Hillsdale.

[Levinthal & March, 1993], Levinthal, D.A. & J.S. March, 1993. "The Myopia of Learning", *Strategic Management Journal* , 14, p.95—112.

[March, 1991] March, J., 1991. "Exploration and Exploitation in Organizational Learning", *Organization Science*, 2, p.71—87.