4 Social Networks and the Generation of Innovations – Theoretical and Empirical Relevance

4.1 The Generation of Innovations in the Knowledge Society

> A great scientist, when he was once asked how he managed to hit upon so much that was new, replied: "By keeping on thinking about it".
>
> (MUSIL 1965: 128)

4.1.1 The Generation of Innovation and R & D

In the literature, a variety of definitions of the term "innovation" can be found. Van der Kooy (1988), for example, identified 76 definitions of innovation (as cited by Biemans 1992: 6-7). Following Zaltman et al. (1973: 7-9), innovation refers to three different concepts: (1) the process of developing a new item, (2) the process of adopting the new item, and (3) the new item itself. While the first two concepts describe innovation as a process, the third perspective defines innovation as the result of a process. In the latter case, innovation is mostly viewed from the perspective of the adopter; for instance, Zaltman et al. (1973: 10) define an innovation as "any idea, practice or material artifact perceived to be new by the relevant unit of adoption", or following Rogers (1983: 11), an innovation is "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (see also Rogers and Shoemaker 1971: 19; Rogers and Agarwala-Rogers 1976: 150). Furthermore, different classifications of innovations can be found in the literature. Knight (1967: 482), for example, distinguishes between (1) product or service innovations, (2) process innovations, (3) organizational-structure innovations, and (4) people innovations (as outlined by Biemans 1992: 10). The distinction between product and process innovations in particular has become popular in innovation studies.

A different approach is to classify innovations in terms of their outcome, either from the perspective of the adopter of the innovation or that of its developer (see Biemans 1992: 11-12). For this thesis, the different perspectives on innovation and classifications of innovations are of no further relevance. The underlying understanding of innovations, here, includes all different kinds of innovation and its

perspectives, since innovations are understood as the generation of new knowledge. And since knowledge is primarily understood as being socially constructed (see section 2.2), the perspective of the generation of innovations, i.e. of new knowledge, puts its focus on the individual and the social relationships between individuals. In the context of an organization, the generation of innovation is functionally assigned to what is known as research and development (R & D).

R & D is described in business management theory as all kinds of activities that aim at leading to the generation of innovation, i.e. to all kinds of new material or immaterial products and processes in the sense outlined above (see, e.g., Brockhoff 1994: 23). The fields of R & D are commonly distinguished according to basic research, applied research, and development (see, e.g., Bemelmans 1979: 33; Kupsch et al. 1991: 1075; OECD 1992: 70-71):

- *Basic research* describes theoretical and experimental exploration of causal connections to gain new insights into the basic characteristics of phenomena and observable facts. It has the objective to enlarge basic theoretical and purely technical know-how without aiming at specific use or commercial application.
- *Applied research* describes goal-oriented use and application of the results reached through basic research. It has the objective to enlarge methodical and technical know-how in such a way that specific use or commercial application can become reality. From the starting point of a concrete problem it aims at finding a general methodical or technical solution.
- *Development* describes the matching of existing scientific-technical solutions with economic needs. It is the systematic use of available know-how oriented toward the introduction of new or improved versions of material, products, machines, production techniques or processes and services.

Of course, these research phases are neither always clearly distinct from each other nor must they occur in any particular time sequence; they might be more or less mixed and overlap with each other (see, e.g., Mansfield and Rapoport 1975: 1381, Backhaus and de Zoeten 1992: 2026-2027).

Taking a closer look at the generation of innovations and its structural processes, we can draw back on a structural model of the technical design process provided by Völz (1983: 292-293) with reference to Müller (1977: 22-23) (see also Müller 1990: 19-22). This model distinguishes between three levels of action (see figure 4.1). During the production stage at level one, the individual performs physical activities by means of technical solutions (i.e., "human-machine systems") under given natural and technical facts. Material processes need human action for performing tasks, decision-making, management and control functions. These actions are strongly dependent on informational processes. The total of all information

processes that aim at the provision of a constructional and technological design, is called action level two. Since the design stage needs clear objectives, the processes that aim at the development of these objectives lie on level three. The planning stage defines the overall objective, method, plan and control strategy. Extending the model presented by Völz (1983) and Müller (1990) from a knowledge perspective, all the processes presented here include processes of knowledge generation, sharing, use, conservation, and forgetting within each level (horizontal axis) and between the different levels (vertical axis).

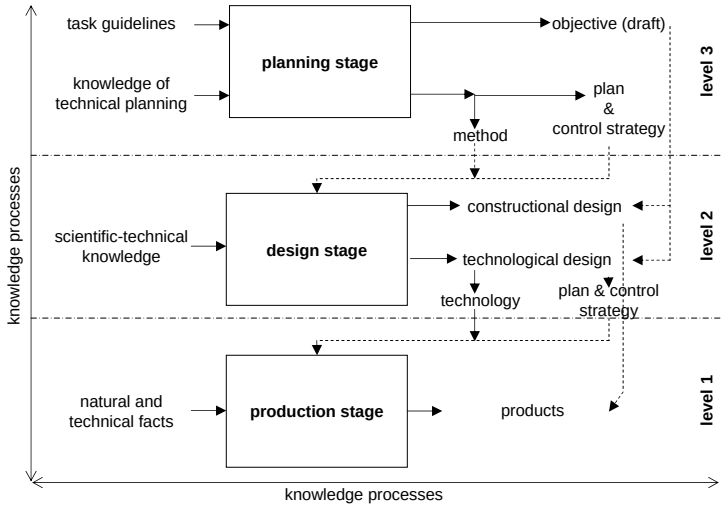

Figure 4.1: Structures of the Technical Design Process (following with modifications Völz 1983: 292 and Müller 1990: 21)

Taking the structural model of the technical design process as a starting point, the knowledge perspective on these processes makes it very obvious that knowledge communication plays a crucial role for the generation of innovations. Based on the horizontal and vertical axis of knowledge processes, combined with the structural elements of the technical design process, we could derive a matrix organization of knowledge processes and their structural elements. This matrix may provide us with the structural elements of knowledge communication for the generation of innovations. Then, by attachment of the involved individuals, we could derive the social network of the technical design process from a knowledge-structural perspective. While this perspective is mainly focused on the internal structural pro-

cesses, a major contribution of the network perspective in innovation research is the systematic exploration of external resources.

4.1.2 Innovation and Networks

Key findings of empirical research in the 1960s focused on the role of external sources for the generation of innovations and thus, on the importance of boundary-spanning networks. As Freeman (1991: 499) emphasizes, they started to demonstrate the "vital importance of external information networks and of collaboration with users during the development of new products and processes". And, as he continues to explain, until that time most innovation studies were only "anecdotal and biographical or purely technical. [...] Even those economists, such as Schumpeter, [...] did not study the specific features of actual innovations in any depth". The SAPPHO project (see Rothwell 1974; Rothwell et al. 1974) was one of the most comprehensive empirical studies during the late 1960s which is representative of this time's research on innovations, although it concentrated on only two branches of manufacturing industry, chemicals and scientific instruments. The most important characteristics that play an essential role for the success and failure of innovations as identified in this project are (as outlined by Freeman 1991: 500):

1. user needs and networks,
2. coupling of development, production, and marketing activities,
3. linkage with external sources of scientific and technical information and advice,
4. concentration of high quality R & D resources on the innovative project,
5. high status, wide experience and seniority of the "business innovator",
6. basic research.

These characteristics show the primary importance of networks and external resources as critical factors for the success and failure of innovations. Moreover, the results of the project already stressed the importance of both, formal and informal networks. During the 1950s, Carter and Williams (1957, 1959) had shown the basic character of multiple links for what they called the "progressive" firm. Piore and Sabel (1984) provide many examples on the role and importance of externalities that are generated by regional networks. They have been historically important since the early days of the industrial revolution. As Freeman (1991: 510) summarizes, "networking is in itself an *old* phenomenon and networks of suppliers are as old as industrialized economies". Nevertheless, a major upsurge of formal and informal networks can be realized in research and literature of the 1980s of both changes in quantitative and qualitative character. "In quantitative terms there is abundant evidence of a strong upsurge of various forms of research collaboration,

especially in the new generic technologies [...], involving extensive international collaboration as well as national and regional networks. There is also ample evidence of a *qualitative* change in the nature of the older networking relationships which have existed for a long time" (Freeman 1991: 507). The latter includes sub-contracting networks, research associations, government R & D projects and programs, computerized data banks, and value added networks.

A new upsurge of all kinds of networks takes place with the spread of new information and communication technologies based on internet technologies since the late 1980s until today. This constitutes their primary importance in what is known as the knowledge society (see also section 2.1). It is the various kinds of information technologies that affect, through their convergence with the telecommunication systems, the network of communications within and between organizations, including the firm and its supplier networks, technology networks, customer networks, etc. And not the information technology industry itself is characterized "by intensive technological networking for the development of its own products, but its diffusion throughout the economy to new sectors of application depends on the development of new networks in every sector [...]. Finally, it provides the technical means for improving communication networks everywhere and for making them feasible in areas where they could hardly have been introduced before. It is a networking technology *par excellence*" (Freeman 1991: 509).

Debates about networks are strongly connected with debates in theoretical economics about markets, hierarchies, and transaction costs (Williamson 1975, 1985). To cite Freeman (1991: 512) again: "It is not without interest that the idea of networks as a 'third form' intermediate between markets and hierarchies was originally suggested by Williamson himself in a footnote about the Japanese *zaibatsu*". Although Goto (1982) regards this as a culturally specific Japanese phenomenon, and indeed Japanese economists and historians have particularly stressed the importance of alternatives to markets and hierarchies and their growing importance with the rise of information technology (see, e.g., Imai 1989; Levy and Samuels 1991), these debates have become popular in all western societies as well.

With regard to the generation of innovations in networks, effects of globalization have contributed to a variety of specific management issues. Geographical dispersion of R & D laboratories lead to the following difficult management problems (as outlined by de Meyer 1993: 110):

- R & D is characterized by economies of scale and scope (Teece 1986),
- R & D activities are often unstructured and intangible (Clark 1985) and require a lot of person to person communication (Allen 1977),
- R & D activities are often close to strategic programs which the company wants to keep secret from the competitors, and
- R & D knowledge is an important invisible asset of the firm.

Connected with the innovation network is, of course, the corresponding communication network. "The communication network is of high importance for the diffusion, validation and integration of newly acquired know-how" (Meyer 1993: 115). One aspect central to communication in R & D networks is ensuring knowledge credibility (see Meyer 1993: 112-113). Then, the activity of networking can be regarded as a core element of the creation of innovations. From this perspective, de Meyer (1993: 116-117) points to four central elements of networks that are subject to research in social network analysis and will be discussed in more detail in later sections (see sections 5.1.4 and 5.7): (1) the roles of the nodes, (2) the density of the communication on the links, (3) the ties to other networks, (4) the dynamics of node roles and link density.

4.1.3 Entrepreneurs as the Drivers of Innovation

Innovators find a new idea, an opportunity, or a niche and turn it into concrete business. Entrepreneurial innovation does not only apply to technological change, but to all kinds of people "who are looking not only for new products but for new ways of doing things—in manufacturing, in finance, in services, in management, in the arts, in economics" (Davis 1991: 142).

A common distinction is made between the inventor and the innovator. While invention is about the production of new ideas, innovation is about making "new things happen" (Davis 1991: 142). This is the crucial point where the entrepreneurial person comes to play a primary role as the driver of innovations: "[t]he successful innovator is a *doer*" (Davis 1991: 142). Nonetheless, entrepreneurial activity does not involve doing only, but also "thinking". As Gartner et al. (1994: 6) put it without a detailed review of aspects of cognition, they "would hazard to say that what entrepreneurs think about, and how they go about thinking about what they think about, is critical to understanding much of what occurs during an entrepreneur's activities".

Entrepreneurship is not merely about new combinations of products or processes, but mainly concerned with variation (Gartner 1993), "so that the new combinations that entrepreneurs bring to life are, by their very nature, *differences*, not the norm" (Gartner et al. 1994: 8).

Creating and leveraging innovation through entrepreneurial activity is strongly related to networking, since entrepreneurship involves a connection of people and resources. Therefore, "[t]he 'entrepreneur' in entrepreneurship is more likely to be plural, rather than singular. The locus of entrepreneurial activity often resides not in one person, but in many" (Gartner et al. 1994: 6). Entrepreneurship, networking, and corresponding network concepts are subject to more detail in section 4.5.

4.2 Knowledge Management in R & D – Expert Views

> The pattern of his success was everywhere the same. Surrounded by the magical halo of his wealth and the legend of his importance, he always had to associate with people who towered over him on their own field, but who took a fancy to him as an outsider with a surprising knowledge of their special subject and were intimidated by the fact that in his person he represented connections between their world and other worlds of which they had no idea at all.
>
> (MUSIL 1965: 227-228)

4.2.1 Role and Impact

A central target of the expert survey held for this study (see section 2.4) was to explore the role of knowledge management with regard to the generation of innovations in research and development (R & D). This was done with a focus on three dimensions:

1. general role and impact of knowledge management in R & D,
2. concrete methods, measures, and instruments of knowledge management for innovative knowledge creation in R & D, and
3. identification of central people for knowledge management processes in R & D.

Therefore, the first question with regard to knowledge management in R & D was:

> According to your opinion, what is the role and impact of knowledge management (KM) in the field of research and development (R & D)?

According to the opinion of almost all participants (about the participants of the survey see 2.4.1), knowledge management plays an import or very important role in the field of R & D. Only few participants do not see any importance for knowledge management in R & D or needs for research in this area or did not give an answer to this question at all (a total of 9.6 per cent).

38.5 per cent of the participants focused on the high importance of knowledge transfer in R & D. This includes knowledge transfer through intra- and / or inter-organizational knowledge exchange (19.2 per cent), knowledge transfer between (academic) disciplines (15.4 per cent), knowledge transfer in general (13.5 per cent), knowledge sharing in expert and competence networks (13.5 per cent), and informal knowledge sharing (9.6 per cent).

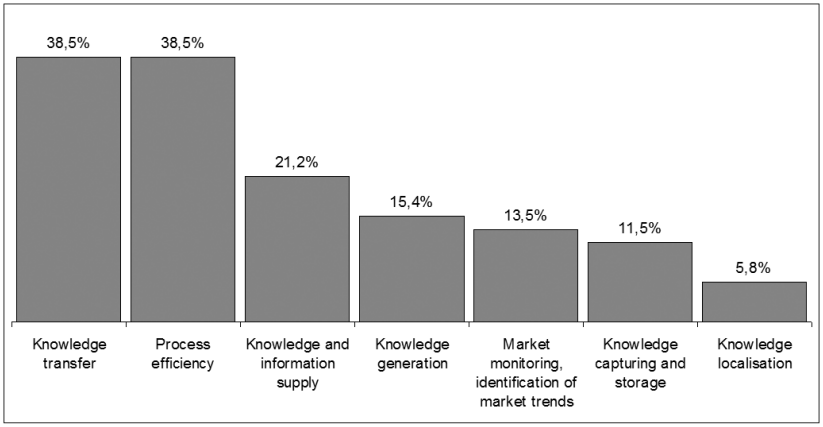

Figure 4.2: Expert Survey: Roles of Knowledge Management in R & D

38.5 per cent of the participants also saw the role of knowledge management in R & D especially in helping to improve efficiency and optimizing processes, like shorter product development and innovation cycles, for example.

Moreover, knowledge management is assigned an important role for knowledge and information supply (like state-of-the-art research and technology) to avoid "duplication of research" and "re-inventing the wheel" (21.2 per cent) and for internal and external knowledge localization (5.8 per cent).

Generation of new knowledge was mentioned as a primary task of knowledge management in R & D by 15.4 per cent of the participants. Capturing of knowledge and knowledge storage (like best practices, experiences from projects, expert knowledge) was mentioned by 11.5 per cent.

Knowledge management also plays an important role for market monitoring (customers and competitors) and market research (identification of trends) (13.5 per cent).

4.2.2 Methods, Measures and Instruments

The next question of the expert survey in the R & D field was:

> Which concrete KM methods, measures, and instruments will gain importance for innovative knowledge creation in R & D?

According to the participants' views (a total of 84.6 per cent), the most important methods of knowledge management in R & D are "networks", "communities" and / or "teams". This especially includes intra- and inter-organizational networks as well as inter-disciplinary networks and knowledge transfer.

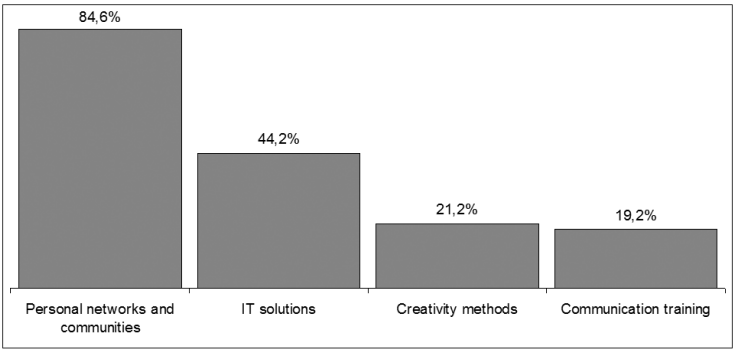

Figure 4.3: Expert Survey: Knowledge Management Methods in R & D

Pointing into a similar direction of methods and instruments, 21.2 per cent of the participants mentioned all sorts of methods to enable and to foster creativity (through means of collaborative workshops, conferences, creative thinking, etc.), 19.2 per cent mentioned communication training (like moderation, conversation, dialogue, storytelling) and other means to facilitate inter-personal knowledge exchange. 5.8 per cent asked for more consumer participation in R & D processes.

While only 1.9 per cent view technical solutions as a primary role of knowledge management in R & D, 44.2 per cent of the participants mentioned information technology (IT) based solutions as important means of knowledge management in R & D. Besides IT systems for automated information and knowledge classification and retrieval (19.2 per cent), this primarily includes IT support for interpersonal communication and knowledge sharing in communities and networks, like expert databases (e.g., yellow maps) (13.5 per cent), on-line "knowledge marketplaces", discussion boards, or groupware (13.5 per cent), reputation systems (7.7 per cent) and individually customized portals (3.8 per cent). Other database applications (like project databases) were mentioned by 9.6 per cent and semantic web technologies were mentioned by 7.7 per cent of the survey participants.

Finally, the participants mentioned methods and instruments for knowledge retrieval in general (9.6 per cent), documentation and (internal) publication of research results (7.7 per cent), and option analysis (7.7 per cent).

4.2.3 Key People

The third question of the expert survey with regard to knowledge management and R & D was:

> "Which participants do you consider as being important for the processes of innovative knowledge creation in R & D? What are their roles?"

Since the survey was based on open questions, the key people in processes of innovative knowledge creation in R & D were identified by the survey participants by using a wide range of different labels. According to 46.2 per cent of the participants, the most important people in R & D processes of knowledge creation are experts, researchers, developers, and scientists. 28.8 per cent of the participants put the focus on “intermediaries” like knowledge brokers and promoters, enablers, facilitators, and moderators. Management and especially top management were mentioned by 26.9 as key people for knowledge creation in R & D. The important role of customers and marketing / sales people for innovative knowledge creation was focused by 26.9 per cent. Also 26.9 per cent mentioned (somewhat meaningless) “all involved persons” as being important. 11.5 per cent of the participants viewed knowledge and innovation managers as playing important roles in R & D knowledge processes. 11.5 per cent mentioned “practitioners”.

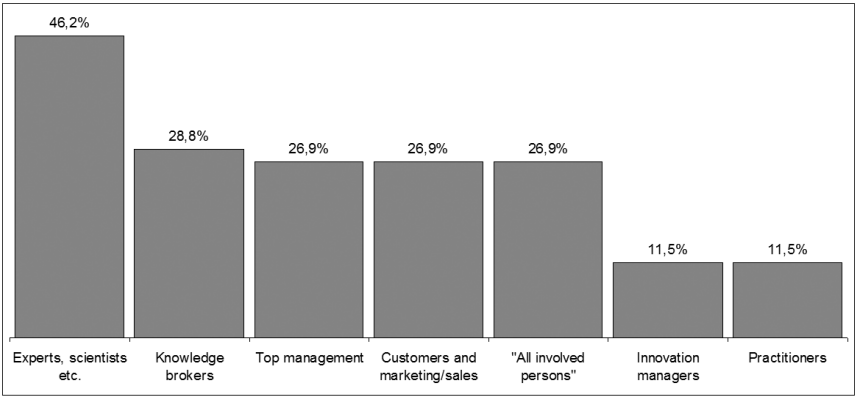

Figure 4.4: Expert Survey: Key People in R & D

4.2.4 Personal Networks and Communities in R & D

Findings of the expert survey related to innovation processes in R & D organizations and environments particularly stress the high importance of knowledge communication and transfer within organizations and across organizational boundaries. As outlined above, knowledge management plays an import role in supporting the social processes of knowledge communication in R & D. Here, networks and communities come to play the primary role according to a majority of the survey participants. These particularly include intra- and inter-organizational networks as well as inter-disciplinary networks and knowledge transfer. Knowledge communities and networks are estimated by the participants as highly important with regard to the facilitation of knowledge sharing, to exchange experiences and to foster knowledge diffusion as well as to connect people (see also sections 2.4 and 3.2). They play a superior role for innovation, especially through enabling creative spaces, creative chaos and productive environments for innovative knowledge generation, as well as a social form of organization to actively influence innovative processes.

As outlined above, the survey participants do not clearly single out the concrete people who play a central role in processes of innovative knowledge creation in R & D. While nearly half of the participants agree on the importance of experts for processes of knowledge creation in R & D, other key people mentioned include the various roles and hierarchical levels involved in R & D processes. This finding may indicate that key people vary within different R & D processes and environments. Nevertheless, nearly a third of the participants mentioned the key roles of knowledge brokers and, additionally, innovation managers who can be understood as institutionalized positions entrusted with the overall task to manage (or better: to facilitate and support) the social processes of knowledge communication and transfer within R & D organizations and their environments.

4.3 Networks and Knowledge Communication in R & D Environments

> Products become obsolete, not only from a technical but also from an economic point of view. Existing products are superseded by new or improved products. The same applies for production techniques.
>
> (BEMELMANS 1979: 33)

4.3.1 R & D, Knowledge and the Organization

Activities and functions of R & D are more than just the process of generating, developing, and diffusing new knowledge to develop products, processes, and services (see Girifalco 1991). Generally, R & D "replenishes 'old' or 'outdated' concepts with 'current' or 'state-of-the-art' knowledge. In most cases, such knowledge advancement occurs incrementally as a result of slow absorption of new knowledge in organizations" (Liyanage et al. 1999: 374; with reference to Martin 1994). The conditions for absorbing new knowledge are determined through "internal managerial processes" and through "external organizational mechanisms and environmental issues" (Winn and Roome 1993) as well as through compliance with standards and quality control systems of customers and suppliers (Clark and Fujimoto 1991).

Firms with R & D activities are engaged in four basic fields of innovation tasks: (1) concept generation, (2) product development and marketing, (3) process innovation, and (4) technology acquisition (see Liyanage et al. 1999: 374; with reference to Ghoshal and Bartlett 1988). Firms can be considered as a form of social organization that specializes in the creation and internal transfer of knowledge. Based on Nelson and Winter's seminal work on an evolutionary theory of the firm (Nelson and Winter 1982), Kogut and Zander's evolutionary approach treats "the firm as a social community whose productive knowledge defines a comparative advantage" (Kogut and Zander 1993: 626).

Often subject to research are the various forms of R & D organization across national and organizational boundaries and the corresponding types of knowledge exchange and efficiency. From the perspective of Kogut and Zander (1993: 625), for example, multinational corporations arise "not out of the failure of markets for the buying and selling of knowledge, but out of its superior efficiency as an organizational vehicle by which to transfer this knowledge across borders. [...] The empirical results show that the less codifiable and the harder to teach is the technology, the more likely the transfer will be to wholly owned operations". Or

as another example, Inkpen studies processes of knowledge creation through collaboration (Inkpen 1996) and learning and knowledge transfer in joint ventures (Inkpen 2000). He distinguishes three types of knowledge: (1) "firms may acquire knowledge useful in the design and management of other alliances" (with reference to Lyles 1988); "[t]his knowledge may be applied to the management of future alliances" (Inkpen 2000: 1020). (2) "[F]irms may seek access to other firms' knowledge in their own operations" (Inkpen 2000: 1021). And (3) "an alliance may generate knowledge that can be used by parent firms to enhance strategy and operations in areas unrelated to the alliance activities" (Inkpen 2000: 1021). The latter is central to his studies and is also called "alliance knowledge".

The research of Kogut and Zander (1993) aims at the examination of the contradiction in discussions of knowledge as a public good or as tacit "by developing continuous scales of the underlying dimensions of codifiability, complexity, and teachability" (Kogut and Zander 1993: 626-627). Furthermore, they question the prevailing assumption that firms exist to internalize markets: "The view we develop is that firms are social communities that serve as efficient mechanisms for the creation and transformation of knowledge into economically rewarded products and services" (Kogut and Zander 1993: 627).

The bond between direct investment and the transfer of firm-specific knowledge as an intermediate good was first made explicit by Caves (1971). An additional condition to Caves' argument is imperfection of markets for the sale of knowledge. As claimed by Johnson (1970), McManus (1972), and Magee (1977), knowledge has the property of being a public good, i.e. it can be transferred at no marginal cost.

Following Buckley and Casson (1976), the public good character of knowledge inheres two critical properties which are that knowledge is claimed to be easily transferred and hard to protect. From this perspective then, internalization is a strong argument to operate corporate networks (see Buckley and Casson 1976: 45). But according to Kogut and Zander (1993: 628), a stronger proposition is provided by Rugman (1980: 368) who argues that multinational enterprise (MNE) arises due to the internalization of the failure of the market for information.

Hennart (1982) states that the costs of information exchange are inextricably linked to the problem of opportunistic behavior of the agents. Or as Kogut and Zander (1993: 629) formulate the statement, "[i]n current parlance, the costs of technology transfer are viewed as stemming from the degree of tacitness of the knowledge."

Teece (1977) argued that technology is not a public good.[43] Costs are derived

[43] As result from the study of 27 projects, Teece (1977) estimates the costs of transfer to range from 2 to 59 per cent of total costs.

from the efforts of codifying and teaching complex knowledge to recipients (see also Kogut and Zander 1993: 629-630).

The outline of these discussions leads Kogut and Zander (1993) to the question of how the implications of tacit knowledge could be understood for the theory of the firm without appealing to transaction costs and opportunism. And they realize in their explorations that "firms define a community in which there exists a body of knowledge regarding how to cooperate and communicate. [...] In our view, firms are efficient means by which knowledge is created and transferred" (Kogut and Zander 1993: 630). And they continue: "Through repeated interactions, individuals and groups in a firm develop a common understanding by which to transfer knowledge from ideas into production and markets. In this very critical sense, what determines what a firm does is not the failure of market, but the firm's efficiency in this process of transformation relative to other firms. It is the difference in knowledge and the embedded capabilities between the creator and the users (possessed with complementary skills) which determine the firm boundary, not market failure itself" (Kogut and Zander 1993: 631). We may add that what applied for traditional forms of formal organization is recently more and more transferred to forms of network organizations, since internal flows of knowledge within organizations are not sufficient anymore to the new demands, and boundary spanning flows of knowledge may provide adequate responses.

4.3.2 R & D Management: Knowledge and Networks

As introduced above, for a long time the focus of research in R & D environments was put on formal co-operative arrangements like joint ventures, licensing, co-production agreements, or management contracts (see, e.g., Contractor and Lorange 1988). But as Hakansson and Johanson (1988: 369) reveal in one of their studies on co-operations between organizations in the field of technical development, more than two thirds of co-operative arrangements are of an informal nature. This shift of focus is reflected in the perspective of R & D management approaches as well. Today, R & D management "is increasingly about managing knowledge rather than simply managing its generation" (Liyanage et al. 1999: 372). It could be added: Managing knowledge in R & D environments means managing social networks.

In the literature, the focus of R & D management is distinguished according to different R & D management generations. It is widely agreed on three generations of R & D management. The upcoming of a fourth generation R & D management is described here as outlined by Liyanage et al. (1999).

- *First generation R & D management* of the early 1960s (see, e.g., Burns and Stalker 1961) emphasized creativity of the individual and venture of sci-

entific discovery with minimal bureaucratic controls. It was driven by the "science push" strategy and concerned with managing research for the generation of scientific knowledge. First generation R & D management was predominantly characterized by "the intuitive mode" and lack of a strategic framework: "This year's budget provides the total framework for R & D" (Roussel et al. 1991: 25, see also 25-30).

- *Second generation R & D management* can be considered as the extension of first generation R & D management. Many authors "emphasized the multidisciplinary nature of R & D, the need for professional project selection and management" (Liyanage et al. 1999: 373; with reference to e.g., Bemelmans 1979; Little 1981; Steele 1989; Schmidt and Freeland 1992). Second generation R & D management transforms intuitive project selection into purposeful project management and thus, tries to respond to "market pull" and "technology push" concepts. First and second generation R & D management both "relied heavily on the treatment of knowledge on individual effort, explicit knowledge and internalized processes" (Liyanage et al. 1999: 377). Roussel et al. (1991: 30-35) identify with second generation R & D management "the systematic mode" and the beginnings of a strategic framework for R & D at the project level that seeks to enhance communications and provide a link between business and R & D management. But it still omits the strategic dimension of third generation management that focuses on "the interrelationships among projects within a business, across businesses, and for the corporation as a whole" (Roussel et al. 1991: 30).
- *Third generation R & D management* provides the linkage between corporate and R & D strategies (see Roussel et al. 1991: esp. 1-5). The close connection of R & D with corporate and business strategies was tried to be achieved by effective communications between research personnel and corporate managers who were advocated to integrate the strategic and operational functions of the organization (Liyanage et al. 1999: 377; see also Roussel et al. 1991). The "strategic and purposeful mode" of third generation R & D management is the first attempt to create a strategically balanced portfolio of R & D across business units, divisions, and the corporation "formulated jointly in a spirit of partnership between general managers and R & D managers" (Roussel et al. 1991: 35, see also 35-40).

These first three generations of R & D management, however, "do not focus on global knowledge, i.e., on the efficiency and effectiveness of knowledge integration and management processes" (Liyanage et al. 1999: 373). None of them systematically attempts to explore the interdependencies between internal R & D processes with external knowledge or technology diffusion. All of these models fail to integrate and combine knowledge from various internal and external re-

sources that resides in organizational and network boundaries and is often known as "boundary spanning" knowledge (see, e.g., Liyanage et al. 1999: 378). Without following the often cited but mostly pointless distinction between tacit and explicit knowledge (see footnote in section 2.2.3), this boundary spanning knowledge can be described as a specialized form of "tacit" knowledge. The knowledge "close to breakthrough discoveries needs to be transformed into words, codes and/or formula before it can be easily transferred. Difficulties inherent to the transfer of tacit knowledge lead to joint research: Team production allows more knowledge capture of tacit, complex discoveries by firm scientists" (Zucker et al. 2001: 21). Nevertheless, these kinds of knowledge processes go far beyond the explicit and tacit categorization.

Becoming aware of the importance of boundary spanning knowledge, *fourth generation R & D management* directly addresses the following R & D management processes (see Liyanage et al. 1999: 378; see also Miller and Morris 1999):

- absorption and integration of external knowledge,
- overcoming the organizational inability to generate knowledge exponentially,
- integration of complementary skills and resources for cost effective knowledge management,
- treatment and management of knowledge as an intellectual asset.

As this brief abstract of R & D management generations shows (see also table 4.1), knowledge and networks are the core concepts of fourth generation R & D management. This fact becomes even more evident by a closer look at what Liyanage et al. (1999: 384-385) call the "knowledge strategy" as one of the key features of the fourth generation R & D management model (besides innovation strategy and industry and technology strategy). Central to the role of networks are the following fields of knowledge strategy (as cited among other key features by Liyanage et al. 1999: 384-385) :

1. extensive networking with academia and industry,
2. dynamic exchange of ideas between researchers and managers,
3. integration of knowledge from various disciplines and gathering technological intelligence,
4. building and operation of cross-functional institutions and research groups,
5. successful integration of changes in knowledge within and across organizational boundaries.

Within the realm of R & D environments, collaboration and networking is often explained with regard to technological (Dodgson 1993), economic (Solow 1988),

Generation	Basic Management Character	Specific Features
First	Incremental resource allocation and the management of R & D as an entity	Science push strategy, mix project portfolio, unlimited time horizons, ease in resource allocation issues, and individual researchers
Second	Project management and project quality	Market pull strategy, project focused, better project evaluation methods, project quality and micro-management of projects
Third	Business strategy links and research planning as a corporate function	Strategically balanced project portfolio, links with business strategy, partnerships, business integration processes and the strategic management of R & D and business
Fourth	External and internal knowledge management, managing research networks and collaborations, strategic research alliances, and linking research, technology and innovation management	Strategic management of knowledge, knowledge organization and external knowledge sources. Linking internal and external knowledge, managing information flows, communication patterns, networks and linkages, organizational relationships, communication strategies and interactions among firms. Integration between research production, and innovation systems.

Table 4.1: Basic Characteristics of R & D Management Generations (see Liyanage et al. 1999: 378-379)

social (Freeman and Soete 1997 (1982)), and organizational (Nelson and Winter 1982) factors. Here, we focus on reasons for network activities due to the very own nature of knowledge and circumstances of knowledge communication in R & D environments.

In his studies of internal R & D networks in global enterprises, Julian Birkinshaw (2002) refers to two special dimensions of knowledge types: observability and mobility. Observability "is the extent to which the knowledge-base of the R & D centre can be understood through observation—by taking a tour of the facilities, by watching the employees at work, or by talking to some employees", while mobility "is the extent to which the knowledge base of the R & D centre can be separated from its physical setting" (Birkinshaw 2002: 247-248). Following Birkinshaw, observability shows some advantages due to its transferability, i.e. it can be passed on to others. However, observable knowledge is also weak to imitation by competitors. Birkinshaw's dimension of mobility of knowledge is the opposite of Kogut and Zander's concept of system embeddedness that focuses on the inseparability of the knowledge activity from its social and physical setting (Kogut and Zander 1993). This distinction between two different types of attributes of knowledge assets (with the additional distinction between the three different types of R & D units: self-contained, modular, home-based) leads Birkin-

shaw to the comparison of two management ways for the overall R & D network: the "integrated" network versus the "loosely-coupled" network.

Focusing on knowledge creation, R & D activities can be distinguished according to the two categories of "exploration" and "exploitation" of knowledge (see Leveque et al. 1993; as cited by Albertini and Butler 1995: 377-378). Exploration means the generation of new knowledge, while exploitation means the extraction of value from existing knowledge. Taking this distinction into account, "[i]n a fourth generation model, the R & D process is determined by different stakeholders' interests in the exploration and exploitation of knowledge. Whilst individuals tend to be driven by the academic value of knowledge, organizations are driven by its exploitation value" (Liyanage et al. 1999: 388). This model supports the conceptualization of networks rather than communities as a theoretical framework for the analysis of organizational knowledge communication. Networks and network participation can be analyzed on multiple levels, i.e. on the individual as well as on the organizational and societal levels (see section 5.2.3), while communities are by definition always based on individual participation.

Looking for suitable methods for fourth generation R & D management, some of the existing tools (see Liyanage et al. 1999: 389-390) have limited relevance to the management of knowledge communication in networks. R & D management tools require not only techniques that deal with the measurement of knowledge, innovativeness and technology related functions and strategies, but particularly methods to analyze and facilitate knowledge communication in networks. As outlined in chapter 5, social network analysis may prove useful for this task (see also Müller-Prothmann 2006b). Its advantages will come true especially when taking the fact into account that it is not "the creation of new knowledge *per se* but the creation of the type of new knowledge which will effectively form synergy with existing knowledge systems of other organizations" (Liyanage et al. 1999: 391).

4.3.3 Internal and External R & D Networks

The systematic handling of synergies with external knowledge resources is another key feature of fourth generation R & D management. It focuses on the application and transferability of knowledge across institutional boundaries. Already in the 1970s, outsiders have been identified as important sources of information (see, e.g., Allen 1977: 126-181) and the collaboration in research networks has been identified as critical management processes for knowledge transfer across R & D units and organizations (see, e.g., Tornatzky and Fleischer 1990; as cited by Liyanage et al. 1999: 386). Thus, the development of international R & D organization as a central issue is complemented with the additional perspective of external R & D organization. Networks that include members of more than one legally-defined

organization are known as "boundary-spanning" networks (Liebeskind et al. 1996: 430-431).

Following Contractor and Lorange (1988: 9-19), the reasons for co-operation in R & D with external partners are: (1) risk reduction, (2) economies of scale and / or rationalization, (3) technology exchanges, (4) co-opting or blocking competition, (5) overcoming government-mandated trade or investment barriers, (6) facilitating initial international expanding of inexperienced firms, and (7) vertical quasi integration advantages of linking the complementary contributions of the partners in a "value chain".

Zanfei (2000: 516-517) describes the example of a new organizational mode of transnational innovation as a "double network" comprising the internal and external networks. Through the example of transnational companies, the internal and external networks and their different relationships and boundaries can be clearly illustrated. Especially for the case of transnational companies, the interconnections between the various internal units play an important role in that they all are involved in organizational knowledge creation and use. These units build the internal networks. However, they "tend to develop *external networks*, with other firms and institutions that are located outside the boundaries of the TNC [transnational company], in order to increase the potential for use and generation of knowledge" (Zanfei 2000: 516). These network relationships involve the central units of the company, on the other hand they "more and more concern the decentralised units as well, which increasingly use such networks to gain access to local sources of information and applications abilities" (Zanfei 2000: 516).

Albertini and Butler (1995) systematically integrate internal and external knowledge resources into the so-called "innovation uncertainty map" based on Pearson (1991). As Liyanage et al. (1999: 377) put it, "[t]he R & D process [...] has to link internal dynamics of the firm with external knowledge relations. The linkage is important to integrate knowledge production with diffusion and utilization".

From a network perspective of knowledge generation and use in R & D environments, the boundary roles in the innovation process gain importance (as outlined already in the 1970s by Tushman 1977): the need for an innovating system to gather information from and transmit information to several external information resources. Based on the process development and innovation diffusion phases and characterized through different types of decisions and problems of coordination as well as through different patterns of communication (see Zaltman et al. 1973; Allen 1977), Tushman assigns different key communication domains and their internal or external orientation to the different phases of innovation (see table 4.2).

The two-step process of communication across organizational boundaries leads to the special boundary roles of gatekeepers and organizational as well as laboratory liaisons. According to Tushman's findings, "beyond the cross-boundary com-

Innovation Phases	Key Communication Domains
I Idea Generation	**Extra-laboratory, extra-organizational communication** with universities, suppliers, vendors, literature
II Problem Solving	**Intra-laboratory communication** with functional areas as well as technical areas outside laboratory
III Implementation	**Laboratory and functional area communication** particularly between R & D and manufacturing and marketing

Table 4.2: Innovation Phases and Key Communication Domains (following Tushman 1977: 588 who adapted the figure from Myers and Marquis 1969)

munication function, boundary roles also seem to be an effective way of dealing with extra-unit uncertainty" (Tushman 1977: 601).

R & D networks can be developed through three basic types of knowledge acquisition and transfer: (1) internalization within the firm, (2) market contracts, and (3) relational contracts. Or as Liebeskind et al. put it: (1) "internal sourcing through the use of hierarchy", (2) "external sourcing through market exchanges" and (3) "external sourcing through social networks" (Liebeskind et al. 1996: 430). Market-based transfers "can be efficient means of transferring knowledge embodied in a product (Demsetz 1991) but relatively inefficient when the knowledge is complex and difficult to codify" (Inkpen 2000: 1022).[44]

As outlined in this section, a number of authors assume the importance of formal and informal network co-operations for innovations, especially in the field of international R & D environments. For at least 20 years, inter-organizational industrial clusters and networks have been recognized as key drivers of innovations (see, e.g., Piore and Sabel 1984) and are assumed to be key players in R & D activities in providing pools of shared resources and networked knowledge. However, the debates in knowledge management widely neglected them. Moreover, none of the recent studies on knowledge communities takes the existing theoretical approaches or empirical studies into account. This leads to the conclusion that it seems sometimes to be of more value to successfully pour new wine into old bottles than failing to reinvent the wheel. And although the approaches of innovation research of the last years as well as recent debates in knowledge management emphasize the importance of internal and external factors as preconditions of R & D,

[44] The same argument is true for the conceptualization of communities as knowledge markets and approaches to introduce market mechanisms, price systems, and incentives for knowledge sharing as promoted, for example, by Schmidt (2000); see also section 2.3.

their combined effects on innovations and organizations are nearly unknown until today and need further research (see also Freeman 2002).

In many cases, the starting point of research is the international (industrial) innovation system, and results are presented as taxonomies of network typologies and isolated dependent variables that have some influence on these constructs. Hellström et al. (2001: 257) suggest, for instance, that "active mapping of particular R & D networks of interest should be an important strategic management tool for R & D managers".[45] Demanding also further research "to understand the exact coupling processes between inside and outside knowledge and its management attributes", Liyanage et al. (1999: 391) focus on research management tools that "are likely to emerge by examining networking, organizational learning and managing intellectual capital concepts". Social network analysis could be one of these tools among others and could contribute to the facilitation of knowledge sharing in social networks as proposed by Müller-Prothmann and Finke (2004a) and Müller-Prothmann (2006b) and is outlined in further detail in chapter 5.

4.3.4 R & D Networks and the Dimension of Space

There is a long history of research into human interaction and physical proximity (see, e.g., Leavitt 1951; Gullahorn 1952; Steinzor 1950; Hare and Bales 1963; Festinger et al. 1963 (1950); for an early study on the influence of architecture on interpersonal communication in R & D networks see, e.g., Allen 1977: 234-265). When speaking of multinational enterprises (MNEs) or transnational companies (TNCs) as networks of innovators (like, e.g., Zanfei 2000), the spatial dimension comes to play a crucial role, i.e. the duality of locality and globality. To at least take the spatial dimension into consideration, this section will briefly point to some important characteristics without discussing them in more detail since they go far beyond the scope of this study.[46]

Commonly, local contexts are different. Thus, they provide sources of differential advantages, i.e. "there are high location-specific advantages from the decentralization of R & D"; or to put it another way: "internal networks are by and large a response to high and increasing diversity of local contexts" (Zanfei 2000: 521). Local contexts can be considered as sources of competencies and technological opportunities. This provides arguments for the need of autonomy of decentralized R & D centers within transnational companies as independent units. Decentralized R & D centers are characterized by Zanfei (2000: 526) as follows:

[45] They propose a method for mapping R & D activities in a network database of the co-operating projects and institutions based on internet technologies on the example of research in the telecommunications sector.

[46] For the case of communities as well, the role of space is outlined briefly in section 3.3.

- local R & D laboratories are powerful "sensors" of technological opportunities; the better they are "locally embedded", the more advantages they provide,
- host-country-based R & D laboratories play a role that is complementary to non-formalized innovative activities carried out by manufacturing and sales units abroad,
- local R & D laboratories mediate between the pool of knowledge circulating within the transnational company network; the body of contextual knowledge is accumulated at the affiliate level.

With a reference to Cohen and Levinthal (1989), Zanfei points to the assumption that the R & D personnel in a transnational company generally share a common language, a system of conventions and of behavioral norms that enable them to communicate more easily across national boundaries.

Nevertheless, of course a variety of barriers of free knowledge flows exist within transnational R & D environments mentioned by Zanfei as well. First, he mentions the constraints on the adoption of new technology. It can be assumed that highly autonomous subsidiaries may not be willing to utilize knowledge that is available within the transnational company complex. Second, he takes into consideration the obstacles to the transfer of knowledge. From his point of view, "[t]he autonomy of subsidiaries may also put a brake on the willingness and capability of decentralised units to contribute their own knowledge to the network" (Zanfei 2000: 527).

Although these barriers of knowledge sharing exist without doubt, networks can be assumed as enablers of direct contacts between the partners of knowledge transfer. When Lam (2003: 676) speaks of the uniqueness of multinational enterprises as knowledge creating organizations due to "their ability to create 'transnational social spaces' for learning", it is their network character on the individual as well as on the organizational level that facilitates this uniqueness.

4.3.5 Social Networks in R & D Environments

According to Jain and Triandis (1990: 21-43), R & D management should always be guided through its business, technology, and innovation strategies that are realized by manifold enabling mechanisms like people, ideas, communication networks, funds, and cultural elements. To take all of these aspects into account would go far beyond the scope of this work. Here, the focus is put on knowledge communication in R & D environments through social networks in a very narrow sense.

Following the distinction of the different phases of research (see section 4.1.1), Tushman (1982: 351-352) characterizes the key features of research projects, de-

velopment projects, technical service projects and their corresponding communication networks as follows (as cited by Jain and Triandis 1990: 29-30):

- High-performing *research projects* are characterized through extensive and decentralized communication patterns. External information from professional areas outside the organization is acquired through direct contacts and gatekeepers. The contacts within the organization are directed toward individuals who could provide effective feedback and evaluation. "In general, there was less reliance on supervisory direction and more on individual initiative and peer decision-making and problem-solving" (Jain and Triandis 1990: 30).
- High-performing *development projects* are characterized through their focus on communication patterns directed toward operationally oriented areas ("how to get things done"; "what works, when") both within and outside the organization. External communication is moderate and usually mediated by gatekeepers. Internally, the supervisor mediates the majority of the communication. Additionally, widespread and direct communications with the user exist (in the fields of marketing and manufacturing, for example).
- High-performing *technical service projects* are characterized through "supervisor-dominated communication patterns" both within and outside the organization. The external communication partners include for example suppliers, vendors or customers. The supervisor plays a role as mediator for all external resources.

With regard to the different phases of research, "different R & D activities require different communication networks" (Jain and Triandis 1990: 31). As shown by experience, there is an "evolution of language, concepts, values unique to the types of projects undertaken and, at times, unique to the organization itself." And while this common understanding facilitates communication with a project team (or within a densely connected network), "[t]his local language and other characteristics make communication with the outside—that is, beyond the organization project boundary—difficult and prone to bias and misunderstanding" (Jain and Triandis 1990: 30; with reference to Tushman 1982: 357).

Furthermore, following the types of relationships on the different levels of collaboration, organizations, and individuals (as outlined by Liyanage et al. 1999: 387-388), the networks in R & D can be distinguished according to their level of individual, organizational, or institutional (societal) knowledge management processes as illustrated in table 4.3.

Following Collinson and Gregson, the "[i]nitial contacts from social networks evolve into business-focused networks, and then into strategic networks, which allow firms to innovate and to thrive by their links to other organizations" (Collinson

Network Levels	R & D Process	R & D Objective
Collaborations	Integration	Resource complementary, reduce risks, pool resources
Institutional / Organizational	Linkages	Value creation, long range planning
Individual	Creation	Knowledge creation, creativity and inquiry

Table 4.3: Network Levels and Knowledge Management Processes (see also Liyanage et al. 1999: 387-388)

and Gregson 2003: 192; with reference to Aldrich and Zimmer 1986; Butler and Hansen 1991; Dubini and Aldrich 1991; Falemo 1989; Flynn 1993; Johannisson 2000). This shows the conceptual similarity of the role of social networks in innovation management to their role in entrepreneurial networks (see section 4.5).

The focus on R & D management from a perspective of social network points to the fact that "[t]he management of research collaborations is far more difficult than managing research at organizational and individual levels" (Liyanage et al. 1999: 387). First, we need to take the cross-level effects into account. And second, we need to take into account the societal level and the search for enablers to institutionalize innovative knowledge transfer in society (see also section 4.4).

The transfer of innovations in society is often subject to social network research known as diffusion studies. "*Diffusion* is the process by which an innovation is communicated through certain channels over time among the members of a social system. It is a special type of communication, in that the messages are concerned with new ideas" (Rogers 1983: 5). Following Rogers (1983: 10-34), we can distinguish four elements in the diffusion of innovations: (1) the innovation itself, (2) the communication of innovations (channels), (3) the dimension of time in the diffusion of innovations, and (4) the social system in which the diffusion of the innovation takes place.

4.3.6 Communication and Management of Knowledge in R & D Networks

During the last two decades, the linear model of subsequent phases of research as outlined in the previous chapter has been abandoned in favor of recursive models (see Kline and Rosenberg 1986). These models do not assume sequential phases anymore (Schmoch et al. 2000: 5-7), but recursively interconnected phases that are passed through multiple times ("multiple cycling"). This shift of perception of the technology development process is significantly further extended through approaches from a network perspective (Reinhard 2001: 15). A network per-

spective on the technology development process is primarily based on the Coase Williamson theory of markets and hierarchies (see also section 4.4.1). Following this theory, networks differ from other types of organizational interactions in that they achieve co-ordination neither through market mechanisms nor through hierarchy (see also section 4.4.1). Rather, social networks reach co-ordination on the normative basis of the partners' mutual objectively and subjectively felt advantages (see Hakansson 1989: 15-26; Freeman 1991: 506-510). Thus, they provide a distinct type of co-ordination mechanisms, which are especially useful for the efficient organization of innovation activities (Reinhard 2001: 15). This network perspective on knowledge transfer as a type of co-ordination that is distinct from market mechanisms and hierarchical co-ordination proves the fundamental misconception of knowledge sharing as so-called knowledge markets. Other authors who criticize the linear model of research phases speak of an "interactive" or "coupling" model of innovation (see Asheim and Cooke 1999). Collinson and Gregson (2003: 191) speak of "distributed innovation" which means "collective action amongst firms in a distributed innovation network which cannot be reduced to market transactions and formal contracts". Although not all of these authors speak of networks, the various concepts of social or organizational interaction, collaboration, and co-ordination in innovation management imply the network perspective more or less focused.

Looking at knowledge communication in innovation management, we can borrow some of the insights on the knowledge management model for knowledge flow in the R & D process as outlined by Armbrecht et al. (2001). They share the conception of a central position of human beings in the processes of knowledge creation and transfer. Their knowledge flow models conceive of the complexity of interaction and suggest a model of "a highly interpersonal and iterative process of filtering, focusing and expanding in which the creative process takes place" (Armbrecht et al. 2001: 32). They study aspects of knowledge management that are unique or especially important for the process of R & D through interviews with R & D managers and derive therefrom a catalog of best practices. The highest priority issues for knowledge management as mentioned in these interviews are (Armbrecht et al. 2001: 33):

- "What kind of culture facilitates knowledge flow and how can it best be designed, incorporated and managed?"
- "How can the knowledge of experts and people leaving the organization be captured?"
- "What can be done to accelerate the R & D process?"
- "How can the creativity envelope withing the R & D organization be expanded?"

Armbrecht et al. (2001) find the critical influence of culture, infrastructure and technology as enablers of effective knowledge flows, and based on these factors the two knowledge flow practices of (1) networks and (2) sharing, learning, and ideation. As central to the topic of communication and management of knowledge, they identify two general themes of the network practice in R & D processes (Armbrecht et al. 2001: 35-36):

- networks of experts from diverse backgrounds are consulted on major developments (embedding multiple core competencies in a single product concept, contact sources for experts),
- (particularly valued in larger companies) networks of experts who work in the same field but are dispersed organizationally or geographically (communities of practice).

These findings support the three important management requirements for R & D networks as emphasized by Liyanage et al. (1999: 378): creativity, network linkages, and knowledge exploitation. A researcher team at the Centre for Research on Innovation and Competition at the University of Manchester (CRIC) suggests for priority in research in three areas (as cited by Collinson and Gregson 2003: 191): (1) coordination mechanisms that facilitate innovation networks, (2) risks and incentives for network participants, (3) competitive advantage, demonstrated by additional returns to members, which result from "superior" networks and highly efficient coordination mechanisms. As outlined in chapter 5, social network analysis provides not only a conceptual framework for research on innovation networks, but also an analytical tool for the empirical study and support of networks within and between organizations that may contribute to further insights into these areas of research.

4.4 Institutionalization of Knowledge Transfer in R & D: Networks as Intermediaries

> It is these relationships between the individuals, firms and institutions in the region that matter—not their simple presence. [...] Creating a dynamic high-tech region is not a matter of combining ingredients. It is one of building institutions and relationships—both locally and nationally—that support the development of innovative enterprises.
>
> (SAXENIAN 1988: 74-75)

4.4.1 Networks as a Third Form of Organization Beyond Market and Hierarchy

In the literature, different types of organization of exchange are identified. Commonly, the authors distinguish between co-ordination through market mechanisms and co-ordination through hierarchy (or bureaucracy), facilitated by means of price and authority. Some authors add a third form of co-ordination to market and bureaucracy, that of "clans" (Ouchi 1980), facilitated by trust (Bradach and Eccles 1989), for example. During the late 1980s and early 1990s, the researchers started to recognize networks as a third form of organization that is distinct from market or hierarchy. Following Powell (1990), exchanges through social networks constitute a separate and distinct form of organization, i.e. exchange predicated trust. Liebeskind et al. (1996: 430) differentiate social networks from markets and hierarchies within the theoretical framework of Coase (1937), Masten (1988) and Williamson (1991) as follows:

1. "Unlike hierarchies, but like markets, social networks involve *exchanges between legally distinct entities*".
2. "Unlike markets, but like hierarchies, *social networks support exchanges without using competitive pricing or legal contracting*".

In social networks, shared norms of trustworthy behavior develop through socialization and tradition and may evolve over time. "Therefore, a social network can be defined as *a collectivity of individuals among whom exchanges take place that are supported only by shared norms of trustworthy behavior*" (Liebeskind et al. 1996: 430). This kind of perception of a social network converges with the conceptualization of community as outlined in section 3.3. But the network concept allows for the establishment of indirect relationships of trust (see, e.g., Burt 2001). Therefore, loosely coupled networks can be more adequately considered as trustworthy means of knowledge transfer based on indirect relationships.

As outlined for the case of entrepreneurial (section 4.1.1) and innovation networks (section 4.5), networks are conceived as an efficient arrangement for the communication of knowledge. Following the argument of Powell (1990), social networks are the most efficient organizational arrangement for sourcing information due to the difficulties of assigning a price (in a market) or of communicating through a hierarchical structure: "Networks are particularly apt for circumstances in which there is a need for efficient, reliable information. The most useful information is rarely that which flows down the formal chain of command in an organization, or that which can be inferred from price signals. Rather, it is that which is obtained from someone you have dealt with in the past and found to be reliable. You trust information that comes from someone you know well" (Powell 1990: 304). Or as Liebeskind et al. (1996: 431) express it, "social networks serve as sources of reliable information".[47]

4.4.2 Institutionalized Intermediation through Social Networks in R & D

Here, it is argued that social networks provide effective means to institutionalize intermediaries for knowledge communication within and between organizations. This argument is based on the facilitation of trustworthy relationships for the exchange of information and knowledge through networks due to their character as a distinct organizational arrangement beyond market or hierarchy as outlined above. This distinct character also provides the basic argument for overcoming the misinterpretations of the concept of so-called knowledge markets as promoted by some authors (e.g., Schmidt 2000).

Although from the perspective of knowledge adopted here, ultimately all exchanges of knowledge take place between individuals, while organization-level arrangements can support individual-level exchanges (see Liebeskind et al. 1996: 433) or hinder them only. Liebeskind et al. (1996) classify according to their results of empirical studies on new biotechnology firms (NBFs) "market exchanges" as: (1) exchanges between the scientist-employees of a firm (NBF) and employees of other organizations with which the firm has some type of formal contractual agreement for the supply of scientific knowledge, or (2) exchanges between the scientist-employees of the form and individuals (a) who are not employees of the firm, and (b) who are not employees of any other organization with which the firm has some type of formal contractual agreement for the supply of scientific knowledge, but (c) are parties of a formal, legally enforceable, individual contract with the firm for the supply of scientific knowledge. According to their classification, "social network" exchanges are exchanges of scientific knowledge between

[47] The same argument applies for the case of social networks of academic scientists ("Invisible Colleges"), i.e. they ensure reliability of scientific information (see, e.g., Crane 1972; Merton 1974).

scientist-employees of a firm and individuals who are not employees of the firm or of any other organization with which the firm has some type of formal contractual agreement for the supply of scientific knowledge, and who are not parties of any formal, legally enforceable, individual contract with the firm (Liebeskind et al. 1996: 433).

Promoting the institutionalization of knowledge exchange through social networks in R & D for purposes of the generation of new knowledge and innovation, the conflicts arising between individual and organizational values must be noted at least briefly: "It is generally accepted that the dissonance between individual and organizational values and goals is perhaps greater in the R & D function than anywhere else in the organization except on the production shop floor" (Martin 1984: 212). Goal and value conflicts between the individual researcher and the organization can be pointed out with dichotomic keywords like "publication" versus "innovation" or "generation of new knowledge" versus "commercial exploitation". As stated by Martin (1984: 214), "research staff identify more closely with the informal network and status system of their professional peers rather than that of the organization".

These conflicts demand matching individual and organizational needs. The researcher is embedded in the formal organization and the manifold informal networks within the organization on the one hand and on the other hand he or she is a member of other formal and informal networks with his or her professional peers that are not (or only partly) congruent with the networks of his or her organization. Being the interface between the internal and external networks, individual persons have a gatekeeper or brokerage function for information and knowledge flows from the organization's outside world to the inner organization (for a more detailed look at the structural nature of brokerage roles see also section 5.7.3). These might be brokerage roles for technical knowledge, scientific knowledge, or market knowledge, for example. To grant access to the outside knowledge sources and, thus, to new knowledge, inventions, and state-of-the-art science, the organization is strongly dependent on their brokers. Therefore, the brokerage roles should be strongly and purposefully supported. And moreover, the organization must develop strategies to sustain access to outside knowledge sources even in case it looses the individual brokerage person, for instance, in case of illness or exit. A suitable strategy might be to install "double" brokerage roles, i.e. to introduce some kind of apprenticeship model that aims at introducing a second person to the broker's personal relationships. Identification and support of the critical brokerage roles within and between organizations can be reached through methods of social network analysis as outlined in chapter 5, especially in section 5.7.5.

4.4.3 Advantages and Examples of Institutionalized Innovation Networks

The basic idea of the institutionalization of social networks as intermediaries for knowledge transfer in the field of R & D is support by empirical studies. In the 1960s and 1970s already, researchers in business science have started investigations in network structures of R & D laboratories (see, e.g., Allen and Cohen 1969; Allen 1977; Frost and Whitley 1971; Katz and Tushman 1979; Tushman 1978). In the 1980s and 1990s, research on intra-organizational networks in industrial enterprises has excessively increased and lead to the general consensus that networks matter. While there are various studies on general networks within and between organizations, studies on knowledge sharing through social networks within and between R & D organizations are hard to find. Further research is needed from a knowledge perspective, like the study presented here tries to approach. Moreover, studies on social networks especially in the field of applied research are even more rare. Only few studies exist in the field of product development (e.g., Biemans 1992; Gabbay and Zuckerman 1998).

In a study already mentioned above, Liebeskind et al. (1996) examine social networks in R & D on the example of new biotechnology firms (NBFs). According to their results, social networks show the following advantages in R & D (Liebeskind et al. 1996: 432):

- early access to, or knowledge about, new discoveries,
- direct integration of external knowledge into the ongoing R & D program through collaborations (that could not be achieved with pure market exchanges) (see also Cohen and Levinthal 1990; Grant 1996),
- reduction of sunk costs, market and transaction costs,
- protection against appropriation (more than markets),
- access to unique resources (expert knowledge).

Liebeskind et al. (1996) found the social networks in new biotechnology firms to be deeply rooted organization-level and individual-level exchange arrangements.

Projects and studies on the institutionalization of knowledge transfer in innovation networks include for example the "Virtueller Technologie- und Kompetenzmarkt Hessen", which is part of the TechnologieTransferNetzwerkes (TTNHessen) (see Schmidt and Stratmann 2001), the case study on R & D networking in the pharmaceutical company of Glaxo Group Research (see Albertini and Butler 1995), which emphasizes the relationships between internal and external knowledge, or the management of a network of R & D laboratories through means of observations of 16 clinical case studies of European, North American and Japanese companies (see Meyer 1993). Other English language literature on R & D management responses to the environmental challenge can be found in a paper by Winn and Roome (1993).

Another example of the intermediation of knowledge through institutionalized networks are various recommendations for the organization of the scientific knowledge and technology transfer in Germany. Initially, the technology-political initiatives in the field of technology transfer between public research institutions and private enterprises date back to the recommendations of the "Kommission für wirtschaftlichen und sozialen Wandel" (Commission for Economic and Social Change) in 1977. The commission recognized as the core problem the difficulties of diffusion relationships between research and small and medium sized enterprises resulting from their different goals and cultures (see Reinhard 2001: 14). The recommendations of the commission lead to the establishment of various transfer organizations for consultancy and the mediation of knowledge and new discoveries. Since the early 1990s, a variety of studies have questioned the efficiency of these transfer organizations due to their conceptual and structural deficits (see, e.g., Reinhard 2001; Schroeder et al. 1991; Reinhard and Schmalholz 1996). Basically distinct from these transfer organizations, networks allow for the direct contact between the transfer partners without intermediaries. Therefore, it can be concluded that networks serve as intermediaries by establishing direct contacts: they allow for the institutionalization of knowledge transfer as an intermediary without (formal) intermediaries.

An overview over the situation of transfer organizations in Germany and the study of their conceptual role for knowledge and technology transfer between academia and business practice is provided by Czarnitzki et al. (2001). In this study, several recommendations are given to strengthen networking activities of the intermediary institutions. The authors state that some networking activities are happening already, but that they still remain on a low level of intensity (Czarnitzki et al. 2001: 47-48). The same research team found network activities to be central for the knowledge and technology transfer in a previous survey with participants from universities and other public research institutions on the interaction between academia and private economy in Germany (Czarnitzki et al. 2000). This study, sponsored by the German Federal Ministry of Education and Research (BMBF), explores roles, positions, and relevance of universities and public research for knowledge and technology transfer. A newer study analyzes possibilities and influence factors to enable technology transfer between academia and business through means of internet technologies (Czarnitzki and Rammer 2003).

A network approach for the improvement of innovation processes can also be found in the "InnoRegio" initiative of the German Federal Ministry of Education and Research (BMBF). This initiative of 1999 aims at a sustainable improvement of the employment situation and the economically competitive strength of the former East German regions through the establishment of regional networks. These (formal) networks are established for joint innovation projects in co-operations be-

tween private and public sector, science, education, and economy (for the results of a study on communication and relationships in the regional innovation networks of the “InnoRegio” initiative see Müller et al. 2002).

4.5 Entrepreneurial Social Networks

> The most important is the character of the entrepreneur, to create and build something new and more effective.
> (FALEMO 1989: 169)

4.5.1 Networking and the Entrepreneurial Person

Focusing on the role of social networks in research and development (R & D) environments, the networking activities of individual network members play a central role. From this perspective, we have to put our focus especially on entrepreneurs as people who can be characterized as maintaining excessive networking activities. Generally, entrepreneurs are described as people who have a high capability of taking advantages from hidden opportunities, who are able to mobilize resources, who find opportunities to open up new markets, and who are able to link existing products, services, or ideas for new combinations. Entrepreneurship then may be defined as the "process by which individuals—either on their own or inside organizations—pursue opportunities without regard to the resources they currently control" (Stevenson and Jarillo 1989; as cited by Dubini and Aldrich 1991: 305). Therefore, entrepreneurship plays an important role for the allocation of resources in the economic system, especially for using new resources and finding new uses of already well-known resources (see, e.g., Falemo 1989: 169). Often, entrepreneurs are also characterized by the comparison with managers: "Entrepreneurs, in contrast to managers, thrive on unsettling and turbulent conditions. Their greatest gains are made when discontinuities and gaps appear in society's economic fabric" (Dubini and Aldrich 1991: 305). Managers themselves maintain external contacts not with entrepreneurs in a narrow sense, but with people "who, in a different degree, have entrepreneurial characteristics" (Falemo 1989: 169). The empirical study by Falemo (1989) with a focus on small and medium sized enterprises in the production section in a county of northern Sweden showed that "[t]hrough external persons, most managers channeled resources which in turn had importance for the firm's marketing and product development" (Falemo 1989: 171). This organizational-boundary spanning network to an entrepreneurial-like external person allows, through network factors and personal characteristics, the transfer of competence via a strategic organizational affiliation to a particular firm without formal employment (see Falemo 1989: 176).

The mobilization of resources to pursue opportunities "requires entrepreneurial contacts, knowledge, and confidence" (Dubini and Aldrich 1991: 305-306). It also involves the exploitation of indirect contacts to raise financial resources, man

power, and effort for a venture with an uncertain future. This kind of characterization shows that entrepreneurship is inherently a social network of knowledge communication for the generation of innovations. And entrepreneurial action is a networking activity. Networking can be treated "like any other social skill that can be learned" (Dubini and Aldrich 1991: 306-307; with reference to Grieco and Hosking 1987; Johannisson 1987).

Often, networking is felt to be a distinct activity from ordinary business behavior (Dubini and Aldrich 1991: 307). Different from market-mediated transactions, where people never see each other again, in network-mediated transactions people expect to see each other frequently and are in a long-term relationship. As a consequence, market-mediated transactions are basically characterized by "opportunism, uncertainty, and exit", while networking, where people deal with each other frequently over an extended period, is basically characterized by "trust, predictability, and voice" (Dubini and Aldrich 1991: 307-308). This basic characteristic of networking is especially convincing when looking at the findings of game theory on co-operative behavior. Therefore, networking can be described as the expansion of "one's circle of trust" (Dubini and Aldrich 1991: 308). But to equal this kind of trust with the network term of strong ties (see section 5.1.4) as Dubini and Aldrich conclude this argument, has already been found to be wrong by Granovetter's (1973) studies on "the strength of weak ties". As de Meyer (1993: 116), for example, states, "[c]onfidence between engineers has perhaps, like nuclear radiation, a half-life time", they may lose some strength of their relationships. Nevertheless, their basic relationship may resist, although on a weak level. When Dubini and Aldrich (1991: 308) continue that the "*diversity* of entrepreneurs' network is crucial to the scope of opportunities open to them", they exactly point to the importance of weak ties. Thus, indeed, we can agree with their statement that "most personal networks will include a mix of weak and strong ties, and it is the relative balance of weak to strong that is crucial" (Dubini and Aldrich 1991: 308). But from a network perspective it is not the strength of ties that explains entrepreneurial opportunities. It is the concept of structural holes that is more suitable for the explanation of entrepreneurial opportunities in network terms as outlined below (section 4.5.2, see also section 3.5.3). Without reference to the concept of structural holes, it is exactly this concept that is central to these authors' request for increasing network diversity for successful entrepreneurial action (Dubini and Aldrich 1991: 311-312).

Moreover, Dubini and Aldrich (1991) distinguish between "personal networks" in the entrepreneurial process and their aggregation to what they call "extended networks". These extended networks might be aggregated again on a higher level and be then analyzed as intra-firm or inter-firm relations. The personal network "consists of all those persons with whom an entrepreneur has direct relations (or,

for some purposes, indirect relations via direct relations)" (Dubini and Aldrich 1991: 307). While personal networks "are constructed from the viewpoint of a particular individual", extended networks "are the collective result when interconnected personal networks are examined" (Dubini and Aldrich 1991: 309). They argue that this distinction is fundamental since "[t]he need for separating the two concepts is not just formal, as such things as a company's goals, values, culture [...] might at a certain point conflict with its owner's" (Dubini and Aldrich 1991: 309). Nevertheless, this distinction is similar to the distinction between ego-centered and whole network analysis as social network analysts would rather call them (see section 5.1.3).

4.5.2 The Entrepreneurial Capital of Structural Holes

Once Nohria (1992: 3) has called the literature on social network research a "terminological jungle in which any newcomer may plant a tree". Burt (1992), definitely not a newcomer in the field of social network analysis, has planted one of the largest trees in this jungle with his theory of "structural holes", not undisputed with regard to its conclusiveness (see also section 3.5.3). "[N]etworks rich in the entrepreneurial opportunities of structural holes are entrepreneurial networks, and entrepreneurs are people skilled in building the interpersonal bridges that span structural holes" (Burt 2000: 11).[48]

Central to Burt's concept of structural holes is the functional importance of so-called "bridges". Granovetter (1973) distinguished in his popular study on "The Strength of Weak Ties" between strong, weak, or non-existing ties between people. Due to insights from group psychology on cognitive balance, he found that if an actor A has strong relationships with two other actors B and C, it is unlikely that B and C are only weakly or not connected with each other. Granovetter called that combination the "forbidden triad" (Granovetter 1973: 1363). In his study, he found that those actors play an important role for information sharing (in his study, information sharing for the purpose of finding new job opportunities) that build connections through a weak relationship between groups of actors that are otherwise not connected. These connections he called "bridges", i.e. "a line in a network which provides the only path between two points" (Granovetter 1973: 1364). Therefore, bridges facilitate information sharing between two groups that would not exist without this bridging relationship (Granovetter 1983: 204-205).

[48] As Burt notes, the higher responsiveness of networks compared to a bureaucracy, i.e. easily shifting network time and energy from one solution to another, has been vividly illustrated in networks of drug traffic by Williams (1998) and Morselli (2001) or health insurance fraud by Tillman and Indergaard (1999), for example.

Without them, the network would be highly fragmented into separate groups that are not connected.

This insight by Granovetter provides the basic foundations for Burt's concept of structural holes. Actors who bridge two unconnected groups have strong influence and control of information flows between these groups. A network actor benefits most from his or her social capital, if he or she can play a brokerage role between two groups due to his or her bridging position. Since he or she controls information flows between those groups, he or she can play one group off against the other group. Drawing back on Simmel (1992 (1908): 134-143), Burt calls this role the "tertius gaudens" ("the third who benefits", see Burt 1992: 30-32).[49]

The bridging position of structural holes provides the entrepreneurial capital of actors in terms of network theory. "The advantages of bridging structural holes emerge from an individual generating constituency for new ideas synthesized from the diverse information clusters to which a network entrepreneur has access. Creativity and learning are thus central to the competitive advantage of structural holes" (Burt 2000: 20). Burt (2000: 43-67) identifies five corresponding contingency factors:

- motivation: personality and culture;
- network content (kinds of relations);
- peers and task uncertainty;
- network closure;
- social capital of outsiders.

[49] See also the outlines of section 5.7 on betweenness centrality.

4.6 Limits of the Network Concept

> Networking may result in a time-consuming and fruitless effort, and leave potential partners highly frustrated.
> (DUBINI AND ALDRICH 1991: 305)

4.6.1 Big Mother: The Metaphor of Social Net(work)s and its Critiques

Nets and networks as symbols have a long tradition on the various cultures, especially as symbols of catching and gathering.[50] According to Keupp (1987: 12), the network concept is of remarkable simplicity and belongs to the kind of socio-scientific knowledge that raises the question of non-experts about why these academics care so much about such a trivial everyday phenomenon.

Fröhlich describes networks as being the projection screens for hope and idealistic conceptualizations of social organizations with regard to social groups (minorities), organizational structures, the individual person, and to alternative sullenness of technical and scientific development: the net is a "soft" euphemistic term of systems (Fröhlich 1996: 8) and networking is nothing else than "socialization light" (Fröhlich 1996: 9). Nonetheless, Fröhlich admits that a certain reality of the network metaphor cannot be neglected: the most typical feature of nets are their (usually large) holes, i.e. empty sets of relations and network nodes that are marginally connected and, thus, only indirectly linked to others. But the loose coupling of nets characterizes only the surface of subjectively experienced reality and do not provide any reason to give up the perceptions of fundamentally densely interconnected relationships of economic, technical, political, and other big organizational deeper structures, underlying below the surface, and the actual interconnections between groups and individuals along extensive chains of actions (Fröhlich 1996: 9).

Following this argumentation, we must ask how to realistically analyze and trace the deep structures mentioned by Fröhlich. There will rarely be an alternative possibility than exploring the phenomena on the surface and use these results for the attempt to draw conclusions on the underlying deeper structures. From this perspective then, we will find that social network analysis indeed provides a suitable theoretical concept as well as an analytical method with practical relevance within the scope of our subject of research, despite all objections.

[50] See also Fröhlich (1996: 1); with reference to Oesterreicher-Mollwo (1978: 117), Biedermann (1989: 306), Heinz-Mohr (1984: 221), and Grimm and Grimm (1991 (1889)).

4.6.2 Limits of Social Network Analysis as a Theoretical Framework

Barabási (2003) believes in the emergence of a new scientific discipline: networks. Following Barabási (2003: 216-217), networks can be found everywhere, in nature, physical, technical and social organization. Nevertheless, he admits that "[n]etworks do not offer a miracle drug, a strategy that makes you invincible in any business environment. The truly important role networks play is in helping existing organizations adapt to rapidly changing market conditions. [...] Yet no matter what organizational level we look at, the same robust and universal laws that govern nature's webs seem to greet us. The challenge is for economic and network research alike to put these laws into practice." Therefore, Barabási's interest lies in finding the universal laws of networks. Other authors as well claim the demand to develop a comprehensive theory of networks in general or social networks in particular (for networks in general see, e.g., Barnes and Harary 1983; for the case of social networks see, e.g., Mitchell 1969; or for the case of a network theory of organization see, e.g., Salancik and Krackhardt 1995).

According to Salancik and Krackhardt (1995), interactions should not be treated as given facts that are subject to network analysis. Rather, causes and reasons of the emergence or non-existence of relationships should be studied. This would lead to a universal theory of networks and enable us to produce detailed results with regard to a variety of questions on network structures, roles, and relationships.

A comprehensive theory needs to cover all aspects of its subject and provide reasons and explanations on its subject. Moreover, a theory has the aim to systematically arrange, to select, and to explore the possibilities of its subject. With regard to a theory of networks, it should provide internal and external orientation: the subject itself should be structured and embedded in a more general context. Then, the theoretical framework should include selective functions of networks of a basic character and factors that influence network emergence and development. Finally, the theoretical framework should enable us to derive axioms that are of practical relevance, i.e. to provide access to possible actions. We will find that the scope of social network analysis as theory is limited to some extent.

As outlined above, here, social network analysis serves as a simple and pragmatic theoretical approach to the study on social organization of knowledge communication. And the aim is not to develop a comprehensive theory of networks, but to overcome the normative and idealistic limits of community approaches for organizational purposes on the one side and on the other side to pragmatically adapt a sophisticated scientific method for the purposes of organizational and business practice. Here, the aim is definitely not to develop of a comprehensive theory of its own. This approach does not exclude a general orientation of social network analysis toward a theoretical framework, but it shares the doubt that social

network theory itself can be the theoretical core. This perception of social network theory allows us to share the perspective of Emirbayer and Goodwin (1994). These authors state that social network analysis is mostly viewed as a set of empirical methods. They do not raise demands for the development of a theory of its own, rather they promote to critically analyze its theoretical foundations, i.e. the theoretical presuppositions and conceptual strategies of social network analysis (Emirbayer and Goodwin 1994: 1412). They conclude that the potential of social network analysis as an empirical method is not fully exhausted yet and must be further developed. But this conclusion does not include the demand to extent the method of social network analysis to a comprehensive theory of its own. Social network analysis should be viewed as an additional sociological model and method to derive "a fuller conception of social action" (Emirbayer and Goodwin 1994: 1447).

4.6.3 Limits of Social Network Analysis as an Empirical Method

Exploring the weak points of social network analysis as an empirical method, we can identify five different kinds of limitations among others that are of primary importance:

1. methodical weakness, especially concerning the process of data collection;
2. restriction to limited dimensions of interaction;
3. descriptive character;
4. boundary specification problem;
5. snapshot character.

Using social network analysis as an empirical method, a set of empirical research methods builds the basic tools for the collection of data. These include interviews, questionnaires, content analysis, or observation for example. Of course, weakness of these basic tools leads to weakness of social network analysis as well. Looking at studies of social networks, we may find that failures or weaknesses of these methods are sometimes more or less neglected. At least some of the potentially weak points should be named here. They include effects of distortion in interviews, general problems with self-assessments in surveys, subjectivity and failing of observations, and, of course, quality (reliability and validity) problems (see, e.g., Spöhring 1989: 27-35). Besides these general weaknesses of social research methods, results of social network analysis are often under suspicion of the influence of social acceptance, i.e. the persons questioned are supposed to give answers that seem to be socially wanted (see, e.g., Diekmann 2001: 382-389); but this suspicion can rarely be confirmed. Problems of representativeness can be neglected since social analysis always focuses either on a single case or on universal

laws of networks, but rarely on representative social surveys or a similar kind of studies. But difficulties arise with the completeness of data. And with regard to the process of data collection, social network analysis is weak to violations of privacy issues without doubt (see also section 5.3).

We must take into account that the restriction of social network analysis to a limited set of dimensions of interactions produces a small scope of the result only. We should always consider that further aspects, which are not subject to study here, may have much more influence than we assumed. On the example of inter-organizational learning, Prange (1991: 164) asks us to bear in mind that relative autonomy of the individual person plays an important role for learning. Depending on the circumstances of a concrete study, a theoretical foundation is necessary to justify the individual research design.

Since social network analysis is based on the study of bilateral interactions, it provides a merely descriptive picture of structures and positions. Further going aspects and characteristics of social networks, like shared identity or shared norms of the network members for example, cannot be covered through social network analysis in a strict sense. Therefore, knowledge processes focusing on communication structures and its related aspects, like advice and support networks, knowledge flows and communication efficiency, for example, are best explored through methods of social network analysis, while further attributes of network members and their relationships must be identified by other additional means (like additional survey questions, observations, or analysis of other available documents and data).

In principle, social networks based on relationships are unbounded. But the observer has to set suitable boundaries for analytical purposes. It is relatively easy to draw network boundaries on the basis of clearly defined attributes, for instance, on the basis of analytical units like a focal organization, country, or a technical network. Here, the set of network actors is defined by attribute data. Network nodes do not necessarily need to be connected with each other, nor do network nodes or event sets of network nodes need to be connected to the rest of the network; i.e., relations (and whole sets of relations) may be empty. This positional method of network definition, i.e. the ex ante definition of the set of network actors, is used for theoretical and empirical purposes throughout this work, since it serves best for studies of knowledge networks in organizational environments (see also sections 3.5.2 and 5.3.5). Another method to identify network members is the reputational approach, where a list of nominees is produced by knowledgeable informants (see also section 5.3.5). Here, the set of network actors is defined by their relationships. Nevertheless, from this approach "[a]ll such boundaries are arbitrary. Different actors will draw different boundaries. They are a result of perspectives, intentions, and interpretations" (Hakansson and Johanson 1988: 370). The boundary specification problem of networks does not arise from an external analytical perspective

only, but also from the network members themselves. On the example of industrial networks, Hakansson and Johanson (1988: 371) explain: “All actors have a rather clear view of their own interaction and bonds with other actors even if the views of interacting actors are not necessarily consistent. Neither does this mean that the views of different individuals in a firm are consistent”. The boundary specification problem cannot be discussed in detail here. It can only be concluded for our own purposes that we have to be clearly aware of the corresponding difficulties and to carefully address them in every single case of a study.[51]

A social network analysis is only a snapshot of some characteristics of social organization. But interaction always causes both stability and change (Hakansson and Johanson 1988: 374). “A network analysis taken in a snapshot of time might miss the organizing that is going on and the stable system that eventually evolves” (Salancik and Krackhardt 1995: 348). We must always take this snapshot character of a social network analysis into consideration when analyzing and interpreting our results. A network is always “a product of its history. The actors—organizational or individual—have memories of their interaction” (Hakansson and Johanson 1988: 371). To overcome the snapshot character of social network analysis, it is necessary to continuously analyze the network over time. Using surveys with questionnaires or interviews for data collection is expensive with regard to time and money of the researcher and the interviewees. This makes a continuous survey of the network impossible (or at least prohibitively expensive). Commonly, longitudinal-studies of social networks survey the network at fixed points in time, say, for example, twice a year. Nevertheless, these kinds of network studies are nothing else than a chain of subsequent snapshots. We may find other methods of social network analysis, like the logging of email-traffic or video-observations, that really provide continuous network observation. But these methods inhere other weaknesses, like the restriction to one mode of communication only, as for the case of email-logs, or the study of merely spatial movements, as for the case of video-observations. A mix of different tools of data collection may help to overcome methodical weaknesses as well as difficulties due to the snapshot character of analysis. Here again, we have to justify our research design depending on the circumstances of a concrete study.

[51] On the boundary specification in more detail see, e.g., Laumann et al. (1989).