

On And Off The Beaten Path: How Individuals Broker Knowledge Through Formal And Informal Networks

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On and Off the Beaten Path: How Individuals Broker Knowledge through Formal and Informal Networks

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Abstract

Although informal networks are often emphasized as facilitating knowledge transfer, we use network data obtained from a multi-unit high-tech firm to show that the formal network also significantly contributes to inter-unit knowledge transfer. Individuals centrally placed in a network are, in addition, more involved in knowledge transfer, especially, the evidence suggests, in the case of the formal network. Focusing on the brokerage roles that individual fulfill, we find that knowledge transfer between units is more likely to occur through externally oriented brokers than internally oriented brokers in the formal network, but not in the informal network. Overall, the results show that there is more than one path to transfer knowledge.

On and Off the Beaten Path: How Individuals Broker Knowledge through Formal and Informal Networks¹

1 Introduction

The current market circumstances for firms are characterized by increasing competitiveness. As organizations shift their efforts more towards innovation, the value of knowledge is increasing. Grant (1996) argues that under competitive circumstances knowledge forms the most valuable asset of an organization. Knowledge may, however, be spread throughout the organization and not be available where it might best be put to use. Transfer of knowledge within the organization to gain competitive advantage has thus gained considerable attention in the literature (Grant, 1996; Teece et al., 1997; Moorman and Miner, 1998; Hansen, 1999). Scholars have emphasized that effective transfer of knowledge between employees within an organization indeed increases the creativity and innovativeness of that same organization (Tushman, 1977; Ghoshal and Bartlett, 1988; Amabile et al., 1996; Moorman and Miner, 1998; Kanter, 1983; Hargadon, 1998; Perry-Smith and Shalley, 2003). Knowledge transfer, as defined here, is the movement of useful know-how or information between individuals (Appleyard, 1996, p.3; cf. Cummings, 2004). This may include task information and feedback regarding a product or work procedure. The transfer across boundaries within an organization, however, is not self-evident.

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While the literature on network has been very helpful in highlighting the role of informal interpersonal ties as a basis for knowledge transfer (e.g. Granovetter, 1973; Hansen, 1999), the *actual* process through which organizational knowledge is transferred has been relatively under-explored in the literature (Schulz, 2003; Reagans and McEvily, 2003). For instance, besides a formal network, there may be an informal network within a firm; how do these affect knowledge transfer? At a more micro-level, what are the specific network mechanisms that affect knowledge transfer between individuals? How does the centrality of an individual play a role, within a formal and within an informal network? Do the different communication roles that individuals may take up affect knowledge transfer, and are these affects similar for formal and informal networks? To investigate these and other questions, this paper studies the knowledge transfer process within a multi-unit company. We focus on the formal as well as the informal structures through which knowledge is transferred within an organization. In addition, we distinguish different roles – internally and externally oriented – that individuals may have in networks and analyze which ones of these are involved in the knowledge transfer (innovation) networks.

2 Knowledge transfer in multi-unit companies

Knowledge transfer within multi-unit companies tends to be based on the grouping by product market combinations. This structure with few hierarchical levels and a limited functional specialization of management offers divisions a relatively high level of autonomy in their actions. Although a unit (divisional) structure offers benefits such as specialization at the level of divisions and focus, at the same time it limits the inter-unit knowledge utilization and transfer.

Among the reasons are managerial myopia and incentive structures that are not geared to long-term goals.

Schumpeter (1934) noticed the importance of combining and re-combining existing knowledge within a company as a source of innovation. To be able to use existing knowledge, offering organization a sustainable competitive advantage, they need to have sufficient insight in the knowledge actually available and the actual processes of knowledge transfer between its divisions (Kogut and Zander, 1992). Effective intra-firm transfer of knowledge is heavily dependent upon the existing stock of knowledge (Cohen and Levinthal, 1990) as well as the degree to which the appropriate structure for transferring knowledge is developed within a company. The structure of the communication patterns within organizations that facilitate the knowledge transfer to take place is believed to be of considerable importance to direct the transfer of knowledge in an effective way (Tsai, 2001; Hansen, 2002). However, combining and recombining knowledge is by no means obvious, especially due to the social dimensions of communication patterns (Szulanski, 1996, 2003). Thus, the dynamics resulting from this social dimension of knowledge transferring within organizations are still under-explored (Tsai, 2001).

For instance, finding the person that has the knowledge that one is looking for is often difficult within a multi-unit organization (Szulanski, 2003; Hansen, 1999; Hansen and Haas, 2001) The relative autonomy of divisions within a multi-unit organization structure creates a lack of awareness of each other's activities on an individual and a unit level, possibly limiting knowledge-transfer. Also, within a unit that specializes in a certain knowledge field, knowledge tends to be of the tacit kind. The advantage of the tacit nature of knowledge is that imitation by competitors is relatively difficult (Nonaka and Tacheuci, 1995), but at the same time the tacitness

of the knowledge requires a high degree of personal contact in order to be effectively dispersed throughout the company (Teece, 1998; Hansen, 1999).

Furthermore, as an individual's absorptive capacity being based on earlier experiences and the social, professional and hierarchical context within an organization (Cohen and Levinthal, 1990), this capacity will be limited or biased due to the specialized nature of divisions. Yet there are of course good reasons for specialization, because it stimulates efficiency, thereby also facilitating incremental innovation. This suggests that the formal network of an organization may play a hitherto somewhat neglected role in intra-organizational knowledge transfer. Therefore, a starting point of this study is that in addition to the informal structure, it is important to incorporate the formal structure for knowledge-transfer as well.

3. Formal and Informal Communication Structures

Surprisingly enough, research on the direct relationship between the network structure and the degree of knowledge-transfer in an organization is rather limited as the literature thus far has clustered around two indirect approaches. The first approach, as Reagans and McEvily (2003, p.241) pointedly observe, is one in which knowledge-transfer is often simply assumed to be the causal mechanism linking network structure to performance (cf. Reagans and Zuckerman 2001; Tsai 2001). However, the processes at work and the nature of the relations at play is left unexplored. The second approach that is common in the network literature, attempts to look at the actual network structure by studying tie strength (Hansen, 1999). Tie strength refers to the nature of a tie between two individuals (nodes in a network). The relationship between tie strength and knowledge-transfer is not a perfect measure for the relationship between network structure and

knowledge-transfer due to the difficulties in making a distinction between the influence of network cohesion and the influence of tie strength, as argued by Reagans and McEvily (2003). Their attempt to tackle the problem by approaching network structure as a combination of social cohesion and network range can be regarded as a useful contribution in the explanation of the relation between knowledge-transfer and network structure.

Nevertheless, this explanation, although a significant step forward, still underestimates the social dimension essential to communication networks (Emirbayer, 1997). Information that can be obtained on the individual actor level about participation in the knowledge transfer process is under-utilized in the literature. By looking at the way in which individuals act within a network structure – their roles – the influence of network structures on the degree of knowledge-transfer can be studied more closely. First, however, we will need to discuss the context for individual role behavior in more detail in terms of organizational communication networks.

According to Monge and Contractor (2002, p.440) communication networks are “the patterns of contact between communication partners that are created by transmitting and exchanging messages through time and space”. The content of the messages can be used to distinguish between the different communications networks within an organization. A broadly accepted distinction when discussing intra-organizational communication structures is the distinction between the formal and the informal network (Allen, 1977; Mehra et al., 2001, Madhavan en Grover, 1998). The formal network is the intra-firm communication structure that is derived from the formal relations as formulated and standardized by corporate management. Communication that flows through the formal network is dictated by the planned structure established for the organization (cf. Simon 1976, p.147). This planned structure includes formal

procedures, schemes and rules deemed important mostly for the execution of daily operations (Adler and Borys, 1996). Although altering formal communication structures is more easily accomplished than changing informal ones because they are more tangible, intentionally changing formal communication structures often will not yield intended benefits (Krackhardt and Hanson 1993). This is mainly due to neglecting the influence of informal networks, cutting through the formal structures and thereby operating as some sort of “communication safety net” (Cross et al. 2002). When the formal network takes too long, or when the relations required to get certain things done have not been formally established, the informal network (“the grapevine”) comes into play. Already in the early sixties Blau and Scott (1962) observed that it is impossible to understand processes within the formal organization without investigating the influence of the informal relations within that same organization.

The informal network refers to the "interpersonal relationships in the organization that affect decisions within it, but either are omitted from the formal scheme or are not consistent with that scheme” (Simon 1976: p.148). The informal network provides insight into the general way ‘things are getting done’ within the organization, often bypassing and sometimes undermining the formal communication structure. The benefits of the informal network are that information is transferred relatively fast (Cross et al., 2002). Informal channels provide insight into the *de facto* authority within the organization (Krackhardt and Hanson 1993). Besides this, the informal network provides the opportunity for information and knowledge to flow in both vertical and horizontal directions, which contributes positively to the overall flexibility of the organization (Cross et al. 2002). The main drawback is however the lack of transparency (Cross et al. 2002) and the risk of the occurrence of old boys network that might create a negative political climate

within the organization. Informal networks in particular, are believed to drive knowledge-transfer (Cross et al. 2002; Stevenson and Gilly 1991; Jablin and Putnam 2001; Madhavan and Grover 1998). Compared to the formal network, it offers a higher degree of flexibility. The relative ease of knowledge-transfer offers the possibility to adapt quickly to changing market circumstances and to tap into unconventional/new knowledge sources. On the other hand, informal networks lack the transparency that formal networks offer: divisions are there for a reason. This transparency reduces uncertainty regarding the location of expertise and also regarding obtaining the resources for intra-firm knowledge transfer. Thus, no type of network can be said to have an inherent superiority when it comes to knowledge transfer.

In short, we argue that there are two parallel yet related routes by which to transfer knowledge. One route is through informal contacts between employees of different divisions, the other route is through formalized inter-unit contacts. Both these networks determine the shape of what we call the ‘innovation network’, a network where knowledge regarding innovation is transferred across intra-firm boundaries. This results in the following hypotheses:

***H1a:* The formal network correlates positively with the innovation network .**

***H1b:* The informal network correlates positively with the innovation network .**

4. Centrality & Network Roles

The previous section argued that both the formal and informal inter-unit communication networks contribute to knowledge transfer. In addition to the hypotheses at the network level, it is

useful to analyze the specifics of the network structures in some more detail, as the presumed contribution of these networks to inter-unit knowledge-transfer will depend on the specific individuals who do the actual knowledge transferring.

Centrality

The relative autonomy of units that comes with a unit structure often results in a situation where independent knowledge-islands may be discerned. Knowledge brokers play an important role in matching these dispersed knowledge sources (Sharon et al., 2000; Cross et al. 2001; Hargadon, 2002). Brokerage is the process in which intermediary actors in networks facilitate transactions between other actors lacking access to or trust in another actor (Marsden 1982, p.202). Such knowledge brokers are central employees that act as a link-pin between two or more employees and make the transfer of knowledge possible (Ibarra and Andrews, 1993). For instance, more frequent and more diverse communication relates positively to inter-unit innovation (Madhavan and Grover, 1998). However, not every actor is equally well placed to fulfill this knowledge broker role as different network positions offer different opportunities for individuals to access a variety of knowledge sources (Burt, 1992; Tsai, 2001). The degree to which actors fulfill such positions within a communication networks is frequently investigated using betweenness centrality as a measure (Wasserman and Faust, 1994). Betweenness centrality indicates an individual's degree of control of the communication within a network (Freeman, 1979). Put differently, *"...betweenness centrality is used as a measure of power or influence because two actors wishing to interact must go to other actors between them, thus these other actors have high betweenness centrality. (Haunschild and Beckman, 1998, p.824)."*

Several other centrality measures have been developed describing the flow of and access to information one individual has compared to others within a network, focusing on the speed of knowledge-transfer (closeness-centrality), of the number of contacts (degree centrality) (cf. Freeman, 1979; Brass and Burkhardt, 1992). However, we argue that it is not so much the speed of knowledge transfer or the mere number of contacts, but rather being involved in the actual knowledge flows that is essential when discussing knowledge transfer (see also Brass and Burkhardt, 1992), and thus betweenness centrality is the most appropriate centrality measure. This leads to the following two hypotheses.

H2a: Individuals in a formal network who are centrally placed contribute positively to the degree of inter-unit knowledge transfer regarding innovation.

H2b: Individuals in an informal network who are centrally placed contribute positively to the degree of inter-unit knowledge transfer regarding innovation.

Network Roles

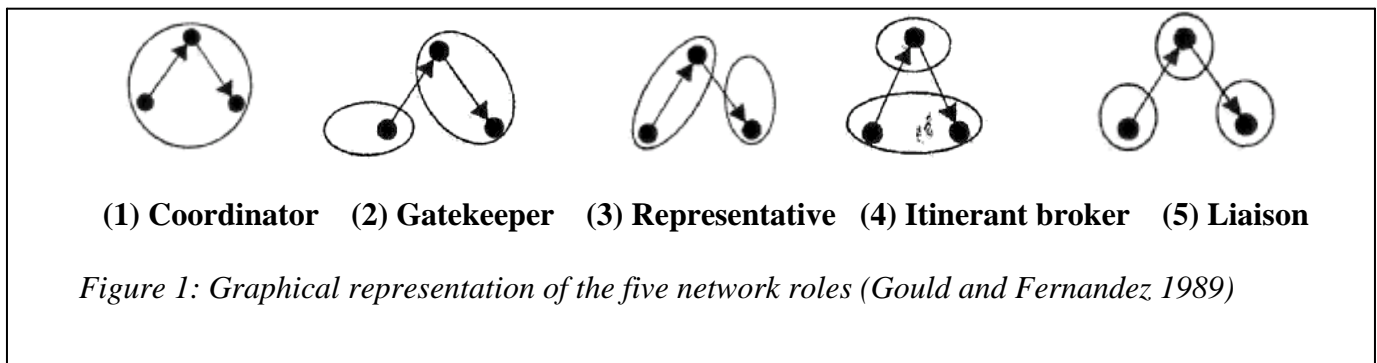
The previous section argued for the importance of an individual's centrality as determinant of knowledge transfer. However, by solely looking at centrality, valuable information about the contribution of individuals and the roles they play in the knowledge transfer process is left out. For example, centrality-based measures treat a tie between two employees of different divisions the same as a tie between two employees of the same division, even though those ties have quite different implications for intra-firm knowledge transfer. More generally, traditional centrality-

based measures neglect information about any exogenously-defined groups in the network, such as organizational divisions. Thus, analyzing the direction of communication between such groups in networks can generate additional insight into the process of knowledge-transfer. This makes it important to take unit membership of the individuals who transfer knowledge into account.

Similarities in individuals' behavior suggest the presence of a network role (Garton et al. 1997). Several authors have categorized network roles by referring to an individuals' membership of a social groups. Kahn et al. (1964) were among the first to underscore the importance of "boundary positions" within an organization, referring to the maintenance of in-depth contacts of an employee with employees from other organizational units, or even outside of the company. Merton (1968) distinguished between the 'local' and the 'cosmopolitan'. Where the local is mainly oriented towards his direct social environment leading to social integration, the cosmopolitan is more interested in the world outside his own community, stimulating social differentiation (Merton, 1968; Taube, 2003). In an organizational setting, Allen (1971) focused on the technology gatekeeper, even though this conceptualization collapses diverse communication patterns together into one single profile (as we will show below). Rogers and Kincaid (1981) distinguish between communication roles in a more fine-grained fashion between bridge, liaison, isolate and cosmopolitan based on the attribution of different subgroups. However, they neglect the direction of communication and the affiliation *between* actors involved in the triadic relation.

A conceptualization of brokerage roles that does take this distinction into account is the one suggested by Gould and Fernandez (1989). In the brokerage relations they distinguish, it is possible for three actors in a triadic relation to all three belong to the same subgroup (i.e.

division), or for just two actors to belong to the same subgroup and the third actor to a different subgroup, or for all actors to each belong to a different subgroup (see Figure 1, in which the top node of the triangle is the broker). The direction of the knowledge-transfer is explicitly taken into account and given that all possible triadic linkages with subgroups are present, it is straightforward to see that this categorization of brokerage roles is exhausting.



The added value of distinguishing these five roles derives from the distinction between knowledge flows *between* groups versus knowledge flows *within* groups (Gould and Fernandez 1989). The two actors among whom knowledge-transfer eventually is taking place and the actual broker who accommodates the knowledge-transfer are in a triadic relationships with each other.

The five network roles that Gould and Fernandez (1989) distinguish are coordinator, gatekeeper, representative, itinerant broker, and liaison (partly cf. Rogers 1976). Organizational units are the circles in Figure 1, and the roles described are of the nodes that connect the other two in each example. When an individual brings two persons from his own divisions in contact with each other he is a *coordinator*. An individual who screens outside his own division and collects knowledge from an actor outside to transfers this to an actor within his own division is a *gatekeeper*. A gatekeeper receives external knowledge. A *representative* transfers knowledge

received from an actor from his own division to an actor in another division, representing his own division to the outside. An *itinerant broker* transfers knowledge between individuals who both belong to the same division, which is not the division of the itinerant broker. Finally, a *liaison* acts in a triadic relationship where none of the actors belongs to the same division; contact between sender and ultimate receiver is only indirectly reached through this intermediating party. It is important to note that an individual can fulfill more than one role at the same time, and that different individuals can fulfill the same role to varying degrees (Gould and Fernandez, 1989; Fernandez and Gould, 1994), even within a single network (formal or informal).

Internal versus external orientation

The earlier discussion of the influence of the formal and informal network on knowledge transfer within an organization pointed to the fact that, to a large extent, the degree to which an employee is capable of fulfilling a central position within a network determines his capacity to be able to contribute significantly to the knowledge-transfer in the organization (Tsai, 2001). The five different brokerage roles emphasize the different settings in which intra-firm knowledge-transfer takes place as this richer conceptualization takes unit membership into account.

These different network roles may have a different impact on the extent knowledge is transferred, in both the formal and informal networks. The number of contacts outside one's own division determines to a large extent the degree to which an individual has the potential to contribute to the innovative capacity of the organization (Perry-Smith and Shalley, 2003). Thus the direction in which the communication is taking place matters. Individuals in certain roles may spread the awareness about existing knowledge sources in an organization outside their own unit.

Such individuals have an external orientation. In contrast, when an individual is focused on knowledge (coming either from inside or outside his own unit) dispersion within his own unit, his behavior is internally oriented. In the literature looking at networks and network roles, this refinement is generally not discussed, even though the distinction between the internal or external orientation of individual employees is not new (e.g. Gupta and Govindarajan, 2000; Schulz, 2003).

The importance of access to knowledge not available in one's own unit, particularly in the earlier phases of the innovation trajectory (Hargadon, 2002), make externally oriented roles more important compared to internally oriented ones in the earlier phases of the innovation process. It is, however, incorrect to conclude that the internally oriented individuals are unimportant for organizational networks. Knowledge needs to be absorbed, developed and possibly transformed before it can be applied within the division, let alone transferred with another division. Before knowledge can be absorbed properly there has to be a proper network structure to guarantee access to this knowledge (Hargadon, 2002).

The five network roles of Fernandez and Gould (1989) can be split into two internally and three externally oriented ones. The coordinator and gatekeeper both represent an internal orientation, as they transfer the knowledge they have to individuals within their own unit. Representatives, itinerant brokers and liaisons are externally orientated as they open up their own knowledge base to individuals from other divisions (even though in the case of the itinerant broker the knowledge the two other actors are both in the same division, yet they have no direct tie, thus needing brokerage to be linked). As argued previously, an individual employee may fulfill several brokerage roles at the same time. It is therefore also possible that an employee

fulfils an internal orientated brokerage role in one network while he may have an externally oriented role in another. A comparison between the different orientations a person may have in different networks – formal compared to informal networks, for instance – may give insight into the overall orientation of that individual.

In short, internally and externally orientated network roles have different functions for a firm and both are needed. However, to stimulate knowledge-transfer *between* units of an organization, the previous discussion suggests that externally oriented roles are likely to be more important. Thus, the following hypotheses will be tested:

H3a: When an employee fulfils an externally oriented network role within the formal network, this will positively influence inter-unit knowledge transfer regarding innovation.

H3b: When an employee fulfils an externally oriented brokerage role within the informal network, this will positively influence inter-unit knowledge transfer regarding innovation.

5. Method

Organizational setting

Recognizing the need of more empirical support for the theoretical findings to underscore the importance of inter-unit communication structures (Hansen and Haas, 2001), this paper draws upon empirical research in a multinational electronics and engineering company headquartered in

a European country. The subsidiary studied, operating since the late 19th century, is in a different European country and employs some 4000 employees. Access to the company was negotiated through the senior innovation manager of the company who operates directly under the supervision of the board of directors. The company is organized according to a unit structure with a high level of autonomy and responsibility for the separate divisions and the divisions are organized according to product-market segmentation. Recently, the company shifted from offering specific products towards offering ‘total solutions’ to its customers. As the company now aims at offering integrated and innovative solutions based on its technical competencies that cross unit boundaries, this makes it highly dependent on the internal knowledge transferring (innovation) networks.

As a consequence of the strategic shift, the company has reorganized its activities according to a number of strategic multidisciplinary themes, one of which is the theme ‘transportation’. According to top management this theme has a high priority but at the same time is being insufficiently explored yet. Therefore this study focuses on four functional divisions that all exploit activities related to the transportation theme as well as two main staff functions related to new business development (the innovation department and the market information department). The unit structure constitutes a natural membership boundary (see Hansen, 1999) and it is therefore that employees, sorted by unit membership, form the object of analysis in this study of inter-unit transfer of knowledge. The selection of these divisions is made based on the input gathered during several interviews with the senior innovation manager and the new business managers in the separate divisions. Through the senior innovation manager the commitment of the unit directors was sought and secured.

Data collection process

To test the formulated hypotheses, data on the social relations within the company was gathered, focusing on the formal and informal networks within the organization as well as the inter-unit innovation network. In order to be able to study the formal and the informal structures in a firm, they need to be defined in comparative terms. We follow Farace, Monge, and Russell (1977) to define social networks – formal and informal – as repetitive patterns of interaction among members of an organization. Data on the individual level for each of these networks is collected using semi-structured interviews with managers and other employees and a network survey. The interviews served a two-fold purpose: first, to become familiar with the organizational setting and thus gain input for the proper design of the network survey and second, to determine the appropriate response group within the company. In social network studies the most pragmatic approach in an organizational setting is believed to be the survey methodology (Borgatti and Cross, 2003; Wasserman and Faust, 1994). To gain a representative view of the different networks given the time frame for this study in combination with the relative complexity of the organization, this study uses snowball methodology as the basis for this survey. Snowball sampling is especially useful doing so when the population is not clear from the beginning (Wasserman and Faust, 1994), which is the case in this particular company because of the ‘total solutions’ shift and the subsequent blurring of unit boundaries. Snowball sampling is based upon several rounds of surveying or interviewing where the first round helps to determine who will be approached as a respondent in the second round and so on. The first round of snowball sampling can be totally at random but it can be also based on specific criteria (Rogers and Kincaid, 1981).

To reduce the risk of 'isolates', i.e. isolated persons within the organization who do possess relevant knowledge to a particular subject, but who are being left out by the study due to the lack of accuracy of random sampling (Rogers and Kincaid, 1981), this study opted for a first round consisting of specifically targeted respondents. The selection of the first round of respondents to fill in the questionnaire was based on the expertise of the innovation management department (one of the two staff departments involved in the study). This department was asked to create an overview of employees who are most active in the field of transportation and who are members of the earlier selected divisions. This resulted in a list of nine employees in four functional divisions. The selection was validated by seeking the judgment of the manager of the market information department (the other staff department involved in the study). The survey was first tested on a small sample of ten respondents whom had been personally informed of the purpose of the study to increase their level of cooperation. The final version of the survey was sent in two rounds. The names mentioned by this first round of respondents formed the input of respondents for the second round. The first round consisted of 9 employees. Together these 9 people named 42 other employees who all formed the second round of targeted respondents. The final overall response rate was 96 percent. This percentage includes the 63% who filled in the whole questionnaire including the matrix and the 33% who indicated in their opinion not to have any relationship with the transportation theme. 4% did not respond to the first mailing and the later three reminder mailings. No further surveys were sent out because the responses of the second round indicated that the vast majority of people related to the transportation theme had been identified and surveyed. The networks analyzed are thus essentially egocentric networks, an approach commonly adopted for the purposes of this kind of research. A different approach, used

for different purposes, would be a sociocentric approach; such an approach allows one to specify the boundaries of the group or population better (Marsden, 1990, 2002). Due to the method of snowball sampling adopted and based on the responses from the survey, we may be sure to have included all (relevant) actors in the network.

The survey was constructed in a digital version that could be distributed by e-mail and every survey form was accompanied by a personalized cover email introducing the project to the respondent, signed by the senior innovation manager to improve response rates. An email survey was chosen to reduce the time needed to complete the questionnaire, thus improving response rates. To further reduce the time needed to fill in the survey, the survey form was constructed in a matrix style, such that names had to be inserted only once in the horizontal column of the survey form by the respondents after which they could automatically be used for all three network questions. We did not opt to fix the number of contacts throughout the survey because the number of employees named partially determines the position of the individual employee in the network (Friedman and Podolny, 1993). However, we did issue a guideline of naming at most six employees to make sure that only the most important contacts per employee were mentioned. To reduce ambiguity regarding the interpretation of the questions by the respondents, the network questions were formulated in the native language.

Variables

As common in network studies, the structure of each of the three networks (formal, informal and innovation) has been explored using one network question for each network (Borgatti and Cross, 2003; Rogers and Kincaid, 1981). The independent variable *formal network* is measured by

asking respondents to indicate the persons with whom they exchange information, knowledge, documents, schemes and other information sources to successfully carry out their daily activities. This approach is derived from the work of Mehra et al. (2001) and Stephenson and Krebs (1993) who use a similar question to gain insight in the manner in which the organizational hierarchy has been practically implemented within the organization. Similar to the way the social interaction network is measured by Krackhardt and Hanson (1993), Ibarra and Andrews (1993), Burt (1992), Mehra et al. (2001), Cross et al. (2002) and Krebs (1999), the independent variable *informal network* has been measured by asking with whom one discusses what is going on within the organization. This way insight is gained in the personal preferences and insights of employees regarding informal communication within the organization. The dependent variable for the first two hypotheses is the *innovation network*. Derived from the work of Cross and Prusak (2002), Stephenson and Krebs (1993) and Krebs (1999) the innovation network has been measured by asking individual respondents with whom they initiate a discussion of new ideas, innovations and improvements regarding products and services their division offered in the field of transportation.

Behind every name on the survey the respondents were asked to indicate the frequency of communication. This form of valued rating was conducted using a five point frequency measure varying from daily to yearly. The information regarding the frequency of communication in the innovation network formed the input for the measure of the frequency of inter-unit communication related to innovation, which is the dependent variable to test hypotheses 3 and 4. The independent variables internally- and externally-oriented roles needed to test hypotheses 3 and 4 were measured based on the five brokerage roles distinguished by Gould and Fernandez (1989). Information regarding these roles is derived from the network structure of the informal

and the formal network. The position of the individual respondent is assessed for both the formal and the informal network. As the orientation of this study is on the internal versus the external orientation, we combine brokerage scores for certain brokerage roles, depending whether the recipient of the tie originating from the broker is in the same division as the broker (i.e. internal brokerage) or in a different division (external brokerage). Specifically, the results of the coordinator and the gatekeeper role are being combined to give an indication of the total *internal* brokerage role. The scores for the itinerant broker, representative and the liaison are combined to give an indication of the total *external* brokerage role per employee. As this study is interested in the *actual* number of inter-unit contacts that are being maintained within the networks, we follow Friedman and Podolny (1993) in using the raw brokerage score instead of the partial brokerage score (Gould and Fernandez, 1989; Fernandez and Gould, 1994).

6. Analysis

To test hypotheses 1, the correlation between the formal and innovation respectively the formal and the innovation network will be measured using the quadratic assignment procedure (QAP) (Hubert and Schulz, 1976, Krackhardt, 1987) with 2500 permutations. From this calculation the correlation coefficient (r-square) and the standardized regression coefficient (beta) can be derived. The r-square gives an indication of the explanatory value of the informal respectively formal network on the innovation network. The interpretation of the derived beta will be used to interpret the individual influence of the independent variables formal network and informal network (see also Kilduff and Krackhardt, 1994). The independent variable with the highest beta-value has the largest influence on the innovation network as dependent variable.

To test hypothesis 2a and 2b the betweenness centrality scores were calculated per employee engaged in the formal respectively informal network using Ucinet 6.0. (Borgatti et al., 2002).² Inter-unit communication per employee is calculated as share of his total communication (%), which is an indicator of the communication profile per employee. The analysis is based on two nominal independent variables ‘central’ versus ‘peripheral’ and the percentage of inter-unit knowledge transfer within the innovation network that makes up the dependant variable. The relationship between betweenness centrality within the formal network respectively the informal network and the degree of inter-unit knowledge-transfer regarding innovation was analyzed using non parametrical Mann-Whitney tests to correct for the absence of a normal distribution in the dependent variable.

To gain insight in the influence of internally versus externally oriented roles on the degree of inter-unit communication concerning innovation, and so coming to an answer on hypotheses 3a and 3b, the brokerage score per employee in the formal and in the informal network will be calculated using Ucinet 6.0. (Borgatti et al., 2002).³ Following Friedman and Podolny (1992) and Gould and Fernandez (1989), we have calculated the raw brokerage scores, instead of the partial brokerage scores. Partial brokerage scores modify the raw brokerage scores by taking into account the existence of alternative paths between source and destination, which is appropriate when there are significant benefits to be expected for individuals of leveraging their position. However, such monopoly power of communication is not likely to be a very significant factor in our setting, given the organization’s explicit goal of promoting inter-unit knowledge transfer, nor does our qualitative data indicate otherwise. We therefore use the more appropriate raw

² In line with Freeman (1979) and Wasserman & Faust (1994) the betweenness centrality, C^b , for person i ,

brokerage scores in our study. This way it is possible to determine for every individual employee the level to which his communication profile corresponds with one of the five roles as determined by Gould and Fernandez (1989). As already outlined above, the five brokerage roles have been split up in internally oriented versus externally oriented and thus the communication profile can be recoded into a nominal variable ‘brokerage orientation’ for the formal respectively informal network. The ratio variable ‘percentage inter-unit communication per employee within the innovation network’ is calculated as the percentage of total communication (weighed by communication intensity) that is devoted to inter-unit communication. This analysis is based on the non-parametrical Mann-Whitney test due to the absence of a normal distribution in the dependent variable.

Using Ucinet (Borgatti et al., 2002) the formal network and the informal network can be graphically displayed as follows (where peripheral nodes of individuals who did not have further contacts have been removed to improve the clarity of the figures):

mediating between persons j and k, is: $C'b(n_i) = \sum g_{jk} (n_i) / g_{jk}$; where $j < k$.

³ The relevant formula is (Gould & Fernandez 1989, p.101): $b_{ioj} = \sum_i \sum_k [b_{io} (ik) / g_{ik}]$; where $i \neq j \neq k$, and $g_{ik} \neq 0$.

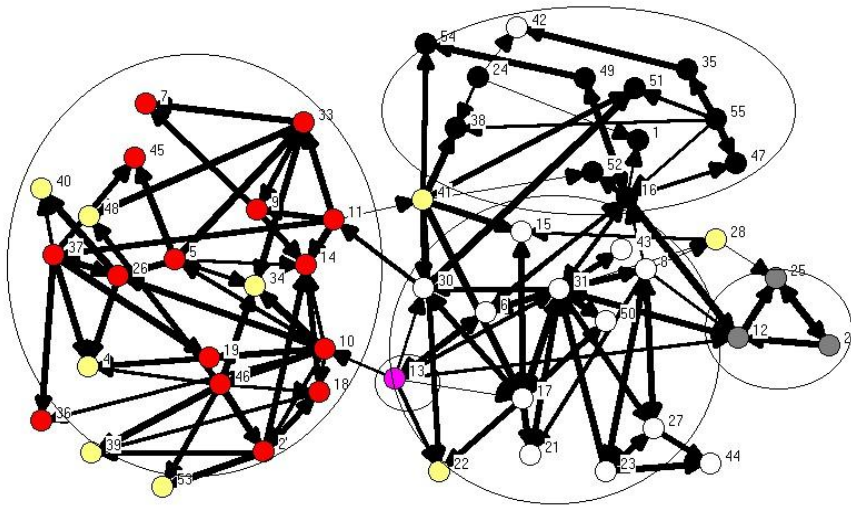


Figure 2: The formal network ($N_{total}=110$, $N_{figure}=52$)

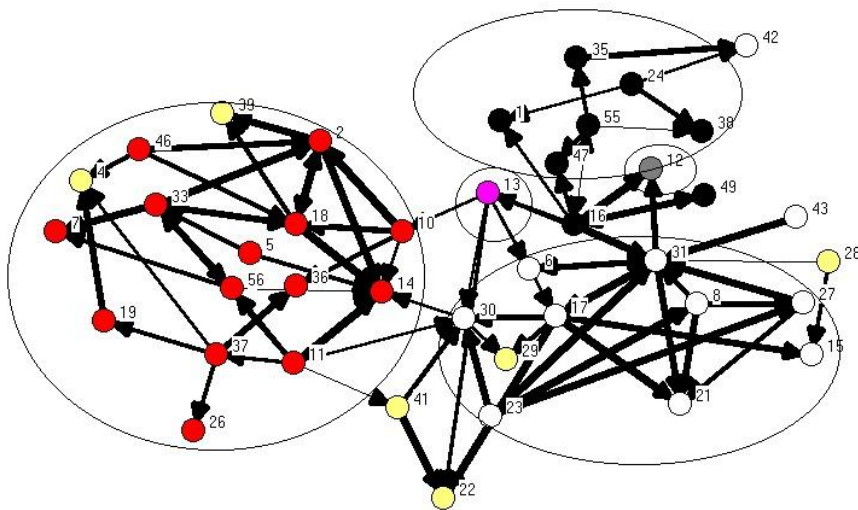


Figure 3: The informal network ($N_{total}=87$, $N_{figure}=41$)

The circles represent different organizational units. As discussed above, we hypothesize that formal and informal networks explain the knowledge transferred within this organization. The

network where new ideas, innovations and improvements regarding products and processes are discussed might be called the ‘innovation network’; it is presented in Figure 4.

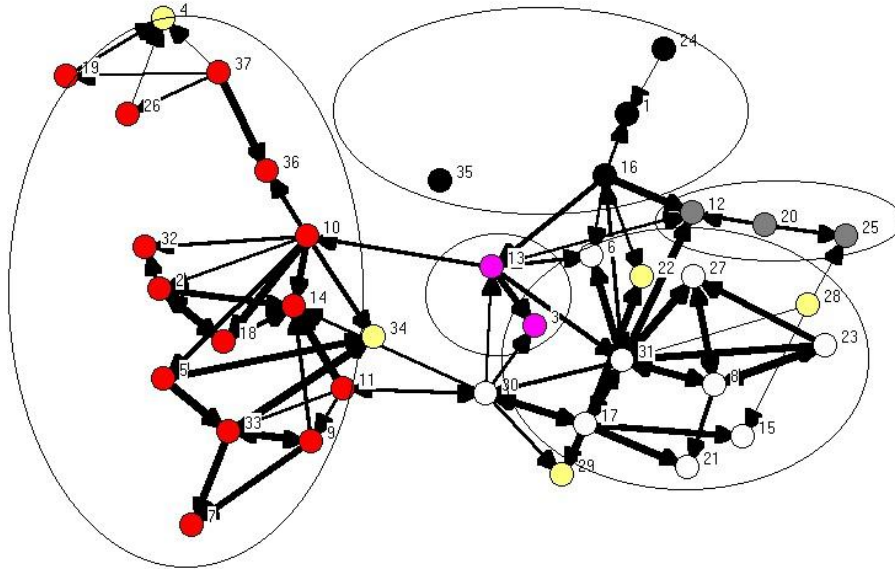


Figure 4: The innovation network ($N_{total}=82$, $N_{figure}=37$)

As is to be expected (e.g. Homans (1951)), the formal and informal networks overlap to a certain extent (QAP correlation 0.529, $p<0.001$), but at the same time the two networks are sufficiently different – in line with findings by, a.o., Fernandez (1991) – to be able to determine their separate effects on knowledge transfer. In addition, even if and to the extent that the formal and the informal network overlap, they do provide separate or alternative avenues for knowledge transfer. The QAP correlation between the formal network and the innovation network is 0.739 ($p<0.001$). The QAP correlation between the informal and the innovation network is 0.649 ($p<0.001$). This shows that both the formal and the informal are correlated with the innovation network, thus lending support for hypotheses 1a and 1b, indicating that there are indeed two, at least partly separate, paths for knowledge transfer.

To ascertain this positive relationship on a more detailed level, a QAP regression analysis was conducted to assess the individual influence of both independent network variables on the dependent variable ‘innovation network’. The R^2 shows that 59 percent ($p < 0.001$) of the variance in the innovation network can be explained by a combination of the formal and the informal network. The regression coefficients show that the beta for the formal network ($\beta = 0.460, p < 0.001$) is larger than the beta of the informal network ($\beta = 0.360, p < 0.001$). First of all, it is important to note that *both* the formal as the informal network have a strong positive influence as predictors of the innovation network, whereas previous research has often emphasized only the role of the informal network. Furthermore, because the size of the beta-score serves as an indicator of the influence of the respective independent variable on the dependent variable innovation network, it seems valid to conclude that the formal network is even a somewhat stronger predictor of the innovation network than the informal network.

To investigate the relation between betweenness centrality in the formal network and the degree of inter-unit knowledge-transfer regarding innovation the Mann Whitney procedure has been used. We used the Mann Whitney test to investigate the relationship between centrality within the formal network and the percentage of inter-unit knowledge transfer regarding innovation. The results show that a high degree of betweenness centrality within the formal network strongly increases the involvement in inter-unit communication (Mann-Whitney $U=265.0, p < 0.001$, effect size⁴ $r=0.717$). In addition, we found a strong relationship (Mann-Whitney $U=245.0, p <$

⁴ Calculated as $r=Z/\sqrt{N}$ (Rosenthal, 1991).

0.001, effect size $r=0.560$) between the level of betweenness centrality in the informal network and the percentage of inter-unit communication regarding innovation. The level to which an individual fulfills a position that is highly central appears to be a useful predictor of the level of involvement in inter-unit communication, thus suggesting the acceptance of hypothesis 2a and 2b. The large effect sizes (Cohen, 1992) underscore the often-found importance of centrality for knowledge transfer. Additionally, the difference between the effect sizes of the formal and informal network suggests that a central position in the formal network might be more important for knowledge transfer than a central position in the informal network.

A limited number of individuals within this organization involved with the theme of 'transportation' bear the brunt of the inter-unit transfer of knowledge. Of the 28 persons (out of 110) that fulfill some sort of brokerage role in the formal network 17 do so as a coordinator, 9 do so as gatekeeper, 19 as representative, 5 as itinerant broker and 9 as liaison. Of the 21 brokers (out of 87) in the informal network, 14 act as coordinator, 5 act as gatekeeper, 12 as representative, 1 as itinerant broker and 5 as liaison. This shows that, as argued in the theoretical section, concrete individuals can and do take on more than one network role at the same time.

	Coordinator		Gatekeeper		Representative		Itinerant broker		Liaison	
	formal	informal	formal	informal	formal	informal	formal	informal	formal	informal
Coordinator	1,000	1,000								
Gatekeeper	0.068	-0.055	1,000	1,000						
Representative	0.398(***)	0.321(*)	-0.124	-0.113	1,000	1,000				
Itinerant broker	0.164	-0.233	0.324	-0.119	0.260	0.237	1,000	1,000		
Liaison	-0.118	-0.119	0.653(***)	0.648(***)	-0.06	0.069	0.596(***)	0.453(**)	1,000	1,000

*** Correlation is significant at the .01 level (2-tailed).

** Correlation is significant at the .05 level (2-tailed).

* Correlation is significant at the .10 level (2-tailed).

Table 1: Correlation between the different roles in the Formal (N=28) and Informal (N=21) Networks (correlation based on the non-parametric Kendall's tau)

Table 1 presents the correlations of the different roles persons fulfill in the formal and informal networks, using the raw brokerage scores on the individual level within both these networks (cf. Gould and Fernandez 1989). The low number of significant correlations between roles suggests that the different roles do indeed capture qualitatively different role behaviors. This needs to be interpreted somewhat cautiously though, because a larger sample size might have yielded more significant inter-role correlations. The significant correlations between gatekeeper-liaison and coordinator-representative are somewhat striking, because they combine an internal role with an external role – both in the formal as well as in the informal network. This seems to run counter to previous research in an inter-organizational setting that found a differentiation of roles for boundary spanners (Friedman and Podolny, 1993) and intra-organizational research on the role differentiation of middle managers (Huy, 2002). A possible explanation for these seemingly

conflicting results may be found in the studied settings: labor negotiations (Friedman and Podolny, 1993), organizational change (Huy, 2001) and knowledge transfer (this paper). It seems likely that the underlying actual managerial behavior in each setting is different and may thus require or enable different role behaviors and role combinations. However, this needs to be analyzed further, for instance with the use of more qualitative, observational empirical material of knowledge transfer processes.

We group the five different roles in internally and externally oriented ones, as discussed earlier, in order to test hypotheses 3a and 3b, again using the Mann-Whitney test. Internally oriented employees in the formal network seem to devote their communication efforts significantly less to communication with colleagues from other division relative to communication within the own division than do externally oriented employees (Mann-Whitney $U=6.50$, $p = 0.016$, effect size $r=0.632$). The significant and large effect adds weight to our position that making a distinction between internal versus external orientation is useful when discussing the relative involvement in inter-unit communication of employees. Hypothesis 3a is therefore accepted.

The same test for the informal network does not show significant results (Mann-Whitney $U=13.50$, $p = 0.279$, effect size $r=0.30$) when analyzing the relationship between internal versus external orientation and percentage of inter-unit communication related to innovation. Hypothesis 3b can therefore not be accepted. A distinction of orientation in the informal network did not seem to be relevant as internally oriented employees do not seem to communicate relatively more inter-unit as opposed to intra-unit as do externally oriented employees. Although this result goes against our hypothesized relation, it is somewhat less surprising if we consider that the informal

network carries a significant affective component, for which Gould and Fernandez argue that the brokerage concept makes less sense (Gould and Fernandez, 1989, footnote 3 on p.97).

7 Discussion and Conclusion

Inter-unit knowledge transfer is necessary to increase the innovative potential of an organization. This paper has dealt with the question how communication networks within an organization influence this inter-unit transfer of knowledge, and we make two main contributions.

Our first contribution is at the network level. It is often argued that it is especially the informal communication structure within an organization that has great potential to contribute positively to the inter-unit process of transferring knowledge (Cross et al. 2002; Stevenson and Gilly 1991; Jablin and Putnam 2001; Madhavan and Grover 1998). Although our data supports this finding, we also find that the *formal* network forms a significant basis for the innovation network within a unit organization, even more so than the informal network. Formal structures are thus there for a reason. This finding offers opportunities for organizational management to positively influence the knowledge transferring process concerning innovation. Selecting and involving employees with relations in the formal respectively informal network that do not exist in the innovation network can help to improve the structure of the innovation network while building forth on existing social relationships. This approach allows one to reap the benefits of the existence of trust between the employees involved, thereby reducing the costs related to lengthy investments in trust building efforts. The strength comes from the involvement of employees that maintain relations in the formal or informal network, which are non-redundant at least in the current innovation network.

Our second contribution is the level of individual actors within the network. Most research thus far has focused on establishing the importance the centrality of the actors in the network (Burt, 1992; Tsai, 2001) for knowledge transfer, and our data indeed underscores the significance of centrality for both the formal and the informal network when analyzing processes of knowledge transfer. However, centrality has its limitations and recent efforts are seeking to go beyond centrality, including network range and cohesion as relevant elements (Reagans and McEvily, 2003). Starting from the observation that actors in a network are often members of exogenously-defined subgroups such as organizational divisions, but that this group membership has rarely been taken into account thus far, we add an important factor to this effort, namely that of the network role. This study found support for distinguishing between internally versus externally orientated brokerage roles (based on Gould and Fernandez' (1989) exhaustive typology of brokerage roles) as a predictor for the degree to which an employee will be involved in inter-unit transfer of knowledge. Only externally oriented roles in the *formal* network, and not in the informal network, however, significantly contribute to knowledge transfer between units of a firm.

Practical implications

These findings give a first indication that the brokerage concept is valuable for an organization when setting up an effective communication network with the intention to support the innovative capacity of the company. When selecting the appropriate person to support the innovation network of an inter-unit organization it therefore seems to be appropriate to take the different brokerage roles as a first point of reference. Given the importance of access to

knowledge in the early phases of the innovation trajectory, the innovation network is strengthened by attracting employees with an external orientation and placing them in a central position in the formal network. Organizational stimuli, such as bonuses and other appraisal systems geared at stimulating an external orientation could contribute to reach this goal.

By mapping organizational networks as indicated in this paper an organization can anticipate possible disruptions of both the formal and the informal networks. The consequences of an employee's departure from the organization for communication and knowledge transfer networks can be assessed and dealt with better. In addition, an employee's performance within the organization can also be assessed by analyzing his communication profile. Someone's brokerage role scores, especially for formal communication, may be compared with what one would expect for someone in a particular position. In Table 2, for the formal network, a staff member may be compared with non-staff members; the distinction between staff and non-staff makes sense mostly in a formal environment. The communication profile of staff members as measured by brokerage scores for different roles differs from that of non-staff members – indeed in a way one would expect. Still, a staff member's communication profile may deviate from a profile one would expect. A similar argument holds for the unit director involved in the 'transportation' theme whose communication profile is also shown in Table 2. This might, we submit, be an indication of his performance.

Brokerage roles	Non-staff	Staff	Unit Director [‡]
Coordinator	6.18	0	13
Gatekeeper	10.88	8	14
Representative	5.58	0	4
Itinerant broker	1.60	0	1
Liaison	3.38	8	1

[‡] Unit involved with the ‘transportation’ theme discussed in this paper.

Table 2: Brokerage roles in the formal network, comparing different functions

Limitations

Having said this, there are some limitations to our study that should be acknowledged. Our sample size was relatively small, as well as the centrality and brokerage data being skewed to some degree, and together this allowed a less detailed investigation of hypotheses 2 and 3 than we would have liked. For instance, the data did not allow for a more fine-grained empirical analysis of relationship between the five brokerage roles distinguished by Gould and Fernandez (1989) and knowledge transfer. Also, we would have liked to investigate the relationship between centrality and brokerage type (which Friedman and Podolny (1993) did for two of the five brokerage roles) in more empirical detail. Such topics are left for further research, and we hope to have shown that the brokerage concept is indeed a fruitful concept to study in empirical detail. Another issue that deserves mentioning is that although we established the importance of the formal network for knowledge transfer, we did not investigate the actual mechanisms through

which this takes place. Further observational work is needed to study this in more detail, also to relate the roles with other aspects of actual managerial behavior. Finally, there are also some factors that may limit the generalizability of our results. The organization we studied is part of a large multinational and, much like other large firms,⁵ has a fairly formal organizational culture. This may have contributed to our finding of the importance of the formal network, even though we believe that this effect will not be substantially different for this organization when compared to others. It remains to be seen whether the importance of the formal network holds in smaller organizations with a more informal culture.

In the last two decades, social networks analysts have worked hard (and succeeded) to establish the network view as a viable perspective on organizations by highlighting the influence of informal, personal networks that occur outside formal organizational structures and are less bound by subgroup membership. This success may have come at a price though, as it is perhaps under-appreciated that organizational divisions are there for a reason: formal structures and subgroup memberships do matter, as we demonstrate. Incorporating this in future studies may lead to an even richer network-view of organizations.

⁵ See Pugh et al. (1969) and work in line with it.

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