

INNOVATION IN COMPLEX NETWORKS –THE STATE-OF-THE ART AND PROPOSITIONS FOR FURTHER RESEARCH

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Abstract

Due to the pressures of globalisation and the nature of technological development it becomes more and more important to understand the complexity of the innovation-related organisational networks. This paper conducts a literature review on the role of internal and external networks in organizational innovativeness, and more specifically on R&D and innovation performance. The aim of the paper is to recapitulate the main theoretical approaches and provide propositions for further research in the area. Findings from exploratory interviews are used to reflect the review on the previous literature. The exploratory interview data was collected from three multinational companies in the paper and ICT industries. The qualitative database consists of 25 focus group (FG) -interviews with altogether 132 participants. The participants represented three companies and different organisational stakeholders: management, workers, innovators, innovation experts, as well as trade union experts. Also those working in interfaces with external stakeholders, e.g. in customer interface, partner interface, supplier interface as well as in university collaboration were also included. This large qualitative data has been analysed with ATLAS-TI-program. The data analysis shows that trying to cope with the internal – external duality in relation to innovation and innovative activities is a great challenge. Another finding was that the literature on innovation networks seem to have concentrated on two broad and separate areas of inquiry: the internal and external networks. However, there seems to be only a scant literature studying the interaction of these two phenomena. Furthermore, even if the role of informal networks in innovation has been recognised, they have been overlooked in much of the literature focusing on formal organisations.

1. Introduction

The interest on organizational networks began with the idea that organizations are open systems operating in close connection with their environment. Selznik (1949) already stated that there is a connection between the organization and its operating environment. However, until the year 1960 businesses were seen as closed systems (Johanson et al., 1995) and the classical organisational theory focused on universal forms: it was considered that there is one best way to organise (e.g. Weber, 1947). Organisational design theories deal with the relation between organization structure and its ability to innovate (e.g. Burns and Stalker, 1981, Mintzberg, 1979). The idea of organisations as open system was accepted after Lawrence et al, 1967², Galbraith, 1977 and Child, 1977, introduced their contingency theory (Johanson et al., 1995) and thus the one best form-thinking was challenged (Pettigrew et al., 2000). According to the contingency theory there is no one best organisational structure (Chandler, 1962) and the organisational structure emerges as a result of people's decision-making behaviour and bounded rationality. Organisations aim to respond to external changes by adjusting their structures. (Johanson et al., 1995). On

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² Originally in Pettigrew, A., M., & Fenton, E., M., 2000, The innovating organization, Sage Publications, Great Britain

the other hand, *micro-economists* such as Teece (1998) have highlighted the idea that certain types of organisations are more suited to certain kinds of innovations (systemic and autonomous) and to certain kinds of business environments. It is hereby considered that innovation should take place in more formal setting inside the organisation. (see e.g. Dougherty et al., 2004, on new product teams and innovation and Karim et al. (2004) on acquisitions and internal development and innovation) According to Dougherty et al. (2004) clear organisational boundaries enhance collaboration as people know with whom they work and how they work. Karim et al., (2004, 527) see that it is important, from the innovation point of view, time after time to define the external and internal boundaries of a firm time after time through “acquisition, internal development and business unit reconfiguration”. Recently, the interest has, however, no longer been in the purely formal structures. Some researchers see that innovation would benefit from more informal organizational settings. The interest has focused on organisational processes, boundaries as well as on relationships (Pettigrew et al., 2000).

Earlier, competition was mainly considered resource-based and factors such as economies of scale and scope as well as market position and financial power appeared significant. (Van Aken et al., 2000) Nowadays competition has become knowledge-based. (Prahalad et al., 1990 and Teece et al., 1994). The toughened knowledge-based competition and the pressures from the changing environment have forced organisations to develop relationships outside the traditional boundaries of the organisation, because no single organisation is able to gain and maintain all technological and market capabilities necessary and relevant. (Lawson et al., 2001) Hence, R&D collaboration with third parties, namely, various types of knowledge exchange between firms, research institutes, universities and other institutions has become a key issue. It has also replaced the stand-alone type of R&D (Van Aken et al., 2000) where R&D has been largely pursued by functional departments alone without cross-functional integration (Mote, 2005). The knowledge-based and collaborative R&D has been called the fifth generation R&D (Rothwell, 1994) or more broadly “networked R&D” (Blomqvist et al., 2004).

This means that innovation has lately been considered increasingly as a result of combining distinct knowledge and expertise located in different organisations. These types of network linkages may impact innovation through interaction and bringing complementarities together. This paper argues that *external* and *internal* innovation networks should be seen as related. Hence, there is a need to study them at the same time. (See also Helble et al., 2004 and Hillebrand et al., 2003) Otherwise, if development activities only concentrate on one side of the phenomena (internal or external networks) the results may not be optimum. (Hillebrand et al., 2003) These arguments find support in the survey conducted by Linder et al. (2003) with 40 companies from several industries. The survey demonstrated, that 45% of innovation springs from external sources (in the retail-industry correspondingly 90% and in the pharmaceutical industry 55%) and, on the other hand, 55% of the innovations spring from internal sources. Additionally, the informal networks are seen to have a possibility to contribute significantly to innovation. Therefore this paper also emphasises that taking the informal or formal nature of these relationships into account is important in relation to innovation activities. (See also e.g. Kratzer et al., 2005).

The literature review in this paper was conducted to gain an overall picture of the previous research topics, levels of the study, main findings and possible research gaps. First, in this paper the key concepts and some conceptual “tools” for network research will be discussed. Secondly, literature dealing with internal and external innovation networks and their impact on innovative performance and outputs will be under review. Thereafter, the rest of the paper is dedicated to creating propositions (based on the literature review and

the focus group-data) for micro level collaboration taking place in R&D and innovation project teams. The focus here is on the micro level as cross-functional teams/projects have been seen as a mean of improving collaboration across business functions and, hence, to improve the quality of the products, make timely decisions and lower costs. (See e.g. Katzenbach et al., 1993) The focus group-data is used to reflect the propositions on the real life context in three multinational companies. The challenge in these companies seems to be that that knowledge may be located everywhere in the organisation and in the external environment and, hence, it may not be available where it is needed or best used. One more challenge seems to be the interplay of the formal and informal organisation as the innovations seem to be born “regardless of the formal organisation”. These challenges will be addressed at the end of this paper. This paper is not a complete, all-encompassing overview of the previous quantitative scholarly research in the area. The overall aim of this paper, however, is to recapitulate the main theoretical approaches and thereafter provide some hypotheses/propositions for further research especially on the micro level networks.

2. Literature review

There is an ever-growing need to understand how the social structure helps or impedes economic performance. (See Uzzi, 1996). Already in 1985 Granovetter argued, that the behaviour of individuals is embedded in the network of social relationships (social embeddedness). Granovetter also claimed that human behaviour is influenced by variety of contextual factors and individuals’ actions emerge due to a variety of intentions, e.g., from kinship, emotions, personal identity and prestige to economic self-interest. On the other hand, Granovetter saw the TCA approach³ (neo-economical functional approach) as an “undersocialised” view of human behaviour. According to Granovetter’s approach the actor both aims at maximizing their economic self-interest and bases their decisions on their own preferences, and also acts according to the norms and institutional constraints. (Johanson et al., 1995). According to Granovetter (1992, 25), it is, furthermore, important to take social relationships into account because the individual economic self-interest is always related to other motives that are non-financial (e.g., status, power). Secondly, behaviour (economic and other kind of behaviour) is related to social context that influences the individual’s behaviour. Thirdly, all economic and other institutions are seen to emerge due to social behaviour. (Johanson et al., 1995)

Key concepts

In the organisation theory literature the concept “network” has been used rather freely (For more detailed discussion see Johanson et al., 1993). The network-concept can simply be used to mean that each individual has contacts with other individuals. Additionally, it can be seen to include a situation in which the other people are also in contact with some other or several other individuals etc. (Wasserman et al., 1994) The simplest form of network can be two actors and one relationship connecting them. (See for example Johanson et al., 1993) The actors in the network can be, for example, individuals, teams and organisations. They are also called “nodes”. Additionally, in the literature many kinds of concepts are used to describe the variety of ties in the network. For the purposes of this paper, *internal networks* are seen as relationships between R&D teams/projects and different functions, departments and units. *External networks* are seen as relationships the R&D teams/projects have with company external actors such as customers, suppliers and partners. *External formal network* relationships are seen to include formal contractual relationships such as research joint ventures, strategic alliances and research consortia

³ TCA considers that individuals’ actions pursue only one intention: economic self-interest. (Berry et al., 2004)

with universities and research centers (see e.g. Hagedoorn et al., 2000 and Freeman, 1991) *Internal formal networks*, on the other hand, are seen to evolve based on the official organisational structure. (Tushman et al., 1986) *External informal network* relationships are seen to include all the knowledge transfer taking place across organisational boundaries, e.g., between engineers and scientists. (Freeman, 1991) The *internal informal networks* include those kinds of relationships that bypass the official structures of the organisation. (Tushman et al., 1986). In this paper the terms “relationships”, “relations” and “ties” are used interchangeably.

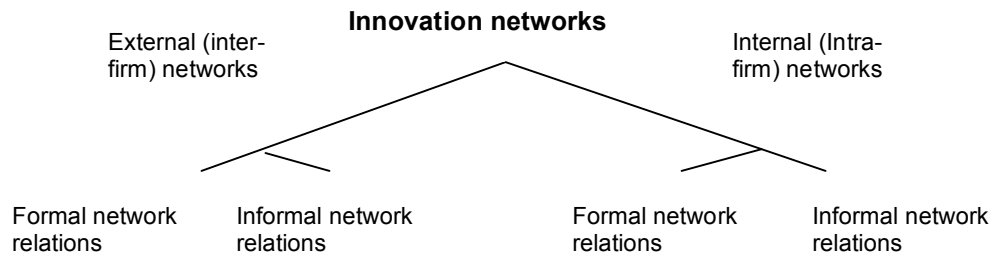


Fig.1. Simple taxonomy of the reviewed innovation network studies

There are some concepts, “tools”, with the help of which networks as well as their effects can be analysed. These are the weak ties, strong ties and structural holes. In his early works, Granovetter, (1973) studied the role of informal ties in relation to the employment prospects of individuals. Granovetter claims that the strategic goals of individuals affect the information that flows in the network. Also the individual gate-keeping qualities play an important role in the information flows going through the network. In addition, Granovetter’s thesis on weak ties showed how boundary-spanning individuals can connect individuals in the society, who otherwise would be left outside and not know about each other due to the group norms and loyalties existing in the groups. Granovetter uses “strength” as a metaphor to describe the influence (Johanson et al., 1995) of gatekeepers (Allen, 1971) or other boundary-spanning individuals connecting the otherwise unconnected groups in the society⁴ (Johanson et al., 1995) or in an organisational context (Tushman et al., 1980 and Katz et al., 1981). The informal exchange of technological information is often also seen to take place through inter-personal relationships. (van Aken et al., 2000). Burt (1997) on the other hand, continued the work of Granovetter (1973) and showed that economic reward that may be gained by those who achieve weak ties (Granovetter, 1973). He called this filling in “structural holes”. In this connection terms “indirect” and “direct” ties are also being used. *Indirect ties* refer to relationships that fill in “missing” relationships between different groups or other collectivities (See, e.g., Reagans et al., 2001, and Ahuja, 2000). *Direct ties*, on the other hand, mean those ties that the focal unit of analysis, namely, the organisation itself maintains towards other parties. Ahuja (2000) summarises that there are different opinions concerning the optimal social structure. According to Ahuja (2000) the other scholars see the optimal social structure to be “closed” i.e. to include dense and interconnected networks (Coleman, 1988). However, according to Ahuja (2000) some researchers speak for a more “open” social structure (Burt, 1992). According to this view, the optimal strategy is creating networks with “disconnected alters” (p.425). In general, there are also different opinions on the role of weak and strong ties and structural holes in innovation (Ruef, 2002, Ahuja 2000). *Strong ties* are to some extent considered hinder the information gathering as widely as informal network in which the information is considered

to be rich. On the other hand, *weak ties* are considered to last a shorter time and provide non-redundant information.

The following chapter will review some external innovation network studies. It seems that the focus of many empirical studies concerning networks and innovation has been on the networks among organisations. These types of external innovation networks seem to have been studied from a variety of perspectives.

2.1. External networks and innovation: review of the previous literature

Already the classic study by Rothwell et al. (1972 and 1974) on the SAPPHO-project demonstrated the importance of external relationships. According to the study, customer-supplier relations as well as other relations with the company's external resources of technological knowledge were considered essential for product and process innovations. Since Rothwell et al. (1972 and 1974) the external formal and informal networks have gained quite a lot of scholarly attention.

Formal networks. Ahuja et al. (2000) studied the position of the organisation in an industrial network. The study concentrated on the indirect ties, direct ties and level of indirectness. The results show that indirect and direct ties influence innovation positively, however, direct ties have more influence. There are also other industry level studies (e.g. Rowley et al., 2000) as well network-level studies (e.g. Dyer et al., 2000 on the Toyota car production network). Rowley et al. (2000) analysed the steel and semiconductor industries concerning their strong and weak ties. They found out that in the steel industry strong ties are more strongly linked with performance. However, In the semiconductor industries they found out that weak ties are more effective. Generally weak ties are seen to enhance gaining novel information. Strong ties, on the other hand, function as social control and route for tacit knowledge exchange. Furthermore, Dyer et al. (2000) suggest that the density of overlapping ties supports further knowledge sharing and learning in the production chain. These studies have their origins in the social network literature.

Research on R&D and innovation management seems to have concentrated on studies, e.g., on different forms of collaboration (Tether, 2002), and collaborative R&D relationships and maintaining them (Belderbos, 2004; Fritsch et al., 2001). Tether (2002) has investigated the patterns of cooperation between innovating firms and external partners in the UK. His study concentrates on the R&D cooperation between the firm and several types of R&D partners⁵. The results of the study show that the extent of cooperative arrangements for innovation appears to depend, first, on the type of firms being considered and, secondly, on what is meant by innovation. Additionally, there are also some studies that have investigated the differences between cooperative and non-cooperative setup. Belderbos (2004) examined Dutch firms and addressed the question whether cooperative R&D has a positive impact on firms' innovative performance. The finding was that supplier and competitor orientation have a significant impact on labour productivity growth. On the other hand, cooperation with universities and research institutes and competitor cooperation positively impact growth in sales per employee of products and services new to the market. New product sales is, furthermore, stimulated by incoming knowledge spillovers (not due to collaboration) from customers and universities and research institutes. Fritsch et al., 2001⁶, studied 1800 German manufacturing enterprises and the characteristics of those enterprises that can be expected to maintain cooperative relationships. They found that

⁵ The R&D partners in the study include suppliers, competitors, customers, universities and research institutes, consultants, government institutes and research associations and research and technology organisations

⁶ "Casual contacts for information purposes" were included in the survey"

cooperative relationships are maintained mainly by quite large organisations with high R&D share. Other similar studies have concentrated on the relationship between research cooperation research expenditures (Kaiser, 2002) and reasons for R&D collaboration and choosing the collaboration partners (Miotti et al., 2003). Kaiser (2002) states, for example, that co-operating firms make more investments in comparison to those firms who are not cooperating. Miotti et al. (2003) concluded that the reasons for collaboration clearly impact also the selection of collaboration partners.

There has also been a line of research concentrating on the *entrepreneurs and their innovation* networks. These studies have addressed topics such as the impact of cooperative relationships on patenting (Shan et al., 1994) and the impact of alliance network composition on start-up performance (Baum et al., 2000). Shan et al. (1994) found that cooperative relationships had a positive impact on innovation in the entrepreneurial setting. Additionally, Baum et al. (2000) discovered that diversity of information and alliance capabilities increased the number of patents in the same context.

Informal networks. Von Hippel (1987) focused on informal networks (in steel mini-mill producers in the USA aiming at sharing proprietary knowledge) in his study. He found that proprietary knowledge is being exchanged both with rivals and collaborators.

In general, external networks and contacts have been studied rather extensively and only few studies can be included here. One set of researchers seem to have studied innovating firms and their research partnerships. These types of studies have mainly concentrated on formal relationships. This research seems to have mainly focused on the existence or non-existence of cooperative relations and their performance impacts. Often these types of studies have also been on a dyad level in comparison to studies focusing on relationships involving many parties and to studies trying to map the larger network or system of relationships. Another stream of innovation network research seems to have investigated the network structures. It has also used the so-called social network approach. Furthermore, it seems that part of the studies approaches networks from a “structuralist” perspective (see e.g. studies by Ahuja et al., 2000, and Rowley et al., 2000 on the industry level) According to this perspective, for example, the examined focal unit of analysis benefits performance-wise from the entire network structure of network relationships and their special characteristics such as density⁷ (see Borgatti et al., 2003). It also seems that studies such as Dyer et al. (2000) in their study on Toyota car production network, follow the so called “connectionist” approach (see e.g. Lin, 2001) This means for example that the examined focal unit of analysis benefits performance-wise from relationships that offer an access to essential resources. Dyer et al., 2000, especially focus on three types of asset specificity: the site, physical, and human (Williamson, 1979).

Next, we turn from the more the exploratory type of knowledge strategy to studies that concentrate more on exploiting the options and knowledge the units of analysis already have. (See March, 1991, about exploration and exploitation). Some studies on internal innovation networks will be reviewed in the following.

2.2. Internal innovation networks: review of the previous literature

Informal networks. When it comes to company-internal network research Rafiq et al. (2000) for example, stresses the importance of informal communication networks between R&D and marketing functions in the context of pharmaceutical firms. Additionally, it has been found that emergent technology flows best through informal networks and many

⁷ Density is “the average strength of the relationship between” the nodes. (Reagans et al., 2001)

researchers (e.g., March, 1991; Starbuck, 1992; Cohen et al., 1990) see knowledge resources (i.e., information flows) essential to innovative activities in organisations. Among other things the informal networks have been studied concerning the role of weak ties in sharing knowledge (Hansen, 1999), impacts of friendly relations and friendships (Kratzer et al., 2005), the network structure (Mote et al., 2005) and the impact of network density and diversity on team performance (Reagans et al., 2001). Hansen (1999) concluded that knowledge (especially complex knowledge) is better transferred through close networks in the context of new product development teams. The study by Kratzer et al. (2005) extends previous research by confirming that informal ties have an important impact on innovative team performance. The interaction of R&D teams has more specifically been studied by Mote et al. (2005). They concentrated on network structures in R&D context and did not only focus on studying the other network/group processes. Furthermore they stressed the notion of networks in R&D instead of organising R&D along functional boundaries. Reagans et al. (2001), on the other hand, addressed the informal networks, organisational tenure and productivity of corporate R&D teams. They found out that the heterogeneity in networks increases productivity, but it may also have negative consequences due to conflicts that may arise among diverse experts. In addition, in their study on the networks of project managers, Smith-Doerr et al. (2004) found out that informal networks are not only significant in relation to information access but they also influence managers' perceptions of the outcomes in innovation projects.

Formal networks. There also seems to be a stream of studies that have addressed formal intra-organisational team level networks. They have concentrated, for instance, on the relationships teams have towards the whole organisation (Ancona et al., 1992) and on the role conflict (Friedman et al., 1992). Ancona et al. (1992), for example, found that teams also have varying strategies coping with the external environment through various communication strategies. Friedman et al. (1992) found that boundary-spanning role may not only be possessed by a certain person, but different people may function as boundary-spanners in different situations.

Informal and formal networks. Already in 1969, Travers et al. demonstrated that different groups have different possibilities to take advantage of their networks and the resources and social capital produced through these networks. (Johanson et al., 1995) In their study Travers et al (1969) randomly chose two groups of senders and two groups of receivers inside USA. The test persons were also selected randomly, and they were expected not to know each other. The senders were given a task to send a small delivery to their friend or acquaintance who they expected to know the given receiver. The other group used their business acquaintances and the other group used personal acquaintances. The professional channels appeared to be more efficient. (Johanson et al., 1995) Additionally, there seems to be a line of research focusing on the *networks of entrepreneurs* and their impact on innovation. For example, Ruef (2002) studied entrepreneurs and their tendency to engage in innovation on the team level. He also included both informal and formal affiliations in his study. The results showed that those entrepreneurs who had a variety of personal networks were considered innovative by their colleagues. On the other hand, those who had more homogenous networks were not considered as innovative.

Although, it seems that a lot of network research has focused on external networks, some research has also examined internal networks. In general, it seems that most of the studies stem from the social network literature. Additionally, these studies have, typical of social network studies, concentrated on micro level networks.

To sum up, it seems that previous quantitative R&D literature on networks and innovation has rather extensively concentrated on the formal inter-organisational networks. The concentration of the previous research seems to be on the external networks and more specifically on intra-industrial collaborations. Also the impact of internal networks has gained less attention in the R&D literature. This is regardless of the fact that the idea of a multinational organisation as a complex network (see Ghoshal et al., 1990) has been widely accepted. Additionally, the studies on informal network and innovation seem not to be very common in the context of large, multinational companies (Ghoshal et al., 1990 and Hansen, 1999). Following Hagedoorn et al. (2000), it can also be stated that informal arrangements have not been studied into great extent in the field of R&D and innovation literature. According to Hagedoorn et al. (2000) this is because the informal arrangements may be challenging to study as there is such a great variety of them. However, many researchers agree that informal ties enhance complex information sharing (see e.g. Cross et al., 2002 and Stevenson et al., 1991) and therefore they should be studied. Informal contacts seem to have importance especially in relation to innovation, because the innovation tasks are often complex and challenging and involve high uncertainty. Therefore, routines and specific ways of working cannot be followed, but there is a need to consult others and work together to solve problems. (Kratzer et al., 2005) According to Cross et al., (2000a) the informal networks can also be seen to “buttress” the formal activities. However, they also note that there are not many organisations that have noticed this. It seems that the role of informal and formal networks have been, to some extent, investigated in the previous social networks literature as the recognition of the dual nature of organisational design is not new. (Skivington and Daft, 1991 Ranson et al., 1980). Additionally, the importance of informal networks has been recognised. However, for example, the studies that connect informal networks to the innovation process are still rare. (see e.g. Kreiner et al., 1993 and Tsai et al., 1998). Many of the studies on networks and innovation also seem to have concentrated on the dyads instead of the whole network. Relationships involving many actors have, however, been studied by only few researchers. For example, Crane (1972) studied the “invisible colleague”, the informal network of scientist to find out how knowledge accumulates in relation to a certain problem or paradigm among scientists. Also the “markets-as-networks”-approach focuses on relationships with many parties among organisations. It aims to demonstrate how these relationships change over time. Additionally, it sees innovation networks as systems of activity. This approach has been developed by Scandinavian marketing researchers. (Håkanson et al., 1995)

Next those studies addressing the dynamics of internal and external networks will be reviewed, since, concentrating only on either of the network relations (internal or external) may be misleading. It may lead to a situation where it is difficult to determine what kinds of ties really impact the performance and innovative outputs. (See Burt, 2000, 361) For the same reason the debate on informal and formal types of ties is also included in this paper.

2.3. On the dynamics of internal and external networks

Some studies focusing on both internal and external networks can be found. However, they have often still been treated as a separate phenomena (see e.g. Smith et al., 1995) The exception to the general view on external and internal relationships as separate phenomena seems to come from the R&D and innovation management literature. (Hillebrand et al., 2003) The R&D literature has, to some extent, explored the relationship between internal and external collaborative relationships. (See e.g. Rochford et al., 1992). These studies do not, however, seem to have concentrated on addressing the

relationships between these two types of collaboration (internal and external). In the study by Langerak et al. (1997) however, the focus is on the external and internal partners and their impact on product development. The outcomes of the study support, to some extent, the idea that those companies with good internal and external collaboration network relationships can operate more efficiently than those, whose both collaboration network relationships are bad or either of them is bad (Hillebrand et al., 2003) Also Helble et al. (2004), in their study examined the importance of both internal and external R&D networks in the context of multinational organisations and their R&D organisations. They found four types of R&D subsidiaries regarding the external and internal network linkages. Additionally, they found that most of the R&D subsidiaries seem to be “semi-linked” meaning that most of the R&D subsidiaries are considered externally important partners, but internally they are not seen as critical partners. Tushman et al. (1980) have also included elements of internal and external networks in their team level study. The focus of their study was not, however, on the interaction of internal and external studies. They studied the relationship between the existence of gatekeepers and subunit performance for different types of tasks. They have especially concentrated on the role played by gatekeepers in mediating external information. They concluded that gatekeepers seemed to have different roles in teams depending on the tasks. Gatekeepers also seemed to have different gatekeeping tasks. All of these studies seem to have concentrated mainly on formal networks.

All in all, it seems that the reviewed research has mainly concentrated on external networks and the interaction of external and internal networks has received less attention. Additionally, it seems that studies have not paid too much attention to the effects of networks on innovative outputs and performance. It, furthermore, seems that in many cases the output and performance measures have been patents.

In the following chapter some propositions will be put forward in order to provide some new illumination to the “gaps” identified in the previous research. The propositions concentrate on project and team-level in large multinational corporations. Hence, there is also an effort to cover a context in which there has not been much research (related to informal contacts and innovation). The propositions aim to build on the basis of both social network analysis and the R&D management and innovation management literature. According to Hansen (1999) the representatives of the R&D and innovation management literature consider that close ties and regular knowledge exchange impact knowledge transfer and hereby productivity. However, following Hansen (1999) the social network literature seems to consider that weak ties create access to new knowledge, and this leads to efficient knowledge transfer. Additionally, the R&D and innovation management literature seem to have concentrated on knowledge transfer and the social network literature, on the other hand, has concentrated on finding knowledge. (Hansen, 1999) In the social network literature it is also often considered that distant relationships and irregular interaction provides a way to access new information (density); whereas in the R&D and innovation management literature close relationships and regular knowledge and information exchange are seen to lead to more efficient communication (closure). (Hansen, 1999)

3. Propositions: External and internal ties in R&D and innovation projects and innovative, R&D performance

The focus group interviews conducted in the three large organisations indicated that innovative and R&D project teams need information from other intra-organisational units globally and also from various external (complementary) partners. This challenge is accentuated, according to some scholars, if we accept the idea of bounded rationality; it is not possible for the project team members to gather too many opportunities for information sharing and processing.

The preliminary findings based on the focus group -data also support the findings of Mote et al. (2005) as they pay attention to the change that has happened in the R&D function recently. Earlier, in research and in practice, organisations such as R&D organisations have often been seen as autonomous units. (E.g. Porter, 1980) This has resulted in functional departments that may be unconnected and have separate interests. However, these types of R&D organisations have decreased and they have been replaced by more project-oriented R&D organisations. It has been realised that, for example, new products are often tightly connected with the whole organisation and "cutting off" these links may not be the right solution. (Dougherty, 1990). This has led to wider cross-functional integration. (Mote et al., 2005) Hence, the R&D and innovation teams/projects are also continuously embedded in systems of relationships or social networks, with other teams, other departments and external partners. Mote (2005) refers to Grabher (2002) who states that there is not yet much knowledge on how the projects interact with each other inside an organisation. The networks of innovators are, however, no longer a special arrangement but more a part of everyday working life.

According to Mote (2005) a holistic research approach might aim at "*exploring interdependencies between projects and the firms as well as personal relations, localities, and corporate networks on and around which projects are built*". (Grabher, 2002, 246)

The propositions here, first, aim at finding out the composition and focus of the external and internal ties the innovation projects and teams have. Secondly, the interest is on the benefits projects may gain through the external and internal (informal or formal by nature) ties they engage themselves in. In this paper organisational innovativeness or innovation is seen as a multidimensional and systemic phenomenon. They can take several forms ranging from organisational and individual tendencies to "*engage in and support new ideas, novelty, experimentation, and creative processes that may result in new products, services or technological processes.*" (see Lumpkin and Dess, 1996 in Salavou, 2004, 34) Summary of the team and project level innovation studies discussed here can be found in the table in the Appendix. 1.

3.1. External and internal network ties

The innovation or R&D project team does operate in isolation. Additionally, the innovation and R&D projects seldom are self-sufficient, but they need information and knowledge from the environment e.g. in the form of ideas, materials and opportunities (see e.g. Lawrence and Lorsch, 1969). In the previous R&D and innovation management literature it has been considered that communication and understanding between the R&D, product design, manufacturing and marketing enhances the timely (from the customer perspective) new product development. (See e.g. Moriarty et al., 1989, and Takeuchi and Nonaka, 1986). Additionally, the role of suppliers, customers and competitors in the new product development has been recognised. (See e.g. Moriarty et al., 1989). Therefore, we propose (concerning the number of relationships):

PROPOSITION 1. *Well-developed external networks/interfaces are positively related to the R&D and innovative project teams subsequent innovation output.*

PROPOSITION 2. *Well-developed internal networks/interfaces are positively related to the R&D and innovative project teams subsequent innovation output.*

PROPOSITION 3. *R&D and innovative project teams with well-developed external and internal networks/interfaces have better subsequent innovation output than those project teams with well-developed internal networks/interfaces and poorly developed external networks/interfaces.*

Position in the network (centrality and density)

Based on the previous studies the location of e.g. an individual or a project team, in the network is also crucial as it impacts performance. (Mehra et al., 2001) Mehra et al. (2001) refer to this as a structural advantage. According to Burt (2000, 347) centrality in the network can be seen as “an asset in its own right”. Based on the previous research (see e.g. Seibert et al., 2001) individuals located centrally in the network gain information more easily than individuals located somewhere at the outskirts of the network. Those individuals, teams and organisations, which are centrally located in the network, can be considered to better gain resources such as information better. Additionally, they seem to get more easily information about the opportunities more easily. (Mehra et al., 2001) Also, when the innovation and R&D project team has more direct and indirect ties the project performance improves due to the more complete, speedy access to the new information (from the internal and external environment) in comparison to other projects. Centrality as a structural property of a network has been linked to innovation in some previous studies. (See e.g. Ibarra, 1993) Centrality is considered as the extent to which the interaction distributed to a small number of individuals instead of being equally distributed to a larger group. It can be described to reflect the variance of the network ties. (Mote, 2005)

Density, on the other hand, reflects all the different interaction the members of the network have engaged in. It is like the mean number of ties and relationships each unit of analysis has. (Mote, 2005) Reagans et al. (2001) found that R&D teams with dense networks have higher productivity in comparison to teams with less dense networks. Teams that have a many contacts between members with similar organisational tenure are less productive than those who have contact with members who have entered the organisation at different times. Hereby, we proposed:

PROPOSITION 4. *The R&D and innovation teams in (internal and external) formal network who are centrally positioned have a positive impact on the subsequent innovation output.*

PROPOSITION 5. *The R&D and innovation project teams (internal and external) in informal network who are centrally positioned have a positive impact on the subsequent innovation output.*

PROPOSITION 6. *The more direct ties that R&D team/project maintains externally and internally, the greater the R&D team's subsequent innovation output.*

PROPOSITION 7. *The more indirect ties that R&D team/project maintains externally and internally, the greater the R&D team's subsequent innovation output.*

3.2. Informal and formal network ties

In our preliminary study, we found that the formal organisational structure in large firms gives quite often people only some opportunities to be in contact with different people e.g.

in different teams, projects or units. This may lead to a situation in which the people, e.g., in innovation teams cannot gain information about the other ongoing projects or knowledge and ideas in other projects groups. The formal structure may, hence, not be optimal and it may not always enhance the information flows and contacts between different individuals, teams and projects in an optimum way. Based on the focus group-interviews it seems, that the three large companies are more or less organised as a matrix in relation to products and markets. This type of organisation seems, according to the interviews, to be reflected in the fairly low hierarchy. On the other hand, this seems to lead to specialisation of the functions which may limit the knowledge transfer and sharing. Furthermore, it seems that large organisations, similar to those we studied, are often complicated and this makes finding the relevant information often even more troublesome. The project or team members may not always even know where the needed information resides. (See also Hansen, 1999)

The informal ties that go across the whole organisation and the formal functional boundaries may provide a way to gain the kind of ideas and information, that are crucial to innovation activities, from distinct parts of the organisation. According to Blau (1964), however, the organisational members are more willing to exchange information and advice when there are personal i.e. informal relationships between them. According to our preliminary interviews we found that these types of personal relationships are often established in professional seminars, organisational meetings and other more informal get-togethers. It was also found that there is often competition between the different teams, groups and departments. In the competitive situations it seems to be important to have personal relationships in order to increase the willingness of organisational members to provide information and to discuss the ideas regardless of the competition.

The research results concerning informal networks have been, so far, contradictory (Kratzer et al., 2005). Some of the researchers find that informal contacts impact negatively on team performance, because they prohibit the critical evaluation of ideas. Additionally, informal relationships are seen to be so satisfying that they diminish the need for making results. From the other point of view, the informal relationships are seen to improve productivity. This is called the cohesiveness-compliance –hypothesis according to Homans (1974). It means that in close informal contacts team members reward each other by showing approval and, thus, they strengthen the position of other team members in the group. This leads to a situation in which the team members want to contribute more to the tasks of the team, and thereby, the productivity also improves.

The different opinions on informal networks and their productivity can partially also be explained by the fact that previous research has defined the term “informal networks” in varying ways (Kratzer et al., 2005). Kratzer et al. (2005) find that friendship bonds and friendly contacts have often not often been treated separately as they should, since, they may have different impact on performance. Kratzer et al. (2005) stress that it would be important to separate informal relationships that also encompass an emotional bond in comparison to an informal relationship, which however “*keeps the surface*” (p. 515). They refer to Van de Bunt (1999) who states that “friendly” and “friendship” ties should be differentiated. These types are not the ends of a continuum, but seem to have different performance effects.

PROPOSITION 8. *The (internal and external) informal network (friendly or friendship ties) of the R&D and innovation project teams is positively related to the R&D teams subsequent innovation output.*

PROPOSITION 9. *The (internal and external) formal network (friendly and friendship ties) of the R&D and innovation project teams is positively related to the R&D teams subsequent innovation output.*

3.3. Heterogeneity of the R&D and innovation project members

Kogut and Zander (1992) state that in order to make use of the knowledge and to gain competitive advantage, there needs to be enough insight in the knowledge at hand. In addition to this knowledge processes are needed for the actual knowledge transfer. According to Burt (2000, p. 352) organisational members from different groups can even be seen to have such a different social environment that they “circulate different flows of information.” Hereby, the fact that R&D and innovative project teams have a lot of network relations leads to a situation in which also the heterogeneity of the project team members also may also impact the overall performance.

These types of situations have been investigated e.g. by Mote (2005) in relation to scientific heterogeneity and Reagans et al. (2001) in relation to demographic heterogeneity. According to Mote (2005) networks play an important role in linking heterogeneity and performance. However, they state that it is not clear how the network mechanisms impact on productivity. They found out that connecting projects to departments, which were well-connected to other projects, was more beneficial than having projects to act as bridges in-between different departments. Reagans et al. (2001) in comparison to Mote, considered heterogeneity to be demographic heterogeneity and examined how network mechanisms impact performance. The starting point for their study was that, on the one hand, homogeneity was seen to enhance productivity and, on the other hand, heterogeneity was also seen to improve it. They found that teams that have many contacts between members with a similar organisational tenure (homogeneity) are less productive than those who have contact with members who have entered the organisation at different times (heterogeneity). Heterogeneity and, hence, different social worlds may, however, lead to challenges similar to the paradox Tushman et al. (1980) examined in their study. They were concerned with the paradoxical situation between specialisation and differentiation. This meant that local language and codes helped understand information, but on the other hand, they could make understanding the information from external environment also difficult. Tushman et al. (1980) suggested gatekeepers as a one solution to this problem.

PROPOSITION 10. *The (internal and external) greater the network heterogeneity (demographic and scientific) of the R&D and innovation project teams the greater the R&D teams subsequent innovation output.*

3.4. Networks as a purely enabling phenomenon?

Networks have often been seen, almost purely, as an enabling phenomenon. It is considered that networks provide access to other relationships (see e.g. Easton, 1992). However, it has been recognised that networks may also have negative and constraining effects. According to Kale et al. (2000) and Baughn et al. (1997) organisations are faced with a paradoxical situation as there is a need to collaborate with others, but, on the hand, they need to protect their proprietary assets and try to avoid leakages of critical knowledge. Additionally, Kamien et al. (2000) also state that the organisation needs to have an absorptive capacity to take advantage of the external knowledge and using external knowledge also includes costs. Additionally, based on the focus group data, administrating a lot of network relations may be laborious. Hence, we propose:

PROPOSITION 11. *Network-relations have an U-shaped relation to innovation output. On the one hand, number of network contacts can be seen to impact positively on innovative performance. However, too many network ties are hard to handle and hence, there might be an inversely U-shaped relationship between network relations and innovative performance.*

4. Conclusions

Our previous study on three multinational companies in the paper and ICT industries showed that, in addition of trying to cope with concerns of the basic business and the new business as well as to pursue their strategic goals to be more innovative, the case firms experienced a challenge of simultaneously trying to explore and exploit external and internal knowledge and relationships (internal vs. external duality) This paper aimed at reviewing the previous literature on internal and external innovation networks. Additionally some studies combining the two approaches were examined. It was discovered that there are not many studies dealing with internal and external innovation networks as a linked phenomenon. However, there are many studies focusing on neighbouring phenomena and, hence, they are helpful starting points for further research in this area. Based on the previous research some propositions were drawn for further research in the field.

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