

KNOWLEDGE NETWORKING

Structure and Performance in Networks of Practice



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Structure and Performance in Networks of Practice

Robin Teigland



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*To my family,
both near and far*

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Preface

This doctoral dissertation was written while Robin Teigland was a Ph.D. Candidate at the Institute of International Business at the Stockholm School of Economics. The research was in part generously funded by the Capability Management in Network Organizations (CaMiNO) Consortium (Askus, Ericsson, Pharmacia, SEB, Skandia, and Volvo) and by the Xerox Corporation. This support is gratefully acknowledged.

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Stocksund, August 20, 2003

CHAPTER ONE

Knowledge Networking

“.....but most importantly I have my network from the internet. I’ve been in this for four years so really there is a core clique of people who know each other and who trade secrets with each other even though we have never met each other face-to-face. We pass over nondisclosure agreements of different companies all the time and trade company secrets.” (Interviewee in a high technology multinational, 1998)

“People from other offices [within the company] call me up pretty often for help because they have heard about me. But it feels really strange to help them when you don’t know them. It then becomes a matter of prestige - why should I help you?” (Interviewee in a high technology multinational, 1998)

THE RECENTLY DEVELOPED knowledge-based view of the firm argues that knowledge is the firm’s most valuable resource, yet as the above quotations reveal, valuable firm knowledge can leak easily across the firm’s legal boundaries while it can get stuck within them. As a result, management in business firms is finding that knowledge cannot be “managed” using the same tools that once were appropriate for dealing with physical goods, thus presenting considerable challenges. A tension arises because much of the knowledge within organizations is controlled at the level of individuals who make discretionary choices about the sharing of knowledge. In addition to the willingness of individuals to share knowledge, another challenge in the management of knowledge lies in the nature of knowledge itself – that knowledge is situated in a local practice. As a group of individuals who have a shared practice conduct their work, boundaries are created around their practice

within which their knowledge is embedded. Within the group, tacit knowledge is shared relatively easily between individuals often without even being made explicit. However, sharing the group's knowledge with others outside the group presents difficulties even if there is a willingness to share due to the embeddedness of the knowledge.

What is common within both these challenges to knowledge sharing is that there is a social relationship, or lack of one, between individuals. Research has consistently shown that social relationships are important to the ability of individuals to gather knowledge and to perform their work (Pelz & Andrews, 1968; Mintzberg, 1973; Allen, 1977; Monge, Rothman, Eisenberg, Miller & Kirste, 1985; Brown & Duguid, 2000; Cross, Rice, & Parker, 2001) and that the creation of knowledge is innately a social process among individuals (Wittgenstein, 1953; Vygotsky, 1962; Berger & Luckman, 1966). However, as research on the work practices of individuals has revealed (cf. Wenger, 1998), these social relationships are often not prescribed by the formal organization and as such are "invisible". Since individuals normally have the discretion to interact with a range of people when they are performing their work tasks, they form relationships based on biases and preferences for others as opposed to what the formal organization dictates. These relationships then form the basis for informal, naturally occurring networks that have been theoretically described as "emergent networks" in order to distinguish them from the formally imposed or "mandated" networks (Aldrich, 1976), which represent the legitimate authority of an organization typically reflected by the organizational chart (Monge & Contractor, 1997). In addition to these networks emerging within the firm, individuals may also develop a set of emergent relationships with individuals outside the legal boundaries of the firm, despite a lack of mandate from management.

While organizational theorists have long discussed the importance of emergent networks (Follett, 1924; Barnard, 1938)¹, it is only recently that both scholars and practitioners alike have showed increasing interest in them due to their ability to serve as vital conduits of knowledge flows. If we return to the two challenges presented in the opening paragraph of this thesis, the hope of researchers is that an improved understanding of these emergent networks of work-related relationships will enable firms to overcome these challenges while facilitating their ability to create and sustain a competitive advantage. In

¹ One of the first studies was by Davis (1953) who developed the "episodic communication channels in organization" or "ecco" analysis, a technique for tracing the person-to-person diffusion of rumors or other items of information in an organization.

addition, an important rationale for studying emergent networks lies in the inconclusive findings relating formal organizational structures to organizational behavior (Johnson, 1993; Monge & Contractor, 1997). In a review of the empirical research on formal organizational structures, Jablin (1987) pointed out the inconclusive nature of studies investigating an organization's formal structural variables, such as hierarchy, size, differentiation, and formalization. More recently, researchers conducting a series of meta-analytic studies have concluded that the relationships between formal structure, organizational effectiveness (Huber, Miller, & Glick, 1990; Doty, Glick, & Huber, 1993), and technology (Miller, Glick, Yang, & Huber, 1991) are largely an artifact of methodological designs (Monge & Contractor, 1997). It is not surprising then that several scholars argue that emergent structures are important to study because they add more to our understanding of organizations than formal organizational structures (Roethlisberger & Dickson, 1939; Roberts & O'Reilly, 1978; Bacharach & Lawler, 1980; Krackhardt & Hanson, 1993; Krikorian, Seibold, & Goode, 1997; Monge & Contractor, 1997).

Despite the growing interest in emergent networks, we still have a very limited understanding of them. First, while considerable research has been conducted on emergent networks², it is really only in recent years that researchers have combined knowledge and learning with the study of these networks. Second, these networks have a variety of names, such as communities of practice (Lave & Wenger, 1991), networks of practice (Brown & Duguid, 2000), invisible colleges (Crane, 1972), social worlds (Strauss, 1978), and scientific communities (Polanyi, 1962b; Knorr-Cetina, 1981). However, there have been few attempts to distinguish between the various types of networks or to review these with a focus on structure or performance. Third, there are relatively few empirical studies of these networks. Due to their inherent nature, these networks are "invisible" with participants often leaving no trail of their interactions, thus presenting a challenge to study. Not too surprisingly then, studies of these networks tend to be of an ethnographic nature. While social network analysis offers the possibility to study the structural dimensions of emergent networks through making them visible, the ability to conduct such studies is, however, often limited due to the extensive time requirements on the part of the firm as well as the potentially "sensitive nature" of the data to be collected. Additionally, due to their recent appearance on the scene of emergent networks, there is extremely limited research on electronic communities, or emergent networks in which interactions are conducted entirely online. Thus, the overarching goal of this thesis is to improve our understanding of emergent

² For a review, see Monge & Contractor (1997).

networks from a business firm's perspective. Before discussing how we intend to achieve this goal, we define the relevant concept of "network of practice" in the next section.

1.2 Defining Networks of Practice

As seen in the previous section, there are numerous labels for networks between individuals that emerge based upon work relationships. For the purpose of this thesis, we will refer to the overall set of various types of emergent networks, from communities of practice to electronic networks of practice, as networks of practice. While this is partially in line with Brown & Duguid (2000), we also feel that this terminology best reflects the characteristics in which we are interested. First, the term, network, is appropriate since it implies a set of individuals who are connected together through social relationships, whether they are strong or weak. Terms such as community tend to denote a stronger form of relationship, but we are interested in all networks of social relationships, be they weak or strong. Second, we use the term practice to represent the substrate that connects individuals in their networks (Brown & Duguid, 2001). The principle ideas are that practice implies the actions of individuals and groups when conducting their work, e.g., the practice of software engineers, nurses, hotel managers, etc., and that practice involves interaction among individuals (Lave, 1988). Thus, what distinguishes a network of practice from other networks is that the primary reason for the emergence of relationships within a network of practice is that individuals interact through social discourse in order to perform their work, asking for and sharing knowledge with each other. Thus, a network of practice can be distinguished from other networks that emerge due to other factors, such as interests in common hobbies or discussing sports while taking the same bus to work, etc. Finally, practice need not necessarily be restricted to include those within one occupation or functional discipline. Rather it may include individuals from a variety of occupations; thus, the term, practice, is more appropriate than others such as occupation. In summary, we define *a network of practice as a set of individuals connected together through social relationships that emerge as individuals interact on task-related matters when conducting their work.*

Before continuing to the research purposes for the empirical studies conducted in this thesis, it is important to state our position regarding networks of practice in relation to the formal organization. Traditionally, organizational literature has used the distinction between formal and informal structures as a way of dividing the interactions that occur in organizations. The formal structure has been used

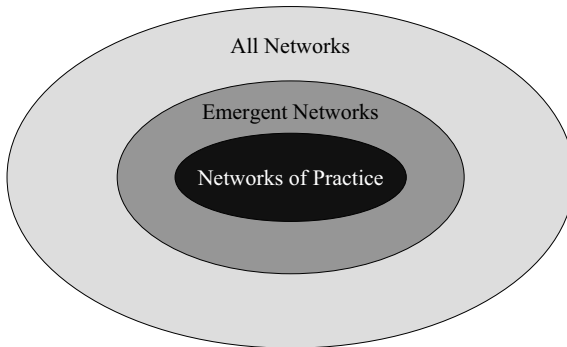
to describe the organizationally specified role relationships between individuals in formal positions (Weber, 1946; Parsons, 1951) while the informal structure has been used to describe personal friendship relationships that often develop in small groups (Barnard, 1938; Homans, 1950). However, several scholars propose that the distinction between formal and informal structures is no longer very useful (Monge & Eisenberg, 1987; Stevenson & Gilly, 1993; Monge & Contractor, 1997) since they argue that this distinction has diminished significantly in recent years and is expected to continue to do so (Monge & Contractor, 1997). Reasons provided for this decline include changes to more team-based forms of organizing, the adoption of matrix forms of organizational structure (Burns & Wholey, 1993), shifts to network forms of organizing (Miles & Snow, 1986, 1992, 1995; Monge, 1995), as well as the increase in lateral communication (Galbraith, 1977) due to advances in information technologies that enable point-to-point and broadcast communication without regard for traditional hierarchy, distance, time, or organizational affiliation (Hinds & Kiesler, 1995, Monge & Contractor, 1997; Faraj & Wasko, 1998).

As a result and contrary to traditional views, emergent relationships that are ephemeral in that they are formed, maintained, broken, and reformed with considerable ease (Palmer, Friedland, & Singh, 1986) are now argued to be the basis for contemporary organizations (Monge & Contractor, 1997). As Krackhardt (1994) states, "An inherent principle of the interactive form is that networks of relations span across the entire organization, unimpeded by preordained formal structures and fluid enough to adapt to immediate technological demands. These relations can be multiple and complex. But one characteristic they share is that they *emerge* in the organization, they are not preplanned" (p. 218, italics in the original).

However, while these relationships do emerge, that is not to say that the formal organization has no effect on their creation. For example, the formal organization may bring together individuals from across the organization. However, once the team is disbanded, individuals may continue to interact based on their own discretion due to the building of affective bonds. While this relationship originally is a formal one, it no longer falls under the "formal" category. Thus, as mentioned, individuals form relationships based on biases and preferences for others, and the creation of affective relationships may lead them to continue to interact regardless of formally defined structures (Stevenson & Gilly, 1993). As a result, the position on networks of practice in this thesis falls between that of the formal organization entirely dictating interactions and that of relationships being truly emergent since the formal structure is argued to bias the shapes of networks of practice. Thus, in order to further clarify our

definition of networks of practice, we see networks of practice as a subset of all potential emergent networks (e.g., friendship, common interest, etc.), and emergent networks as a subset of all potential networks in which individuals can participate (from formally mandated to truly emergent). We depict this clarification in figure 1.1. Substituting now networks of practice for emergent networks, *the overarching goal of this thesis becomes to improve our understanding of networks of practice from a business firm's perspective.* We now turn to an overview of the means with which we intend to achieve this goal.

Figure 1.1 Networks of Practice as a Subset of Other Networks



1.3 Overview of Research Purposes and Empirical Studies

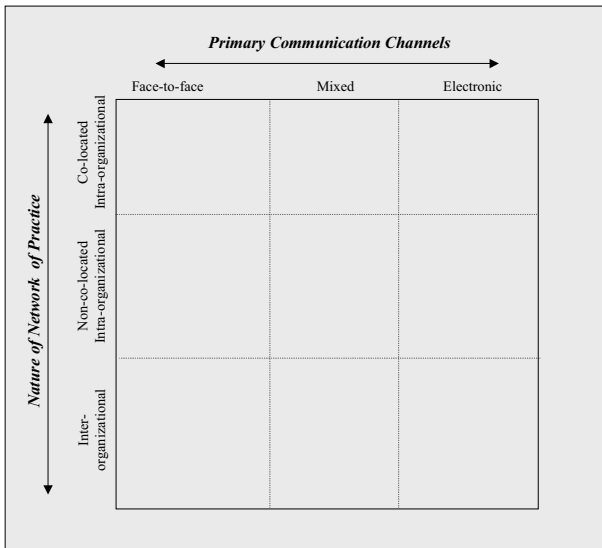
In short, our first step is to conduct an extensive literature review to determine our current understanding of networks of practice within and across business firms. Based on the gaps revealed in this literature review, our next steps will be to develop two research purposes and conduct a series of seven empirical studies examining various networks of practice in order to fulfill these research purposes. We discuss each of these steps in turn below.

1.3.1 Developing an Understanding of Networks of Practice

As mentioned, the first part of this thesis will focus on developing an understanding of the various networks of practice and an overview of the empirical studies conducted to date. In order to structure this discussion, we develop a matrix on which we map the various types of networks of practice. While there are many ways to define the dimensions of this matrix, we have chosen two that we feel reflect the distinctions made in the literature to date on networks of practice. The first dimension is the nature of the network of practice, i.e., a set of individuals may belong to the same organization, and within this organization they may even be co-located within the same

geographic location. The second dimension refers to the primary communication channels used by the members of the network of practice to interact with one another, e.g., face-to-face or totally electronically through internet-based communication. Thus, one type of network of practice includes a group of individuals who are co-located and who communicate primarily face-to-face (i.e., a community of practice) while another network of practice may include individuals from across a variety of organizations who communicate only through the internet (i.e., an inter-organizational electronic network of practice). Figure 1.2 provides an overview of the network of practice matrix used to structure our discussion. Due to the fluidity of networks of practice, the dimensions proposed here are not finite and as such there are overlaps. For example, individuals within a community of practice may communicate both face-to-face as well as through the company’s intranet. However, we feel that the benefit of being able to structure our discussion based on these dimensions outweighs any drawbacks that overlaps might cause. We would also like to note here that this matrix is not intended to be a generic matrix that can be applied in all situations, rather our intention is to use this matrix as a pedagogical tool with which to structure this thesis.

Figure 1.2 Matrix of Networks of Practice



Using this matrix, we discuss the various types of networks of practice as well as conduct a review of the empirical studies of each type of network of practice. This review reveals that there are two significant gaps within the areas of

structure and performance that we then use as a basis for the development of our research purposes, as described below.

1.3.2 Extending Our Understanding through Empirical Studies

When discussing knowledge within organizations, a multitude of levels of analysis should be taken into account and considered together (Tuomi, 1999). In line with this and in order to increase our understanding of networks of practice from a business firm's perspective, the empirical studies in this thesis address two different levels of analysis: (1) the network of practice and (2) the individual. Each of these levels comprises a different research purpose. We briefly present the two research purposes here while we present a more detailed discussion of them in Chapter Four.

1.3.2.1 Research Purpose 1: Structural Dimensions of Networks of Practice

As the literature review will reveal, researchers investigating the various networks of practice have focused primarily on understanding the cognitive aspects relating to the interactions of individuals in networks of practice, such as the development of a shared identity. However, studying these cognitive aspects provides only a partial understanding of networks of practice. Within the past few decades, researchers have been paying increasing interest to the *structural analysis* of social groups. In social network theory, researchers have found that the interactions between individuals within emergent groups create patterns of relationships that in turn can be defined as the *structure* of the network (Brass, 1985; Krackhardt & Porter, 1985; Burkhardt & Brass, 1990; Krackhardt, 1991). Some of the main principles of social network theory are that individuals are embedded in networks of relationships that shape the patterns of behavior in which they engage (Berkowitz, 1988), thus individuals and their actions are viewed as interdependent rather than independent, autonomous units. Furthermore, these network structures and the cognitive processes of individuals in the network are argued to mutually constitute one another. However, with the exception of a small number of studies within limited settings, researchers have left structure by the wayside when investigating networks of practice despite their strong parallels with the structural characteristics of embedded networks. Thus, an application of social network measures to networks of practice should improve our understanding of networks of practice and facilitate our ability to further theorize and conduct empirical studies on them. For example, the development of a set of structural properties may help to detect and analyze communities of practice within organizations, to track their development over time, or to measure their relationship with organizational performance. Against

the background of the above discussion, the first research purpose of this thesis is the following:

Research Purpose 1: To describe the structural properties of networks of practice through the application of social network analysis.

In order to address this research purpose, two studies of two polar forms of networks of practice are conducted: an intra-organizational community of practice and an inter-organizational electronic network of practice.

1.3.2.2 Research Purpose 2: Performance and Networks of Practice

Within recent years, researchers and practitioners alike have been increasingly advocating networks of practice, and as a result, managers in numerous organizations are attempting to support or even construct various forms of networks of practice within and across their organizations (Dixon, 2000; Wenger, McDermott, & Snyder, 2002; Ackerman, Pipek, & Wulf, 2003). Similar to the broader set of organizational knowledge management initiatives implemented with the purpose of enhancing performance through knowledge sharing and creation, it seems that the hope of management is that these efforts will positively affect individual behavior in the workplace and thus ultimately drive increases in firm performance (Davenport & Prusak, 1998).

However, within the network of practice literature, there is a surprising scarcity of solid academic empirical support for this generally assumed positive relationship, with researchers paying little systematic attention to the relationship with performance at any level. While several reasons for this lack of rigorous investigation can be offered, this area of questioning should not go further disregarded, as indications of a potential negative relationship between networks of practice and performance do exist. For example, based on previous research, it could be argued that communities of practice can evolve into core rigidities and competency traps – inappropriate knowledge sets that preserve the status quo and limit new insights, resulting in gaps between the knowledge of the firm and changing market conditions (Levitt & March, 1988; Leonard-Barton, 1992).

Additionally, as we will find in our literature review, the majority of the research on networks of practice generally focuses on the organizational or network level, brushing aside the fact that individuals can make choices regarding with whom they share their knowledge and thus in which networks they choose to participate. For example, the community of practice literature

tends to consider the already existing constellation of individuals, taking a point of departure that individuals want to be a full member of the community of practice and strive to be one, thus they participate in the community of practice, freely sharing their knowledge with other members. Yet, if there is one broad conclusion we can make from the discussion in the following chapters, it is that individuals have a large number of networks within which they may participate and share knowledge. Moreover, previous research investigating knowledge sharing activity further suggests that individuals make choices regarding their knowledge sharing, such as with whom they share their knowledge (e.g., Andrews & Delahaye, 2000). These choices are primarily made based upon individual interests, and it is the variation among individuals and their interests that results in knowledge sharing being a complicated activity often characterized by shirking, guile, and resistance (von Krogh, 2002). For example, theories of self-interest propose that individuals make what they believe to be rational choices to acquire personal benefits through maximizing (or satisficing) their gains or minimizing their losses (Monge & Contractor, 1997). Thus, individuals acting in this manner feel that there must be some reciprocal rewards for participating in knowledge sharing, such as enjoyment, being challenged, increased reputation, or improved performance³. In the context of networks of practice, then we would argue that individuals make their own decisions as to with whom they would like to interact and share knowledge (and thus in which network of practice to participate) based on the potential returns from these actions. While several studies have investigated individual interests in terms of the antecedents to choices to participate within a particular network of practice, such as increased reputation or altruism, (e.g., Lakhani & von Hippel, 2000; Wasko & Faraj, 2000), researchers have paid scant attention to the relationship between an individual's participation and knowledge sharing in a particular network and individual outcomes such as individual performance.

Tying this back to our discussion above regarding performance, we may then fill these research gaps by bringing the level of analysis down to the individual through investigating the relationship between an individual's participation in various networks of practice and individual performance. It is important to be clear here that our research focus is not on the antecedents of these choices, such as the how or why individuals make certain choices to participate in various networks. Rather our interest is focused on the relationship between an individual's participation in various networks of practice once the choice has

³ See Monge & Contractor (1997) for a further discussion on the motives for knowledge sharing and communication in emergent networks and Wasko (2002) for knowledge sharing in electronic networks.

been made and individual job performance. As such, Research Purpose 2 becomes the following:

Research Purpose 2: To investigate the relationship between individual participation in various types of networks of practice and individual performance.

To address Research Purpose 2, we conduct a series of studies at two multinational consulting firms that focus on individual participation in various networks of practice and the relationship with individual performance.

1.3.3 Summary of Research Purposes

In summary, the empirical studies in this thesis have been chosen in order to fill the considerable gaps of structure and performance in the literature on networks of practice. Additionally, these studies serve to fill gaps in empirical research on various types of networks of practice, such as electronic networks of practice. As described in our discussion of knowledge in Appendix One, we argue that knowledge is both an individual-level construct as well as a network-level construct and so it is correctly studied at both these levels. Our approach in this thesis then is to bring together a number of related theories that can inform our understanding of both *individual-level behaviors and network-level activities* as opposed to the *organizational level*. However, our intention is to then apply our thinking and findings back to the level of the firm. Thus, by conducting a multi-level study of various networks of practice, we may then contribute to the extant literature on networks of practice *as well as* to the literature on the knowledge-based view of the firm. While this thesis may be considered to be quite extensive in both review and empirical studies, it does have some limitations. These are described in the next section.

1.4 Definitions and Delimitations

The focus of this study is on networks of practice and in particular on structure and performance in networks of practice. In this context and as defined and discussed above, we investigate only networks of practice in this thesis and not other networks of interaction relationships in which individuals may participate, such as friendship networks. This is entirely in line with previous research within the social network field that has provided evidence that friendship networks do not impact individual outcomes such as job performance (Lazega, 2001). It is also important to note that we are only interested in networks of practice comprised of individuals working within and across business firms. As

noted above, we define practice as an activity, an interaction among individuals (Lave, 1988) doing their “real work”⁴. While practice may connote doing many other things, such as mowing one’s own lawn or volunteering in the parent-teacher association, we are only interested in networks of practice where the practice revolves around the work of individuals conducted to make a living. In connection with this point, we then limit ourselves to individuals and networks of practice within and across business firms. In this manner, we also follow in the footsteps of previous researchers, van Maanen & Barley (1984), who defined an occupational community as including only those individuals who are performing real work in order to make a living.

As for the definitions of the other main terms that we use in our thesis: structure, performance, and knowledge, we begin with structure, the focus of our first research purpose. We follow previous social network researchers and define structure as the presence of regular patterns or regularities in relationships (Wasserman & Faust, 1994) that are represented by networks comprising sets of nodes and sets of ties depicting the interconnections between the nodes (Wellman & Berkowitz, 1988). This definition of structure is to be distinguished from others in the social sciences since it focuses on the “*concrete* social relations among specific social actors” (ibid:5, italics in original). In other social science approaches, while also interested in interpreting processes in terms of patterned interrelationships among individuals rather than on the basis of individual essences, researchers generally focus on different aspects such as symbols, meanings, norms, values, and role expectations (ibid, Scott, 1998). In addition, this network definition of structure is in strong contrast to the more commonly thought of formal definition of organizational structure that refers to the prescribed framework focusing on the differentiation of positions, the formulation of rules and procedures, and prescriptions of authority within an organization (Ranson, Hinings, & Greenwood, 1980)⁵. As mentioned above, we are interested only in the *emergent structure* of networks of practice that is determined by the patterned regularities and processes of interaction between members as they conduct their organizational work tasks. Thus, in the context of networks of practice, the following definition of structure will guide the remainder of the thesis: structure is the regular patterns of relationships between individuals (nodes) that emerge as individuals interact on task-related matters when conducting their work (ties).

⁴ For a further discussion of work and practice, see Orr (1990).

⁵ Interest in the formal view of structure has been heavily influenced by Weber’s (1946) work on bureaucracy. See e.g., Hall (1963), Pugh, Huckson, Hinings & Turner (1968,1969), and Child (1972).

In our second research purpose, we move from structure to performance, and in this thesis, we are interested only in performance in the context of a business firm. We primarily investigate individual performance, which we refer to as the actions or behaviors by individuals when conducting their work-related tasks that positively influence the business firm's goals. Thus, we follow previous researchers who define performance *not* as the concrete consequences or results of an individual's action, e.g., monetary value of sales, but as "the action itself" (Campbell, McCloy, Oppler, & Sager, 1992: 40). Furthermore, we view individual performance as a multidimensional construct (Welbourne, Johnson, & Erez, 1998). At the very least, we would expect to see a split between "exploration" and "exploitation" (March, 1991), where exploration would be manifested as creativity or the development of novel solutions while exploitation would be manifested as completing one's work-related tasks on time and on budget. We further discuss our definition and use of performance as well as the challenges in measuring it in Chapter Five on methodology.

Turning to knowledge, while this concept has been debated and theorized for centuries, it continues to remain elusive. Researchers remain in disagreement as to what knowledge is, and as a result there are numerous definitions, overlapping terms, and perspectives regarding knowledge. (We discuss some of these in Appendix One.) For example, while there seems to be a consensus that a distinction needs to be made based on Polanyi's (1962b) "knowing what" and "knowing how", researchers disagree as to whether the related terms, tacit and explicit knowledge, are two distinct forms of knowledge or the ends of a continuum (Carlile, 1997). Explicit knowledge refers to knowledge that can be easily transmitted in formal, systematic knowledge while tacit knowledge has a personal quality and is deeply rooted in action, commitment, and involvement in a specific context (Nonaka, 1994). Tacit knowledge is embedded in know-how or "the accumulated practical skill or expertise that allows one to do something smoothly and efficiently" (von Hippel, 1988: 76), thus making it hard to formalize and communicate (Nonaka, 1994). For our purposes here, we include in our definition of knowledge both tacit and explicit knowledge (Nonaka, 1994). An additional characteristic of knowledge is that it enables individuals to act in situations (von Krogh, 2002), thus keeping in line with this thesis, we restrict our definition of knowledge to include only knowledge that enables individuals to perform their work-related tasks.

A second major area of debate revolves around the individual/collective dimension of knowledge. The traditional Cartesian view considers knowledge as held by the individual since it sees the individual thinker as the primary wielder and repository of what is known (Cook & Brown, 1999) while a more

recent sociological approach sees knowledge as socially constructed and embedded in the social relationships between individuals (Kogut & Zander, 1992). Related to this, researchers have increasingly focused on the relationship between the individual and organizational levels of knowledge (e.g., Hedlund & Nonaka, 1993; Nonaka 1994; Spender, 1996); however, it is still not clear what makes knowledge individual or organizational (Tsoukas & Vladimirou, 2001). One view proposes that “individuals have private knowledge that can be a basis for organizational knowledge when conveyed through speaking, gesturing, writing, etc. Knowledge *of* the organization is shared knowledge among organizational members” (von Krogh, Roos, & Slocum, 1994: 59, italics in original). For the purposes of this thesis and compatible with this latter view, we see individuals as having private knowledge that they share with others through interactions revolving around work-related tasks. Additionally, it is important to note that since individual knowledge is private, individuals are able to make discretionary choices about the sharing of their individual knowledge, e.g., whether to share knowledge, with whom to share the knowledge, and which elements to disclose.

As for delimitations, despite the strengths of this thesis being a multi-level, multi-site, multi-method study, the generalizability of the study’s discussion and findings is an issue. First, while all the studies conducted comprise knowledge workers, i.e., their jobs primarily consist of processing, articulating, applying and disseminating knowledge (Wasko, 2001) as opposed to making tangible objects with their hands, six out of the seven studies comprise individuals in functions that are not research or science-based, e.g., researchers or scientists in R&D labs, etc. As a result, we may not be able to generalize our findings to networks of practice comprising research or science-based functions; however, we may contribute to the extant literature with our studies on functions such as lawyers, construction engineers, software programmers, behavioral scientists, and management consultants.

Regarding the first research purpose focusing on network of practice structure, only one community of practice and one specific type of electronic network of practice are studied, thus limiting the generalizability of our findings to other organizations as well as other types of electronic networks of practice. For example, regarding electronic networks of practice, various types of interactive technology exist such as listservs, chatrooms, and voice, and the use of these different communication media may affect network of practice dynamics. Regarding the second research purpose on the relationship between network of practice participation and individual performance, we conducted our studies addressing this purpose only in highly knowledge-intensive firms in which

individuals had access to numerous networks of practice through various communication channels. Thus, our discussion and findings on networks of practice within and between firms may not be generalizable to firms of a lesser knowledge-intensive nature. However, we feel that our choice to trade breadth for depth by focusing on deepening our understanding of networks of practice within and across knowledge-intensive firms as opposed to a broad focus across firms of varying knowledge intensity is more appropriate given that developed economies have undergone a transformation from largely raw material processing and manufacturer activities to the processing of information and knowledge (Teece, 1998) and that knowledge work is continuing to increase as a percentage of the total work conducted (Handy, 1991).

Finally, while our study involves individuals who perform highly knowledge-intensive tasks and who use the new internet-based communication media to a high degree, this study is not about the role of the internet in society, firms, or networks of practice. We acknowledge, however, that there are two views on the relationship between the internet and society: the technological deterministic perspective and the social informatics perspective, and it is seemingly in order to present these two views. Proponents of the technological deterministic perspective tend to view the impact of the internet on society as a unilateral process and generally fall into two camps: a utopian or a dystopian point of view (Quan-Haase & Wellman, in press). The utopians argue that the internet will stimulate positive change in people's lives and work by creating new forms of online interaction and enhancing offline relationships (cf. Sproull & Kiesler, 1991; Wellman, 2001) while the dystopians argue that the internet is fostering a decline in social capital and an increase in interpersonal alienation (c.f. Kraut, Patterson, Lundmark, Kiesler, Mukopadhyay, & Scherlis, 1998; Cohen, 2001). Social informatics has arisen as a counter to the technological deterministic perspective, with proponents arguing that the "predictions" of technological determinists have not been fulfilled and that society is not a passive object. Social informatics is based on "social constructivist views" of technology in which technology emerges in dialectic with society (Quan-Haase, 2002) and has been described as a "multidisciplinary research field that examines the design, uses, and implications of information and communication technologies (ICTs) in ways that account for their interactions with institutional and cultural contexts" (Kling, 1998: 1047). In sum, in the social informatics view, neither does technology create uses in society nor does society create uses in technology, but they influence one another. For the purposes of clarification as to our standpoint regarding the internet, we follow the social constructivist view due to its parallel with similar arguments regarding knowledge and structure in the network of practice, knowledge-based view of the firm, and social network literature.

1.5 Preview of the Study and Major Contributions

The main contribution of this thesis lies in improving our understanding of networks of practice from a business firm's perspective through presenting our current understanding of networks of practice based on a literature review and addressing two research purposes related to structure and performance through empirical investigation. As mentioned, this empirical investigation is based on seven separate studies. These studies, however, do complement one another, thus this thesis provides a more comprehensive view of networks of practice and helps advance our understanding further than if the studies had been conducted as separate efforts by different authors. In summary, this thesis contributes to two theoretical areas: networks of practice and the knowledge-based view of the firm, as well as results in a number of practical implications. We discuss some of our findings and implications below.

1.5.1 Networks of Practice

First, the extensive discussion and literature review of the various networks of practice provide us with an understanding of the current "state of affairs" of the network of practice field. The review of empirical studies discusses some fifty-odd studies that we find relevant to our task at hand and summarizes these for each type of network of practice according to three research foci: structure, performance, and cognitive aspects. In short, this review of empirical studies exposes that "what we think we know" is a lot more than "what we know" regarding networks of practice. In particular, through this review we find two significant research gaps, those of performance and structure, in addition to finding a dearth of research relating to electronic networks of practice within and across business firms.

Second, this thesis investigates several networks of practice in various field settings, an important empirical contribution since networks of practice are becoming an integral facilitator of knowledge work and new knowledge creation. In order to address the two above research gaps of structure and performance and as mentioned above, we develop two research purposes and conduct a series of seven empirical studies. These studies include a variety of research sites and data collection methods: 1) interviews and questionnaires of members of an intra-organizational electronic network of practice in the Nordic Operations of Cap Gemini, one of Europe's largest IT services and management consulting company, 2) interviews, questionnaires, and extensive sociometric data (n=1698 in 26 offices in 16 countries spread across Europe, Asia, Australia, and the US) in Icon Medialab, a multinational new media consulting firm, 3) a

sociometric questionnaire in Sundlink Contractors AB, a multinational construction consortium in Scandinavia, 4) 2460 downloaded text messages and a questionnaire in an inter-organizational electronic network of practice of lawyers spread across the United States, and 5) case studies in the R&D operations of three high technology multinationals, including Hewlett-Packard. While the individuals and their networks of practice investigated are from a variety of disciplinary and demographic backgrounds, as mentioned above, they are all considered to be knowledge workers. To analyze the data collected, we used a variety of methods: text analysis, multiple regression analysis, structural equation modeling, and social network analysis, to name but a few.

As for the first research purpose, investigating structure, we synthesize social network concepts and methods with the network of practice literature to improve our ability to reveal these “invisible” networks through the development and examination of structural properties of both a community of practice and an inter-organizational electronic network of practice. Our results reveal difficulty in applying a common set of structural properties across the board to all types of networks of practice. Thus, we propose that the relevant structural properties and corresponding social network measures of a particular type of network of practice are dependent on the primary communication channels used by the network of practice. For example, the more a network of practice depends on electronic communication channels in which interactions are visible to all network members (e.g., listservs, bulletin boards), the more connected members are. Thus, social network measures such as connectedness are not as relevant in online networks as they are in face-to-face settings. These findings regarding structural properties then imply that the cognitive process, such as knowledge sharing, among members vary across the different types of networks of practice. In addition, we find support for applying theories of collective action and public goods to electronic networks of practice and suggest that these may also be applied to other network of practice forms to facilitate our understanding of them.

Regarding the second research purpose, as the review of empirical studies uncovers, we have little empirical support for the claim that there is a positive relationship between network of practice participation and performance at any level. In addition, most network of practice studies focus on only one network at a time, taking the point of departure that individuals have already made their choice to participate in the particular network. However, previous research has indicated that individuals make choices regarding with whom they share their knowledge. Thus, although researchers have expressed the need for a greater understanding of participation in networks of practice, we have yet to articulate

and test a theoretical model examining the relationship between an individual's participation in different networks of practice and individual level outcomes. This research is then critical for the development of a theoretical framework to guide our understanding of the relationship between participation in different networks of practice and individual-level outcomes. In order to address this, we develop and test a series of hypotheses related to individual participation in various networks in multiple research sites.

Our empirical studies reveal significant relationships between an individual's participation in various types of networks of practice and individual performance. Our results suggest then that the relationship between participation in different networks of practice and individual performance is not only contingent upon the strength of the tie but also upon the redundancy of the knowledge in the network. For example, we find that *efficient* performance has a direct positive relationship with participation in communities of practice, yet too much participation in communities of practice comprised of members sharing the same functional expertise may lead to *a lower degree of creative* performance. Our results also reveal that knowledge exchange and centrality are important mediators in the relationships between participation in networks of practice and creative performance.

Further investigation of these performance relationships reveals significant differences between groups of individuals based on their tasks, suggesting that the dynamics of knowledge sharing within the various networks of practice are contingent upon the underlying practice knowledge. This finding, along with the previous findings relating to structure and performance, supports taking a *differentiated* view of networks of practice over a unitary one. Imposing one view on networks of practice masks possible heterogeneity along two dimensions: 1) the knowledge of the practice and 2) the form of the network of practice; therefore, a heterogeneous view of networks of practice may be more important in explaining outcomes than a unitary one.

Finally, we also synthesize our findings from the literature review and our empirical studies on networks of practice and characterize the various types of networks of practice through differences relating to their structure and performance as well as to several other aspects such as the nature of interaction, participation, and identity. In order to facilitate future work on networks of practice, we also propose our own definitions of the various networks of practice in this matrix based on our understanding of those we have developed in this thesis.

1.5.2 Knowledge-based View of the Firm

In addition to contributing to the network of practice literature, our aim in this thesis is to apply our thinking and empirical findings on networks of practice to the level of the firm so that we may contribute to the extant literature on the knowledge-based view of the firm. Turning to the knowledge-based view of the firm literature, despite the increasing interest in this perspective, there is interestingly limited empirical evidence to support this view of the firm. However, we find that our research has implications for Grant's theory of knowledge integration, the firm as a social community (Kogut & Zander, 1992), and the firm as a community of communities (Brown & Duguid, 1991). First, Grant's theory focuses primarily on the issue of coordination (structuring to enhance the effectiveness of knowledge integration), without referring to issues of "cooperation". However, our empirical studies suggest that we need to incorporate a dimension of cooperation in this view of the firm. For example, in order for an individual to access knowledge from members in a network of practice, our results indicate that he or she must be willing to provide knowledge in return. Thus, norms of reciprocity and expectations of returns for knowledge sharing appear to be key factors for participation and knowledge access in all types of networks of practice.

Our findings are also compatible with the views of the firm as a social community (Kogut & Zander, 1992) and a community of communities (Brown & Duguid, 1991). At the local level, we find that individuals are members of face-to-face communities of practice, with a high degree of participation in these communities leading to a high degree of efficient, and in some circumstances, creative performance. Individuals within these local communities may then also participate to a high degree in intra-organizational distributed and electronic networks of practice. These individuals serve as brokers, bridging local communities of practice through exchanging, transferring, and translating knowledge between them.

The view of the firm as a social community also argues that performance differences among firms partly arise due to the ability of firms to transfer knowledge within their boundaries as a result of shared identity, shared coding schemes, shared values, and higher organizing principles (Kogut & Zander, 1992). We find suggestive evidence for this claim in our final study in which the highest performing firm is the one that exhibits a higher degree of shared identity across the firm as well as higher levels of knowledge sharing between members of non-co-located intra-organizational networks of practice.

We also discuss several areas for development within the views of the firm as a social community and community of communities. First, our studies indicate that the issue of an individual's membership in the firm needs to be considered. The traditional perspective on organizational membership in the literature views membership as a binary state. However, if the firm is to be viewed as a social community, we should then be able to apply network of practice thinking regarding membership to the firm as well. The argument would then be that individuals are "members" of a firm to differing degrees. We may then hypothesize that the degree to which an individual is a member of the firm and in the core of the firm's entire network of internal networks of practice will be associated with a higher degree of individual performance. What this implicitly argues then is that full firm members will have mastered the practice of the firm through mutual engagement and collaboration (as predicted by theory, cf. Wenger, 1998) and will benefit through superior performance, whereas individuals who are less firm-like in their behavior and do not collaborate with others in the firm will have inferior performance. If such a hypothesis is not supported, then we have evidence that mutual engagement, collaboration, and community membership are *not* valuable to performance, which would throw into doubt the overlying argument that we see the firm as a social community. We discuss our findings in relation to this hypothesis in the last chapter.

In relation to the above, we then discuss Kogut & Zander's view that the firm is a "social community of voluntaristic action" in light of the literature review and our empirical findings. We argue again that a dimension of cooperation and willingness to share should be incorporated in this view. Our findings suggest that individuals weigh payoffs from participation and knowledge sharing with other members *inside* the firm with payoffs from participation and knowledge sharing with other individuals *outside* the firm in inter-organizational networks of practice. Thus, in order to deepen our understanding, we propose the concept of fuzzy individuals, borrowing from fuzzy algebra, as a means to think about firm membership not as a binary state but as a level of degree of participation. In addition, we discuss a new hybrid organizational form at the individual level, in which individuals are still members of firms, but they also adopt certain market-like behaviors as well.

Furthermore, our work on structural properties of networks of practice suggests that we may develop a set of appropriate structural properties for viewing the firm as a social community of which we provide some examples. These structural properties could then facilitate further theorizing and analysis of the knowledge-based view of the firm.

Finally, we discuss absorptive capacity (Cohen & Levinthal, 1990) and adapt this term as an additional means to describe the ties within networks of practice ties. In other words, we propose that while a tie between two individuals may be weak due to infrequent communication, it may, however, be characterized by a high level of *absorptiveness*. Thus, these two individuals may still be able to share knowledge to a relatively high degree due to the ability to assimilate knowledge through the tie. We suggest that factors affecting the absorptiveness of a tie include the degree to which individuals have shared related previous experience with the knowledge in question. For example, an electronic network of practice focusing on a specific functional expertise, say C++ programming, may be characterized by weak ties among its members, but a high degree of absorptive ties. We would argue then that individuals participating in this electronic network of practice, say through lurking, could still be able to assimilate new knowledge accessed in this electronic network of practice in their local context rather effectively due to their ability to absorb the knowledge on account of their shared previous experience with the knowledge.

1.5.3 Practical Implications

Turning to practical contributions, given the projected growth in knowledge management services and initiatives in the next few years, the findings of this research have practical implications for guiding the design and maintenance of knowledge management systems both within and between organizations. One of the current debates in the literature is whether networks of practice can be created and managed by a firm's management. We do not address this debate specifically. However, our examination of the structural dimensions of networks of practice and the relationship between participation and individual outcomes provides implications for how to structure social systems to support knowledge sharing and creation within networks of practice. A set of further practical implications is also provided.

1.6 Structure of the Thesis

This thesis is structured as follows. Chapter Two discusses the various networks of practice using the network of practice matrix, and Chapter Three presents the results of a review of the relevant empirical studies to date on networks of practice. Chapter Four develops the two research purposes while Chapter Five discusses methodological issues, providing an overview of the methods and data collected in the seven empirical studies. Chapter Six presents a summary of the empirical studies, and Chapter Seven concludes with a discussion of the findings, theoretical and practical implications, limitations, and suggestions for

further research. Finally, Appendix One provides a discussion of knowledge while Appendix Two presents the seven empirical studies in their article format.

CHAPTER TWO

Developing an Understanding of Networks of Practice

THE PURPOSE OF this chapter is to give the reader a basic understanding of the various networks of practice that exist both within firms as well as between firms. In order to do so, literature from several bodies of research has been reviewed⁶. We find during this review that as the literature on these networks of practice continues to grow, so does the number of various labels for these networks, creating a jungle of overlapping terminology. In addition, there are no clearly agreed upon terms for the various types of networks of practice. Thus, as mentioned in Chapter One, we will use the matrix to structure our discussion, placing the various networks discussed in this chapter within the matrix (figure 2.1) and labeling them in the order in which we present them.

We start our overview with a rather lengthy discussion of communities of practice, which will then be followed by a discussion of the other networks of practice in the matrix: intra-organizational and inter-organizational distributed networks that are based on more traditional communication channels and then the more recently emerging electronic networks. As can be seen, there are four areas on the matrix that contain a “0”, indicating that we do not discuss any networks of practice within these areas. While networks of practice within these areas may exist, they either tend not be very common or the literature tends not to discuss them. For example, a group of individuals co-located within one organization generally do not communicate *primarily* by electronic means, thus we have indicated a “0” in this box. Finally, while some empirical studies are discussed in this chapter, a more thorough review of the relevant empirical works follows in the next chapter.

⁶ As mentioned earlier, this thesis will only focus on networks of practice within organizational work settings; however, research on networks of practice has been conducted in a wide variety of settings. For example, researchers have investigated neighborhood groups exhibiting characteristics of communities of practice that emerge around areas such as housing, public safety, and education (e.g., Medoff & Sklar, 1994).

Figure 2.1 Matrix of Networks of Practice

		<i>Primary Communication Channels</i>		
		Face-to-face	Mixed	Electronic
<i>Nature of Network of Practice</i>	Co-located Intra-organizational	1. Communities of Practice	Ø	Ø
	Non-co-located Intra-organizational	Ø	2. Intra-organizational Distributed Networks of Practice	4. Intra-organizational Electronic Networks of Practice
	Inter-organizational	Ø	3. Inter-organizational Distributed Networks of Practice	4. Inter-organizational Electronic Networks of Practice

2.1 Communities of Practice

Early research on communities of practice has its roots in situated learning theory in ethnographic studies of work practices (Orr, 1990, 1996; Lave & Wenger, 1991)⁷. One of the most well known examples of this research is that of Xerox service technicians in which the researcher, Julian Orr, observed that there was a variance between the organization’s formal description of work and the way in which the actual work was performed (Orr, 1990, 1996). When these technicians were faced with problems for which the formal structure often did not provide solutions, they relied on the organization’s informal systems for help, such as story-telling, conversation, mentoring, and experiential learning.

⁷ There is a wider tradition in learning, education, and cognitive theory that has been examining learning in social and situated contexts in the workplace (Abbott, 1993; Gherardi, Nicolini, & Odella, 1998; Marsick & Watkins, 1990; Nicolini & Meznar, 1995). Studies of managers learning in the workplace have also been conducted (Burgoyne & Hodgson, 1983; Davies & Easterby-Smith, 1984; Fox, 1987, 1990). In addition, researchers within psychology have begun to recognize the social and contextual dimension of learning (Augoustinos & Walker, 1995; Farr, 1989; Gergen, 1985; Goody, 1995; Resnick, Levine, & Teasley, 1991; Sampson, 1981).

In so doing, these individuals formed communities of practice, a term introduced by Lave & Wenger in 1991 and defined in the following way:

A community of practice is a set of relations among persons, activity, and world, over time and in relation with other tangential and overlapping communities of practice. A community of practice is an intrinsic condition for the existence of knowledge, not least because it provides the intrinsic support necessary for making sense of its heritage. Thus participation in the cultural practice in which any knowledge exists is an epistemological principle of learning. The social structure of this practice, its power relations, and its conditions for legitimacy define possibilities for learning (i.e., for legitimate peripheral participation). (Lave & Wenger, 1991: 98)

What is particular to the community of practice literature is that the focus is on learning that is situated within the work context of the relationship between individuals and the community. Proponents of situated learning theory view knowledge and practice as inseparable and learning as social construction. Learning is grounded in contexts and artifacts and context is the community in which participants learn how to conduct their work (Lave, 1988; Lave & Wenger, 1991).

For an individual to learn and become a member of a community, individuals go through an informal process of apprenticeship that has been labeled legitimate peripheral participation (Lave & Wenger, 1991). In this process, individuals learn how to function as a community member through participation in the community, enabling them to acquire the language, values, and norms of the community (ibid). For example, individuals learn the informal language of the practice in social situations (Gherardi & Nicolini, 2002). This language can only be learned through informal relationships since it is not the technical language of the trade such as that taught in training manuals (Schenkel, 2002). In addition, members also learn what is necessary to get the job done (Stamps, 1997) and how to handle the tasks and artifacts that they are handed (Davenport, 2002). Learning is gradually achieved as an individual moves from being a novice, gaining access to community practices, to complete socialization and therefore becoming an insider or full member of the community (Wenger, 1998). As individuals participate and earn their status in the community through conducting their work, they construct and reconstruct their social identity in relation to the community. In this manner, the legitimization process of a community of practice differs from legitimization gained through hierarchical

status in more formal groupings such as a team. Lave & Wenger describe the legitimization process in the following quotation:

Absorbing and being absorbed in the 'culture of practice' ...might include [knowing] who is involved, what they do, what everyday life is like, how masters talk, walk, work, and generally conduct their lives, how people who are not part of the community of practice interact with it, what others learners are doing, and what learners need to learn to become full practitioners. It includes an increasing understanding of how, when, and about what old-timers collaborate, collude, and collide, and what they enjoy, dislike, respect, and admire. In particular it offers exemplars (which are grounds and motivation for learning activity), including masters, finished products, and more advanced apprentices in the process of becoming full practitioners. (1991: 95)⁸.

The community of practice concept was further developed by Wenger (1998) in which he brings together concepts of identity, meaning, practice, and community. Following his work, communities of practice have been further defined as *emergent groups of individuals informally and contextually bound who are applying a common competence in the pursuit of a common enterprise* (Brown & Duguid, 1991; Lave & Wenger, 1991; Snyder, 1996; Wenger, 1998). While the term, community, is not readily definable like many widely used terms (Etzioni, 1996), definitions generally place community in direct contrast to society, in which self-interest, individualism, and competition reign (Tönnies, 1887; Durkheim, 1893; Weber, 1978, von Krogh 2002). One sociological definition of community that is helpful in understanding communities of practice is that of Bender (1982:7): “A community involves a limited number of people in a somewhat restricted social space or network held together by shared understandings and a sense of obligation. Relationships are close, often intimate, and usually face-to-face. Individuals are bound together by affective or emotional ties rather than by a perception of individual self-interest. There is a ‘we-ness’ in a community; one is a member.” Etzioni (1996) defined communities by two characteristics that are also prevalent in communities of practice: 1) a web of affect-laden relationships among a group of individuals and 2) a commitment to a set of shared values, norms, and meanings, along with a shared history and identity⁹.

⁸ Educationists are drawing heavily on Lave & Wenger’s work in trying to model the classroom process (e.g., Fleming, 1994).

⁹ Other definitions of community include 1) Sarason’s (1974:1) psychological sense of community as the sense that one is “part of a readily available, mutually supportive network

The first literature further developing communities of practice focuses on the underlying cognitive aspects incurred in practice that serve as the source of coherence for communities of practice. For example, Brown & Duguid (1991) discuss three overlapping aspects of practice: collaboration, narration, and social construction, while Wenger (1998) proposes three related characteristics of practice: mutual engagement, joint enterprise, and shared repertoire. These researchers see the primary requisite for the development of a community as the mutual engagement and collaboration among individuals. As individuals engage in the actions of their work, they collaborate with others. In the course of everyday work, individuals may face unexpected circumstances that the company's formal procedures do not cover or they may be asked to conduct new kinds of tasks, such as creating a new type of product for a customer. As ethnographic studies have shown, individuals then engage in a fluid stream of collaboration, helping each other to perform their tasks. For example, Wenger's claims processors talked and interacted as they worked while Orr's technicians interacted over breakfast. Often this collaboration takes the form of narration. Through the narration of stories, individuals help each other to make sense of circumstances that deviate from the formally described procedures. Storytelling helps individuals to interpret events and diagnose problems through the building of a coherent account of a random sequence of events while at the same time developing a causal map based on their experiences. Used in this manner, stories are more flexible than strict documentation such as that in training manuals since they integrate contextual information, thus providing the ability to interpret each new situation (Brown & Duguid, 1991)¹⁰. These stories then constitute a form of collective memory for the community (Orr, 1996).

Through collaboration and narration, the members of a community of practice negotiate meaning and joint enterprise. Joint enterprise is not a stated goal of the community nor can it be considered to be what is defined in an individual's job description. Rather, it is a result of a complex process performed by a

of relationships upon which one could depend", as well as others defining community within a workplace setting: 2) a group of individuals who have learned how to communicate honestly with each other, whose relationships go deeper than their masks of composure, and who have developed a significant commitment to make others' conditions their own (Peck, 1987), and 3) "a group of people and as a 'way of being' " in which people are brought together in place and time and barriers between people are let down (Maynard, Jr. & Mehrtens, 1993: 13). For a discussion of the psychological sense of community in the workplace, see Klein & D'Aunno (1986). In addition, the term community is finding its way into the management literature in numerous ways. For example, communities for innovation was proposed by Judge, Fryxell, & Dooley (1997) as a means to promote the innovation process in R&D operations.

¹⁰ See Schank (1995), Davenport & Prusak (1998), and Denning (2001) for a discussion of stories as a means to capture and transfer knowledge.

community's members in which they communally negotiate their practice and what is necessary to perform their work while making their work habitable for themselves (Wenger, 1998). As the community negotiates its joint enterprise, relations of mutual accountability to the community arise as well as the development of a common identity. In addition, the community develops a shared repertoire of both a tacit and explicit means of communicating and working, enabling the community to perform its practice in a satisfying manner. The explicit includes the community's own language and vocabulary and artifacts such as codified procedures, documents, regulations, etc. The tacit is the invisible side of the community, e.g., the implicit relations, cues, unarticulated etiquette, etc. - the invisible glue that holds the community together (Brown & Duguid, 1991; Wenger, 1998). In this manner, community members socially construct their world based on the context in which they work, binding themselves together by the context of the situation and creating the social fabric of the organization in an emergent manner (Brown & Duguid, 1991).

Within a community of practice, as people interact and contribute their knowledge to the community, trust increases among community members. As trust increases, members become more willing to share and community knowledge is increased. Thus, motivations to share knowledge within communities of practice are argued to be the expectation of stronger relationships with members as well as higher quality knowledge in future (Davenport, 2002).

A further means of understanding communities of practice is to contrast them with other organizational groups, such as workgroups (or teams) and social networks. In terms of workgroups, while considerable research has been performed on groups within the workplace, e.g., Hackman (1976), the community of practice research differs from this research since communities of practice are by definition *emergent, self-organizing* groups. This is in strong contrast to work groups, that are generally bounded, formal organizational entities, having been created or sanctioned by management (Brown & Duguid, 1991).

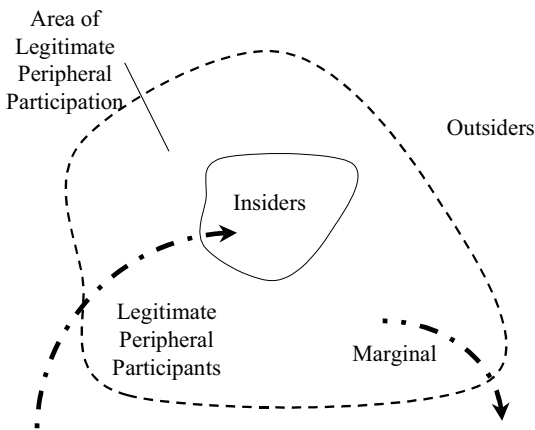
With regard to social networks, a community of practice is similar to an informal social network of interpersonal relationships (Wellman & Berkowitz, 1988), and in fact, Wenger has noted their relationship in several places (1998: 74, 126, 287, 298). He states that communities of practice can be viewed as nodes of "strong" ties within interpersonal networks. However, he takes pains to point out that there is a clear distinction between the two: "A community of

practice is not defined merely by who knows whom or who talks with whom in a network of interpersonal relations...What is of interest to me is not so much the nature of interpersonal relationships through which information flows as the nature of what is shared and learned and becomes a source of cohesion – that is the structure and content of practice" (ibid: 74, 283). Thus, what distinguishes a community of practice from other networks is that a community of practice is a contextually based network consisting of individuals who are involved in a joint enterprise. First, within an interpersonal network, while relationships exist between individuals, they are not necessarily based on the pursuit of a joint enterprise. Rather these relationships occur due to other factors, such as common interests outside of work or discussing sports while taking the same bus to work, etc. The ties may be based only on friendship, and the network does not necessarily have a common goal. Within a community of practice, as mentioned above, members share the same competence, and they use this competence in the pursuit of a common enterprise. Thus, practice is the basis for the community. Second, only those individuals who are seen to be legitimate participants are included in the community, i.e., those who share the values, language, and unwritten code of conduct. The process of becoming a member occurs over a period of time as the individual draws upon the community memory and collaborates with other members. Third, members have an identity that is in relation to the community. In contrast to social networks, individuals within communities of practice interact and collaborate in everyday engagement and give meaning to their actions and their world through these interactions. Membership is jointly determined and is dependent on one's community participation while identity involves how individuals relate to their world and are not formed merely by being part of a social network (Wenger, 1998). Thus, *every community of practice consists of a network, but not every network forms a community of practice.*

In terms of structure, Wenger discusses some structural elements of communities of practice; however, he provides no empirical evidence of these. Arguing that communities of practice have fluid boundaries, Wenger (1998) proposes that there are different levels of participation within a community (figure 2.2): (1) full participation (insider), (2) legitimate peripherality, (3) marginality, and (4) full non-participation (outsider). Categories of participation are not absolutes and instead are contextual and temporal, which means they are fluid and contingent. In full participation, the person is an inclusive member of the community. He or she has gained legitimacy through engaging with other actors of the community in common actions and has acquired the formal and informal ability to behave as a community member (Lave & Wenger, 1991). The member is proficient in the tacit and explicit means of communication and

working that enable the community to perform its practice. However, legitimate peripherality, the second category, connotes a level of only partial participation in the community. Gaining access to the periphery is not unproblematic since boundaries and entrance requirements may exist. For example, full participants may develop close relationships that exclude outsiders, or a complex, detailed understanding of the community's practice may be required to become a full participant. Thus, legitimate peripheral participation indicates that the individual has gained some legitimacy among full participants. An apprentice is one example of a legitimate peripheral participant, gaining community knowledge and acceptance, and on his or her way to becoming a full participant.

Figure 2.2 Categories of Participation in a Community of Practice



Adapted from Tuomi (1999)

As in the case of legitimate peripherality, marginality is a mixture of participation and non-participation. While the boundary between these two levels is unclear, the key difference between them is the participant's trajectory in the community. In the case of legitimate peripherality, the person is either on an inbound trajectory to becoming a full participant or on a circular trajectory around the periphery. However, in the case of marginality, the person's trajectory is outbound, and he or she is thus either moving from being a full participant to becoming an outsider or is restricted to the periphery by the community with little hope of becoming a full participant. Marginal participants may be best understood by looking at practices of discrimination. In such cases, while participants wish to become community insiders, they are continuously

pushed back into identities of non-participation. Finally, the opposite of full participation is full non-participation, or total exclusion from the community. This form of participation may either be decided by the community or by the non-participant since there is no desire to be part of the community.

Regarding the size of communities, discussions tend to ignore this aspect. Wenger does argue that communities of practice are limited in size since they are based upon feelings of mutuality and intimacy that take time to develop through frequent interactions with others (Wenger et al., 2002), but he gives no mention of a “ballpark” number. If we turn to research outside of the community of practice literature, we may gain some insights. According to anthropologists, “real” communities can rarely include more than around 150 people due to the inability of people to develop significant emotional relationships with more than this number during the same time period. In addition, while individuals today may know over 1000 people, they only maintain about 20 active community ties (Kochen, 1989). This is supported by research in non-organizational settings that suggests that North Americans maintain an average of about 20 significant relationships at any given time (Walker, Wasserman & Wellman, 1994). These size limits are argued to be dictated by the “psychological preconditions for transactive memory” that have been defined as “knowing someone well enough to know what they know, and knowing them well enough so that you can trust them to know things in their specialty” (Gladwell, 2000: 190). Thus, it is the recreation of the “kind of intimacy and trust that exists in a family” (ibid).

Turning now to areas of debate within communities of practice, we find two major areas. The first revolves around knowledge creation, innovation, and performance, and the second discusses “management” of communities of practice. With regard to the first debate, the first literature on communities of practice links communities of practice positively to the creation of new knowledge through incremental improvements in local work practices in response to new problems (Brown & Duguid, 1991). However, recent thought on communities of practice has also noted that while communities of practice encourage knowledge flow and innovation within communities, they may limit knowledge flows across communities and as such may place constraints on innovation in the wider organization (Brown & Duguid, 2001; Swan, Scarbrough, & Robertson, 2002). For example, some researchers argue that innovation occurs at the interstices between established groups and work activities since these interstices disrupt or fundamentally alter current work practices (Blackler, 1995). Boland & Tenkasi (1995) discuss this second kind of innovation in their work on communities of knowing, that are similar to

communities of practice yet are found in knowledge-intensive firms. Building on work within science by Knorr-Cetina (1981) and Kuhn (1962), they argue that it is through the dynamic interactions between communities of knowing that new meanings and new knowledge are created in a process they describe as perspective making and perspective taking. Perspectives are made by a community of knowing by “refining its vocabulary, its methods, its theories and values and its accepted logics through language and action within the community” while perspective taking is the ability to be “able to reflect upon and renarrativize the familiar to open up new insights and understanding” (1995:355). Finally, in a theoretical article, Liedtka (1999) links communities of practice with competitive advantage by proposing that organizations that are capable of supporting the qualities of communities of practice across the organization should be able to create and sustain a competitive advantage more effectively than their competitors.

The second area of debate is whether communities of practice can be constructed and managed by firm management. In response to the claims that communities of practice are positively related to organizational performance through innovation, efficient problem solving, best practice transfer, and the recruitment and retention of talent (Wenger & Snyder, 2000), management scholars have focused on ways in which organizations may exploit communities of practice more effectively (Swan et al., 2002). Brown & Duguid (1998) argue that organizations can play a critical role in the construction and support of communities of practice, proposing that management can organize knowledge across communities of practice. Recent accounts by one of the original proponents of communities of practice, Wenger (1998, 2000a, 2000b, Wenger & Snyder, 2000) discusses the means in which managers can construct, support, and align communities of practice in order to exploit them for increased innovation. However, several critics argue that this focus on control of communities of practice for improved performance is a clear shift from Wenger’s original interpretive approach in the seminal work with Lave (Contu & Wilmott, 2000; Fox, 2000; Davenport, 2002). Thus, work on communities of practice tends to fall into one of two classes: those with a more performative perspective and those with a more interpretive or constructivist perspective (Davenport, 2002).

One area that has not been discussed here is the “dark side” of communities of practice. Reflecting on much of the literature to date, the above description of communities of practice paints them primarily in a positive light. However, Wenger has received critique for failing to discuss the wider issues of power and conflicts that naturally occur in social relationships (Contu & Wilmott, 2000;

Fox, 2000). Research on practice prior to the community of practice literature has revealed that resources, power, authority, legitimacy, and different alternatives are defined and at stake within practice (Ortner, 1989; Bourdieu & Wacquant, 1992). In addition, practice is a process of structuring (Giddens, 1979) in which individuals and groups struggle for a share of these resources, power, authority, legitimacy, and different alternatives (Carlile, 1997). Thus, as in any social network, individuals in central positions wield power over resources. Newcomers to the community or organizational changes may threaten these positions, affecting the current set of relationships. Finally, the processes of legitimization may be no easy process. As described above, community of practice participation is jointly determined. Thus, just because one individual would like to become a member of a community of practice does not necessarily mean that the individual is allowed into the community. In addition, from the firm's point of view, research has shown that core rigidities and competency traps may evolve when individuals attempt to preserve the status quo and limit new insights (Levitt & March, 1988; Leonard-Barton, 1992). Thus, communities of practice may turn into cages in which individuals learn not to learn (Wenger, 2000).

In summary, while there are numerous versions of communities of practice touted by both practitioners and scholars, we argue, based on our reading of the literature, that communities of practice are generally tightly knit, emergent groups of people who know each other relatively intimately. They primarily work together directly in face-to-face situations since learning and knowledge are situated within a physical setting. As such, they generally work within the same firm, with exceptions such as consultants based at the client's location. Community of practice members continually and informally negotiate with, communicate with, and coordinate with each other directly in the course of their everyday work, and these processes are a highly implicit part of their work practice (Brown & Duguid, 2000). Artifacts and histories are produced that aid in the sharing of knowledge and the increase of understanding, as opposed to achieving the performance goals such as a team has. There is a high level of sharing of tacit and explicit knowledge among the members, and the key characteristic of communities of practice is that the sum of a community's knowledge is greater than the sum of the knowledge of the individual members (Gherardi & Nicolini, 2000). Finally, within these small groups, reciprocity is strong, and individuals are aware of each other's actions, resulting in a relatively high degree of social control. As we will see, the above characteristics are in contrast to other networks of practice that resemble more loosely coupled systems (Weick, 1979), in which reach dominates several of these characteristics

such as reciprocity. We further discuss the differences between communities of practice and the other networks of practice in the next section.

2.2 Intra-organizational Distributed Networks of Practice

Within an organization, communities of practice may be seen as a subset of larger networks of practice throughout the organization. Intra-organizational distributed networks of practice are emergent relationships of individuals who are dispersed across the organization yet who work on similar tasks using a similar base of knowledge and as such are to be distinguished from dispersed teams that are formally mandated and goal-oriented¹¹. In contrast to communities of practice, which may comprise individuals from several different disciplines or professions, intra-organizational distributed networks of practice are more likely to incorporate individuals from a single discipline or profession. The reason for this is that as individuals are separated from each other's local practice, the practice knowledge that they share in common declines. However, previous research on occupational communities (e.g., van Maanen & Barley, 1984¹²) has shown that when people work in a similar occupation, e.g., as

¹¹ There is a growing body of research investigating dispersed teams and knowledge creation and sharing within them. For example, the MIS literature investigates the use of information technology enabling group processes in the context of virtual organizations, virtual classrooms, virtual offices, virtual enterprises, and virtual teamwork. This literature focuses primarily on group support systems (GSS), computer-mediated communication (CMC), and electronic meeting systems (EMS) in the context of a business environment and how they impact group communication, information sharing, and performance. See, for example, Chidambaram & Jones (1993), Orlikowski (2002), Maznevski & Chudoba (2000), and Sproull & Kiesler (1986, 1991). However, groups investigated in these studies often are formally mandated by management and as such are not emergent, thus falling outside the scope of this thesis.

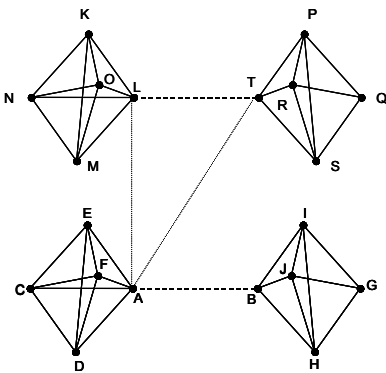
¹² The term occupational community has been used prior to van Maanen & Barley (1984) by several other researchers: Gertzl (1961), Salaman (1974), Hill (1981). However, the purpose of van Maanen & Barley's work was to further develop the term while drawing together this previous research as an alternative means to view behavior than through an organizational lens. The original work on occupational communities differs from networks of practice since the motivation for it was an understanding of organizational social control and problems of social conflict and diversity and as such did not have knowledge and learning as the focus. For example, within the occupational community literature, acquiring new knowledge was important only in terms of maintaining the occupational community's self control, and occupational communities were not seen as a support for individuals to perform their work. Another difference is that the literature on occupational community did not clearly specify whether ongoing mutual engagement was a defining element of the occupational community. Additionally, occupational communities were seen in a negative light in the original literature, which is in direct contrast to that of the network of practice literature. However, later studies focused on the growth of local cultures, the socialization of their members, and the

software programmers, police officers, etc., they develop similar identities, values, and vocabularies. This shared identity and language allow people to communicate, regardless of whether they work in the same physical location or have a previous history of a relationship. As such, individuals from across an organization working on a similar practice may create social networks through which knowledge about practice can both travel rapidly and be assimilated readily (Brown & Duguid, 2000). In this manner, intra-organizational distributed networks of practice are similar to communities of practice in that a shared practice is the substrate that ties members together.

Individuals who participate to a high degree in distributed networks of practice generally serve as brokers (Wenger, 1998). These individuals act as bridges between local communities of practice and serve to transfer and translate knowledge between them. Due to the physically distributed nature of networks of practice, members are generally linked together through weak ties that are not multiplex (i.e., of only one kind, advice relationships, and are less likely to be social). In addition, the contacts of two distributed members are less likely to overlap the weaker the tie is between the two members (Friedkin, 1980). Figure 2.3 illustrates a distributed network of practice.

Figure 2.3 Distributed Network of Practice

Solid lines are strong ties and dotted lines are weak ties.
Distributed network of practice members: A,B,L,T



Adapted from Singer (2003)

“organization” as resulting from negotiation within communities and between external and internal communities (Kunda, 1986; Barley, 1986; Gherardi & Nicolini, 2002).

In a distributed network of practice, coordination and communication are quite explicit as opposed to the implicit communications of a community of practice (Brown & Duguid, 2000). Thus, knowledge tends to be more explicit in a distributed network of practice. Members work to a higher degree through boundary objects or codified objects developed by communities and passed between them, such as artifacts, texts, prescriptions, classification systems, or indexes¹³. In the study of boundary objects, research has shown that the capturing and sharing of knowledge across is no simple process (Star & Griesemer, 1989). When knowledge is abstracted and codified, some of the tacit knowledge is lost in the process. In addition, some aspects of locally developed knowledge are often taken for granted and treated as common sense. As such, individuals often have difficulty describing this knowledge or articulating its relevance to individuals in other locations (Rennecker, 2001; Sole & Edmondson, 2002). This inability to capture all the tacit knowledge may impact the ability of individuals within distributed networks of practice to acquire knowledge from distant settings and use it in their own setting. However, despite the above, knowledge in these networks may be less redundant than that found in member's local communities.

The means by which intra-organizational distributed networks of practice emerge are quite different to how a community of practice emerges since physical closeness is not a facilitating factor. Opportunities to build practice-based relationships across organizations may result from face-to-face meetings such as inter-office transfers, organizational retreats or conferences, or multi-office projects. In recent years, management in numerous companies has made increasing attempts to facilitate the creation of relationships across their organizations by providing the means for people working on similar tasks from across the company to meet. The primary idea behind these actions is to promote knowledge sharing and innovation across internal boundaries. Examples include "technical share fairs" or "knowledge fairs" (Davenport & Prusak, 1998) in which individuals from groups such as research, engineering, and technical service teams are brought together to exhibit information about their projects, expertise, and technical pursuits. In addition, management has focused on "creating" networks of individuals from across the company, bringing them together periodically and providing them with communication technology, such as groupware, in order to promote interactions between the

¹³ Boundary objects were introduced in 1989 by Star & Griesemer, who proposed that boundary objects provide a common ground for social actors from different social worlds to work together. They are "plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites (1989: 393).

face-to-face encounters¹⁴. These networks have numerous names such as knowledge communities or strategic communities, and management even uses the name community of practice for these networks, despite the inappropriate labeling in our view. This trend has been especially prevalent in consulting firms, such as McKinsey, which have supported the creation of networks within areas such as transportation, banking, and finance. Traditional firms in industry have also followed suit. For example, DaimlerChrysler has focused on bringing together individuals who work on brakes across different product lines, e.g., trucks, buses, and cars. Through these different measures, individuals meet previous acquaintances as well as make new ones, thus providing the platform for the development of networks of practice across the organization. Thus, as with communities of practice, the relationships that build networks of practice can also originate due to formal measures implemented by the organization¹⁵.

Resulting from these efforts is a central area for debate as to whether a network of practice of distributed individuals can develop into a community of practice. Some researchers propose that communities of practice are not necessarily face-to-face or contiguous groupings (Brown & Duguid, 1993) and as such may be dispersed across the organization. However, we argue, based on our reading of the community of practice literature, that communities of practice are primarily groups of individuals involved in face-to-face interactions in co-located settings and as such, intra-organizational distributed networks of practice cannot develop into communities of practice. The cognitive aspects of communities of practice described above argue for organizational locale and the resulting face-to-face interactions in co-located sites as a significant factor in the development of communities of practice (Sole & Edmondson, 2002). First, the ability of dispersed individuals to develop a truly common identity in which they share the same values and norms may be hampered by their distance (Katz & Kahn, 1966). Previous research has provided evidence that participation in different sub-units leads to different interpretations of what is distinctive, central, and enduring about their activities and as such leads to organizational sub-identities (Fiol, 1991). Thus, although dispersed individuals may collaborate on activities and negotiate meaning, their identities will more than likely differ due to local

¹⁴ In addition to these distributed networks of practice, organizations are also implementing totally virtual networks of practice. As mentioned earlier, we will focus on networks of practice that are based on face-to-face encounters, and we will come back to the discussion of virtual networks of practice later in this chapter.

¹⁵ Since these communities are of a more formal nature than truly emergent, they are not the subject of this thesis and will not be covered in more detail. Additionally, work on this type of network tends to be more practitioner oriented, often even conducted by practitioners. For more on these strategic communities, see for example, Storck & Hill (2000), Earl (2001), Wenger et al. (2002), and Ackerman et al. (2003).

influences. Second, the primary processes of communities of practice involve mutual engagement, collaboration, and narration, not merely the performance of the same kinds of task (Brown & Duguid, 1991). These are the processes that lead to a shared repertoire and as such, they depend on frequent interaction in which members share experiences and recount stories often in unexpected encounters or informal situations. These stories and experiences serve as the community's collective knowledge and as such guide the actions of the community's members, providing an understanding of the 'way things get done around here'. The dispersed nature of individuals within a distributed network of practice hinders the ability of individuals to informally and frequently interact (Kiesler & Cummings, 2002) and thus the ability to develop to the same degree a body of communal knowledge. Third, the development of a sense of mutual accountability to the group may also be hindered since the dispersed nature may affect the group's ability to develop the necessary degree of trust, commitment, and respect (Orlikowski, 2002). Previous research has also indicated that confidence between individuals working through electronic communications in distributed locations has a "half-life" (de Meyer, 1991). In other words, while confidence may be built in face-to-face relationships, once the individuals disperse to different locations to work, the level of confidence among them declines until they meet face-to-face again.

The final aspect regarding this debate deals with the tacit/explicit dimension of knowledge. As described by Wenger (1998), much of the learning and acquisition of community of practice knowledge by an individual occurs through an implicit mode. This is in line with Reber (1993) who argues that the acquisition of tacit knowledge takes place largely independently of conscious attempts to learn and largely in the absence of explicit knowledge about what was acquired. Thus, the acquisition by an individual of a community's tacit knowledge implies frequent interaction through word of mouth and observation, similar to that of an apprentice and a master, and thus difficult to achieve in non-face-to-face settings. Gherardi & Nicolini (2002) find that everyday "looking and seeing" are two forms of action fundamental in the learning of practice. They discuss the importance of the utterance "Look!" as important for learning how the job is done because it signals the importance of what is happening and the need to internalize the situation.

The importance of "looking and seeing" may differ across work practices depending on the nature of the practice. For example, in work practices such as construction or copy machine repair, learning and tacit knowledge are deeply situated and distribution across physical environments hinders this process. However, in other work practices in which the face-to-face element plays a

relatively less important role, such as software programming, learning and knowledge sharing may occur in a more codified nature and as such may be relatively less situated, thus facilitating the ability with which this knowledge can be transferred through distributed networks.

Further support for communities of practice as intra-organizational face-to-face groups in co-located settings is found if we look at the studies performed to date. The majority of the community of practice studies are ethnographic studies of face-to-face, intra-organizational groups in co-located settings, e.g., Suchman's (1983) office workers, Wenger's (1998) claims processors, Orr's (1990, 1996) service technicians. Recent research has also focused on co-located settings: Carlile's (1997, 2002) auto supply manufacturer employees and Bechky's (1999, 2003) technicians and assemblers. In addition, research on whether distributed teams can display characteristics of communities of practice also supports our argument. For example, in a study of seven geographically dispersed teams in a multinational company, Sole & Edmondson (2002) find that the knowledge of the individual team members is physically situated and thus hinders the cognitive processes identified with communities of practice among the dispersed team members. We will return to a discussion of these and other empirical studies in the next chapter.

In summary, intra-organizational distributed networks of practice are networks of loosely connected individuals who tend to be members of local communities of practice distributed across the firm. Interactions tend to be of a dyadic, reciprocal nature, and they are conducted through both electronic and face-to-face means. However, due to the distributed nature of the network, ties between members are weaker than those in communities of practice and there is a lower degree of overlap among member's contact circles. As a result, the degree of shared identity, language, norms, and values is also lower than in communities of practice. While knowledge is shared through these networks, it tends to be of a more explicit nature, often taking the form of boundary objects. Additionally, these ties require less effort on the part of the individual to maintain and the degree of social restraint on behavior is lower.

2.3 Inter-organizational Distributed Networks of Practice

With recent advances in information technology, the costs of informal communication across a firm's legal boundaries by individuals throughout hierarchical levels and functional competence groups in the organization have been greatly reduced (DeSanctis & Fulk, 1999; Kettinger & Grover, 1997).

Thus, individuals may easily access individuals across the firm's legal boundaries (Cronin & Rosenbaum, 1994) and discuss their work tasks with professional contacts, friends, family, ex-colleagues, or other acquaintances who are working on similar tasks. We refer to these networks of individuals working on similar tasks yet dispersed across organizations as inter-organizational networks of practice.

For individuals not working within a highly professional capacity or at higher levels of the hierarchy, previous efforts to interact with others outside their organizations were often fruitless as they could be time-consuming or against company policies unless specified in the job description. Indeed, individuals may not even have known whom to contact or how to find a relevant person. Furthermore, if management did not provide the resources to attend external conferences or other events, finding other like-minded individuals with whom to discuss work-related problems often proved difficult. Since these communication developments are recent, we know little about inter-organizational networks of practice other than those comprising individuals who are primarily engaged in work with a highly professional content, such as researchers within science-based industries. We now turn to this research that has been conducted within this capacity.

Inter-organizational networks of practice are by no means a new phenomenon. They have existed for hundreds of years and have played an important role in the diffusion of knowledge through society. For example, in the history of science, "gentlemen scientists" belonging to scientific communities sent letters back and forth to enable individuals to keep up-to-date with developments as well as to establish some form of control over the development of the community's knowledge (Pinch, 1990). In addition, they fall under a variety of names and are characterized by varying degrees of connectedness in terms of relationships: scientific communities (Polanyi, 1962b; Knorr-Cetina, 1981), co-citation networks (Usdiken & Pasadeos, 1995), invisible colleges (Crane, 1972), epistemic communities (Holzner & Marx, 1979; Adler & Haas, 1992; Haas, 1992), thought-collectives (Fleck, 1935), paradigms (Kuhn, 1962), and occupational communities (van Maanen & Barley, 1984)¹⁶. The term, invisible

¹⁶ Another well-known inter-organizational grouping is social worlds (Strauss 1978). Social worlds are one of the broadest groupings of individuals, including groups ranging from scientists to stamp collectors to baseball fans. Social worlds are fluid groups of individuals whose glue is based upon a central activity (and potentially related activities). However, since the activities of a social world in their general sense could be hobbies such as stamp collecting, baseball, or politics, they are not necessarily related to an individual's practice or work. While individuals within social worlds are described as developing their identity in

colleges, dates back to the 1640s when a group of ten men, who actually were not professional scientists but were well-educated within one field, would meet informally in the taverns of London. These meetings later developed in 1660 into the Royal Society, the oldest scientific society in Great Britain (Price, 1963; Tuire & Erno, 2001). Since then, invisible colleges have been used to describe groups of researchers within the same branch of science *who have personal relationships with one another* (Crane, 1972). The other above terms, however, tend to have a broader definition of membership. For example, van Maanen & Barley suggest that “professions are viewed as occupational communities” (1984: 287), i.e., boundaries are determined by the profession and not by personal relationships. Despite their broader definitions, we include these in our discussion since research on these sheds some light on our investigation of inter-organizational networks of practice. Finally, in order to avoid repetition, we will use some of these terms interchangeably.

Research on occupational communities has provided evidence that individuals see their work not only as a means of making a living, but as a “central life interest” (Dubin, 1956), deriving meaning and value from their work while constructing their social identity in relation to the occupational community (van Maanen & Barley, 1984). Members share values, norms, and perspectives, and since they are often widely dispersed they maintain their relationships through conferences, conventions, newsletters, publications, and other means. In addition, norms and behaviors are enforced through the use of professional associations to accredit educational programs in their profession, to prevent individuals who are not sanctioned from participating, and to discipline individuals for misconduct or malpractice (Pickering & King, 1995). The majority of research on these inter-organizational networks has been conducted on networks of individuals who are involved in the physical or social sciences working as researchers, thus the following discussion reflects this bias¹⁷.

relation to the social world, such as in a network of practice, there are some primary differences between social worlds and networks of practice. First, research on social worlds has tended not to focus on knowledge and learning. Second, membership in social worlds is generally determined merely by affiliation and is not necessarily determined by the greater group through social interaction. Third, the world is held together through communication and not social interaction since communication may be one way. For example, an individual may affiliate and identify himself with the social world of baseball because he likes to watch baseball on television. However, he does not necessarily have to interact with anyone about baseball, nor may he be interested in learning more about the sport or improving it. As a result, this literature provides little understanding of networks of practice that are non-science based.

¹⁷ While much of the research on science-based networks has been conducted within academic settings, we have chosen to include this body of literature since these networks and

Regarding knowledge sharing and creation within these inter-organizational networks, individuals engage in debate and discussion of each other's ideas and results as well as collaborate on joint research projects (Crane, 1972; Ziman, 1978)¹⁸. In many cases, these informal relationships are more valuable than publications for sharing knowledge since the results of failed experiments are rarely published and learning about these can prevent their duplication. Through these relationships, knowledge and innovations spread across national and cultural boundaries. Due to the universal nature of the knowledge within the community as well as a shared language and values, individuals can communicate relatively easily with one another across these boundaries (Tushman & Katz, 1980; van Maanen & Barley, 1984). In addition to presentations and authorship of publications (Liebeskind, Oliver, Zucker, & Brewer, 1996), personal communication is an effective means of establishing and protecting individuals' intellectual property rights (Price, 1963). Knowledge is often considered to be more of a public good than a private good within the community since the publishing of results makes knowledge available to all within the community.

In addition, the central goals and values of a community are developed and spread throughout the networks (Hagstrom, 1965). Strong norms that are well defined and socially enforced exist within scientific communities, such as reciprocity in knowledge sharing, respect for individuals' intellectual property rights, and honesty in research (Crane, 1972; Blau, 1973; Liebeskind et al., 1996; Debackere & Rappa, 1994; Bouty, 2000). Trustworthy behavior and norms are enforced since the level of participation in the community is jointly determined by the community's members. Individuals who fail to follow the norms and implicit code of conduct can be excluded from participating in valuable exchanges with others, e.g., participation in research teams with leading researchers, access to the latest research findings, etc. This exclusion can then negatively impact their career success (Tuire & Erno, 2001). As a result, the production and sharing of valuable knowledge is facilitated, allowing the frontier of knowledge to progress rapidly and at minimal cost (Liebeskind et al., 1996).

thus the research also include researchers working for business firms, making it often hard to distinguish between the two groups.

¹⁸ The majority of studies on scientific networks have investigated the physical sciences. Garvey (1979) proposed that social science networks are similar to physical science networks, although they may be less highly structured.

Studies of research-based communities of academic scientists have shown that they are generally characterized by a center and a periphery (Schott, 1988)¹⁹. The most important, visible, or active members are generally found in the center, and these individuals influence the direction of the development of the community's knowledge. The activities of the individuals in the core determine the community's dominating theoretical concepts, methods, and chosen research problems and these are then mediated through the network's links to individuals in the periphery (Schott, 1988). Through a process known as or social contagion (Levy & Nail, 1993; Marsden, 1998), new members are socialized into the community and as such transform their personal identities, adapting their attitudes, behaviors, and values to those of the community (Holzner & Marx, 1979). Additionally, power is an integral part of scientific communities, with individuals often using knowledge strategies as components of power strategies (ibid). Thus, the center of a scientific community is not only a realm of activity, but it also is a realm of identity and cultural values of the community (Schott, 1988; Tuire & Erno, 2001).

Work within the occupational community literature argues that individuals who attain a position of centrality in the inter-organizational network generally have a higher degree of knowledge, power, prestige, and honor (van Maanen & Barley, 1984). Individuals who are visible in central positions are seen to be the sages of the community. Similar to Wenger's degrees of participation, within an occupational community, newcomers have a time of apprenticeship or learning in which they learn the "rules of the game". It is suggested that centrality, work performance, and individual careers are closely interconnected factors within these networks. An individual's reputation is gained through expertise in one's work, where one conducts his or her work – "majors" vs. "minor leagues", and whom one knows – e.g., doctoral student and faculty supervisor (van Maanen & Barley, 1984). Thus, these professionally based inter-organizational networks of practice are similar to communities of practice in that they are composed of circles of members who have passed through various "boundaries".

In addition to the above research that takes the perspective of the inter-organizational network, researchers investigating participation in inter-organizational networks of practice have also taken the firm's perspective²⁰. This research has primarily focused on high technology industries and one area of investigation is why individuals communicate informally with others outside

¹⁹ See Schott (1988) for a discussion of the center-periphery model.

²⁰ Research has found that academic and industrial scientists display similar work-related communication patterns. For a study that directly compares these groups within three different fields, see Debackere & Rappa (1994).

the organization. First, von Hippel (1987) writes that when specialist engineers cannot find the required know-how in-house or in publications, they go outside their organization to their professional networks that are developed at conferences and other events when individuals have the opportunity to judge each other's expertise. Further research has found that quite often professionals communicate with others in their professional networks in order to maintain contact with a professional reference group and to keep abreast of technological changes (Aiken & Hage, 1968; Aldrich & Herker, 1977). However, Allen (1970) also finds that low performing individuals choose to go outside for help. He argues that this choice is a way to avoid paying a psychological price of loss of face that occurs when an individual asks a colleague who is not a friend for advice.

Extensions of this research within high technology-based industries provide evidence that participation by individuals in inter-organizational networks of practice leads to knowledge sharing across a firm's legal boundaries and that these activities are generally not governed by contracts or other market mechanisms (Liebeskind et al., 1996)²¹. One of the most well known examples of this is the study of Route 128 and Silicon Valley by AnnaLee Saxenian. In this study, Saxenian proposes that one of the primary reasons for the relative success of the Silicon Valley area is that knowledge is easily shared through informal relationships between individuals belonging to competing firms. This is in direct contrast to the Route 128 area in Boston where informal inter-organizational fraternization is discouraged. These informal relationships often form more rapidly than formal inter-organizational relationships, thus facilitating the flow of knowledge between organizations (Brown & Duguid, 2000).

Of interest to management is that this flow of knowledge into the firm through participation in inter-organizational networks of practice by firm members is generally not a one-way street. Rather, individuals are often likely to exchange

²¹ Considerable research has also been performed on these inter-organizational networks but from the firm's point of view, e.g., inter-organizational boundary spanning activity - a major stream began in the 1960s with the investigation into the communication patterns of scientists and engineers in R&D laboratories (see e.g., Allen (1977), Allen et al. (1979) etc.; see Flap, Bulder, & Völker (1998) for a review) and informal know-how trading - a relatively less investigated stream of research, e.g., semiconductor, specialty steel and mini-mill industry, and R&D operations (Schrader, 1991; von Hippel, 1987; Bouty, 2000). We discuss these later in various sections of this thesis.

or trade knowledge²² with others who might even be working in rival firms (Czepiel, 1975; David & Cochran, 1987; von Hippel, 1987; Schrader, 1991), thus it is argued that knowledge “leaks” across the firm’s legal boundaries (Mansfield, 1985; von Hippel, 1988). However, this research suggests that individuals do not just give the knowledge away to others in their networks of practice. Rather they consciously exchange knowledge with other carefully chosen individuals with whom they often have a long-term relation built on mutual trust and understanding (Schrader, 1991; Bouty, 2000). Research conducted by Schrader (1991) finds that individuals often expect that their chances of receiving valuable knowledge in return from the knowledge seeker are likely to increase after they provide knowledge. Thus, participation in inter-organizational networks of practice results in a feeling of reciprocity and a dyadic exchange of knowledge (von Hippel, 1987; Macdonald & Williams, 1993) with knowledge sharing viewed as an ‘admission ticket’ to the ongoing ‘back room’ discussions within professional networks (Appleyard, 1996).

As a result, participation in inter-organizational networks of practice leads to knowledge leaking out at the same time as it leaks in (Brown & Duguid, 2000). However, research on the relationship between this knowledge trading and performance at any level is scant. One of the primary reasons is that it is very difficult for firms to manage and evaluate the benefits since it occurs “off the books” (Carter, 1989). Secondly, data regarding the sharing of potentially firm proprietary knowledge are difficult to collect due to their sensitive nature. However, there is some initial evidence of a positive relationship between knowledge trading and firm performance (Allen, Hyman, & Pinckney, 1983; Schrader, 1991).

While science-based inter-organizational networks of practice have received considerable attention from researchers, in recent years there has been an increased interest in inter-organizational groups that are not necessarily science-based or profession-based. Mentioned above, occupational communities may also be inter-organizational (Van Maanen & Barley, 1984). However, we argue that occupational communities are not the same as inter-organizational distributed networks of practice since occupational communities comprise individuals who belong to the community merely due to their sharing the same occupation and not based on their emergent relationships based upon interaction while performing work tasks. Thus, while an inter-organizational distributed

²² These studies often used the term know-how trading. In order to keep in line with the terminology in this thesis, knowledge exchange will be used here to indicate know-how trading.

network of practice may comprise individuals from the same occupation, not all occupational communities are inter-organizational distributed networks of practice. In addition, the literature on occupational communities has generally seen these groupings in a negative light in relation to organizations in which there is a constant power struggle between management and occupational communities. One of the primary goals and differentiators of occupational communities is argued to be self-control, or the occupational community's ability to dictate who will and will not be a member, how the content and conduct of a member's work will be assessed, as well as the bargaining power of its members over management within organizations. For example, the literature discusses unionization and professionalization as a means to gain and retain self-control so that the collective career of the community may be advanced. When knowledge is discussed, it is described as a means merely for the community of generating and maintaining self-control and thus, is not the primary focus of the group, in direct contrast to that of inter-organizational networks of practice. Finally, of interest is that there have been very few studies investigating occupational communities (Barley, 1996)²³.

A second development in the area of inter-organizational networks worth mentioning is that of epistemic communities. In its original definition, the term was used to describe groups of individuals, such as those within the same profession or scientific discipline, who share a common frame of reference and set of perspectives with which they construct their reality (Holzner & Marx, 1979). This term has been adapted within the field of international relations to describe groups of individuals who are bound together by "their shared belief or faith in the verity and the applicability of particular forms of knowledge or specific truths" (1992:3) and as such resembles Fleck's "thought collectives" or Kuhn's paradigms. Within international relations, epistemic communities have been used as a lens to understand policy changes and coordination at the

²³ In one of the few studies on occupational communities, Lawrence (1998) conducted a study of a small Canadian Forensic accounting community in a western Canadian province (comprising 10 to 14 established accountants). This limited study of 22 interviews was based on a sampling design that has been labeled as snowballing in which initial interviewees identified successive interviewees and so on. Interviewees consisted of accountants, lawyers, and law enforcement officers. Relevant results revealed that there were both formal and informal rules for membership. The formal rules, such as membership in professional associations, were considered a prerequisite for all potential members; however, the informal rules were those that determined in essence who became an insider of the community. These informal rules involved stereotypes that cast some people as insiders and others as outsiders based on particular characteristics (e.g., sex, age, education, experience), personality, or social processes (e.g., recommendation through word-of-mouth) that worked to include some while excluding others.

national and international levels that have been impacted by communities of specialists. These epistemic communities consist of individuals from a variety of disciplines and backgrounds, have a shared commitment to enhance a particular set of knowledge, and are motivated by the possibility to influence public decision making in their field of expertise²⁴. However, this set of inter-organizational networks falls outside the scope of this thesis since they generally comprise individuals such as governmental policymakers and as such are primarily *not* working for business firms.

Beyond this, little research on inter-organizational networks of practice of individuals who are not involved in science-based industries has been conducted, thus leaving us with a limited understanding of these networks. One of the reasons for this lack of research may be due to the relative difficulty in identifying and studying these emergent networks due to a lack of public record of communications or certain ethical issues in conducting research. In comparison, scientific communities have been easier to research due to the accessibility of publicly available data such as citations and bibliographic references. However, with the global spread of the internet, electronic communities have developed that provide a virtual space for individuals regardless of organizational affiliation, profession, or status to communicate on work-related matters. In addition, these electronic networks often conduct their activity in the public domain on the internet, thus facilitating the ability to research them. We turn to these electronic networks in the next section after we summarize inter-organizational networks of practice.

In summary, the inter-organizational networks of practice described here are similar in many ways to communities of practice: a smaller set of individuals bound together by a common practice and acting communally, a focus on knowledge and learning, strong social norms of behavior and control, and relationships more of a dyadic reciprocal nature. However, there are some differences. First, similar to the discussion above regarding organizational locale as a differentiating factor between intra-organizational networks of

²⁴ Haas (1992:3) proposes that members of epistemic communities have: “(1) a shared set of normative and principled beliefs, which provide a value based rationale for the social action of community members; (2) shared casual beliefs, which are derived from their analysis of practices leading or contributing to a central set of problems in their domain and which then serve as the basis for elucidating the multiple linkages between possible policy actions and desired outcomes; (3) shared notions of validity – that is, intersubjective, internally defined criteria for weighing and validating knowledge in the domain of their expertise; and (4) a common policy enterprise -- that is a set of common practices associated with a set of problems to which their professional competence is directed, presumably out of the conviction that human welfare will be enhanced as a consequence.

practice and communities of practice, we find the same applies to inter-organizational communities, yet to a higher degree. In inter-organizational communities, individuals come from a variety of organizations, thus they tend to be even more heterogeneous in their experiences. Different organizational affiliations may also lead to a more weakly shared identity, language, norms, and values (Fiol, 1991). A second difference between these two types of networks focuses on the knowledge created. In scientific research-based communities, knowledge created is more universal since it is less situated in a physical location or organizational context. However, knowledge created within a community of practice is more situated in a physical location and as such tends to be less explicit and more difficult to diffuse for reasons described above. Additionally, members of a community of practice focus on improving their own competencies and practice and not that of other individuals who may be working on similar tasks in other locations. Knowledge spillover for others outside the community of practice is a by-product of communities of practice and not the main focus. This is in contrast to the scientific and occupational communities discussed above whose members generally work to improve both their own competence as well as create knowledge for the greater set of individuals involved in the same scientific specialty or profession.

Additionally, while we may know quite a bit about science-based and profession-based inter-organizational networks of practice, we know little about inter-organizational networks of practice comprising individuals outside these groups. In other inter-organizational networks of practice, say commercial real estate managers in Stockholm, we would expect to find differences. For example, knowledge could be considered to be more of a private good since there may not be channels or norms to make knowledge public. These differences may then affect knowledge sharing within these networks.

2.4 Electronic Networks of Practice

As mentioned above, recent advances in internet communication technologies have also led to the development of new forms of communication: emergent electronic or virtual networks²⁵. These electronic networks are the source of a

²⁵ It is important to state our position on which perspective we take with regard to the use of computer-based systems in social settings. In an extensive review of empirical studies regarding computing use in organizations and public life, Kling (1980) contrasts two broad perspectives: (1) systems rationalism and (2) segmented-institutionalism. Systems rationalism includes a collection of approaches such as management science, management rationalism, and the systems approach, and this perspective is found to be more helpful in stable settings when there is consensus over important social values. Followers of this

high level of inter-organizational communication, such as listservs²⁶, multi-user domains²⁷, chat rooms, and bulletin boards (Hinds & Kiesler, 1995; Constant, Sproull, & Kiesler, 1996). For example, by 1999 the number of Usenet groups expanded to more than twenty-five thousand different interest groups with more than half a million postings per day (Dern, 1999). Firms are also leveraging these new technologies and are implementing applications such as electronic discussion networks or bulletin boards to promote knowledge sharing between unacquainted individuals across the firm's internal organizational boundaries (Fulk & DeSanctis, 1995; Davenport & Prusak, 1998; Alavi & Leidner, 1999). Similar to the previously discussed networks of practice, electronic networks of practice are also typically emergent networks, forming around a specific practice, such as criminal law, and they have been given a number of names: webs of knowledge, electronic communities, online communities, electronic networks, and even communities of practice²⁸. In our discussion, we will use some of these terms interchangeably to refer to electronic networks of practice.

Due to their relative recent appearance, there is a very limited amount of research on electronic communities. Wellman & Gulia (1999) discuss the dearth

perspective view efficiency, whether economic or organizational, as the predominant value. However, segmented-institutionalism is found to be more helpful in more dynamic settings involving a wider variety of groups in which there is generally more conflict instead of consensus on social values. Followers of this perspective view the predominant values to be sovereignty of individuals and groups over the critical aspects of their lives, the integrity of individuals, and social equity. Economic and organizational efficiency is subservient to these values. Due to the dynamic aspects of electronic networks of practice and our argument that individuals can make their own choices regarding the sharing of knowledge and degree of participation in electronic networks of practice based on individual motivations of self-interest and collective interest, we identify more with the segmented-institutionalists than with the systems rationalists.

²⁶ Listservs are mailing lists that forward email messages to everyone who has subscribed to the list. Members seldom know who each other are due often to the large size of these lists.

²⁷ Multiuser domains (MUDs) attempt to model physical spaces and face-to-face interaction using text-based virtual realities.

²⁸ Electronic communities can revolve around numerous topics and are not necessarily work related. For a discussion of various aspects of electronic communities, see Smith & Kollock (1999) or Lueg & Fisher (2003). In addition to work-related communities, there are four main types of online communities (Hagel & Armstrong, 1997): (1) communities of interest: individuals who share an interest, expertise, and passion in an area, e.g., bird watching, sport scars, etc., (2) communities of relationships: individuals who need to share a personal life experience, e.g., breast cancer, divorce, etc., (3) communities of transaction: individuals who exchange information to facilitate economic exchanges, e.g., wine, and (4) communities of fantasy: individuals who explore new identities in imaginary worlds of fantasy. As mentioned, keeping in line with the focus of this thesis, we will focus our discussion only on electronic networks of practice, or electronic communities that revolve around a specific work practice.

of studies on online communities. As such, we have chosen to discuss intra-organizational and inter-organizational virtual communities together in this section, indicating differences where appropriate. We begin with a general overview of electronic networks of practice.

The unique characteristic of electronic networks of practice is that they enable the creation of weak structural links between thousands of geographically dispersed individuals. Individuals may quickly and effortlessly access a broad source of expertise through a wide variety of knowledgeable individuals with whom they are not acquainted regardless of their demographic characteristics, organizational setting, or local culture (Hinds & Kiesler, 1995; (Sproull & Faraj, 1995, Faraj & Wasko, 1998). In these networks, individuals engage in knowledge sharing, problem solving, and learning through posting and responding to questions on professional advice, storytelling of personal experiences, and debate on issues relevant to the network (Wasko & Faraj, 2000). Individuals benefit from these networks since they gain access to and even randomly come across new information, expertise, and ideas that are often not available locally due to the extensive reach of these networks (Brent, 1994). In addition, these networks enable individuals to gain access to the latest thinking within their field.

In electronic networks of practice, anyone interested in the group's topic may join and the number of participants is unlimited. Little is known about the participants other than an email address and what each individual voluntarily chooses to disclose (see Sproull & Faraj, 1995; Kollock & Smith, 1996; Wasko & Faraj, 2000). Examples of Usenet communities include those revolving around more technical issues such as `comp.lang.c++`, `comp.objects`, and `comp.database`. These technical electronic networks display characteristics similar to scientific communities since they are open to anyone with the express purpose of developing valuable programming knowledge in rapidly changing technical fields (Wasko & Faraj, 2000). Participation in electronic networks of practice is argued to be especially rapid in organizations with individuals who are interested in maintaining interpersonal social ties or as described above, weak structural links, that are based primarily on similar professional interests (Pickering & King, 1995).

Comparing electronic networks of practice to communities of practice, they are similar in that they are a social space where individuals working on similar tasks self-organize to help each other and share perspectives about their occupational practice or common interest (Brown & Duguid, 2000). However, they exist primarily online and have a natural boundary based on membership, and we

believe that there are other critical distinctions between the characteristics of a community of practice and an electronic network of practice. First, communities of practice are generally characterized by rich face-to-face exchanges in person-to-person interactions. As discussed above, the tightly knit social structures of communities of practice facilitate the creation of a shared identity, common language and norms as well as trust, obligation, and social controls. These characteristics have been argued as essential for the continuous incremental improvements in the community's practice (Brown & Duguid, 1991, 1998; Wenger, 1998). However, interactions in an electronic network of practice are limited to text-based, asynchronous, computer-mediated communication. Theories of media richness argue that text-based computer-mediated communication is a *lean* medium of exchange. In other words, it is difficult for people communicating to develop a shared meaning and understanding since this type of communication is impersonal, does not provide immediate feedback, and does not provide additional meanings through body language, voice inflections, dress, posture, or tone of voice (Sproull & Kiesler, 1991; Lee, 1994). Since members are not physically in the presence of each other, norms are not as dominating in electronic communities, allowing for more individual freedom in action (Squire & Johnson, 2000). Additionally, individuals may be scattered geographically across the organization or across numerous organizations and as such may not interact on a daily basis in a face-to-face manner. This type of interaction leads to relatively little direct reciprocity between individuals and as a result, reach dominates direct reciprocity in these networks. In this manner, electronic networks of practice resemble loosely coupled systems (Weick, 1979). As a result, the ability of members to develop a shared identity and repertoire through narration, collaboration, and social construction is hampered.

However, as mentioned, electronic networks of practice have a greater reach than traditional networks of practice, and as such do support the creation of weak electronic "bridging ties" between an unlimited number of like-minded individuals. Discussed above, electronic networks of practice are not limited by size constraints, and membership is typically voluntary and open, unlike communities of practice. Anyone with an interest in the shared practice can participate in an electronic network of practice regardless of social status, racial demographics or geographic location because the technology filters out the social cues associated with face-to-face interactions. Additionally, logistical and social costs to participate are lower than in distributed networks of practice (Sproull & Faraj, 1997). As a result, electronic network of practice participants generally do not have personal familiarity with one another nor do they need to have this in order to seek out answers and advice from other members. Thus,

unlike the previously discussed networks of practice where people know each other personally and form dyadic, interpersonal relationships, participants in electronic networks of practice are typically strangers, personal information is limited to what an individual wishes to voluntarily disclose, and individuals form weak ties with the entire network instead of with a select few. In addition, the open and fluid membership in an inter-organizational electronic network of practice enables dynamic interactions regardless of local organizational rules and hierarchies. Thus, an electronic network of practice increases the likelihood of connecting knowledge seekers with other knowledgeable helpers regardless of interpersonal social ties, potentially increasing access to greater resources than are available in a local community or in one's network of acquaintances.

In electronic networks of practice such as those supported by listserv or bulletin board technologies, it has been proposed that knowledge be considered as a public good (Kollock, 1999). In the formal language of collective action theory, the network participants are the interest group, and the public good is the continuous stream of knowledge produced and jointly held by the network's participants. In an electronic network of practice, the posting of messages is open to anyone and once posted, messages are visible to everyone participating in the network. Thus, anyone searching for advice can either post a new question, or in some networks search the archived discussions to reuse knowledge that has already been exchanged between other members. This ability to make all interactions visible and reach everyone in an electronic network of practice contrasts with the dyadic interactions in a community of practice or a traditional network of practice. Due to this open nature, the network's knowledge is non-excludable. When one participant responds to a posting, then all members may benefit from this knowledge, even though they did not contribute to its production through either posting or responding.

One central research area in electronic networks of practice is why do people spend their time helping others and sharing their knowledge with others who are typically strangers. When an individual shares knowledge with others, this results in the loss of unique value of the individual relative to the others (Thibaut & Kelley, 1959) and thus benefits all others except the individual (Thorn & Connolly, 1987). Therefore, it seems irrational that individuals voluntarily contribute their time, effort and knowledge to help strangers in a network of practice (Wasko & Faraj, 2002). Researchers investigating this paradox have found a variety of factors motivating online knowledge sharing, such as organizational commitment, norms of reciprocity, and enjoyment in solving problems (Constant et al., 1996), trust (Ridings, Gefen, & Arinze, 2002), and an interest in advancing the community, intrinsic rewards, and increased reputation

(Lakhani & von Hippel, 2000). In addition, recent work has focused on applying a public good perspective to the study of electronic networks of practice. Using this perspective, it is argued that knowledge sharing is motivated by moral obligation and mutual interest as opposed to self-interest.

There are two primary areas of debate for electronic networks of practice: (1) whether they can be designed and managed and (2) whether learning and innovation can be supported by them. Regarding the first area, authors commonly focus on the technical aspects of designing and managing electronic networks of practice while failing to discuss the difficulties due to the various social aspects of the community (Hara & Kling, 2002). As for the second area of debate, the recent phenomenon of open source software development projects provides support the idea that knowledge creation can occur through virtual means only. In these projects, individuals from across the world and organizations create knowledge completely online through the development of software programs, e.g., Linux, Apache. The intriguing aspect of these communities is that individuals “freely” and “voluntarily” collaborate to develop software that they or their organizations need (von Hippel & von Krogh, 2003). The result is that the innovation no longer is an individual task, but a joint effort produced by the “community”. Recent work examining the open source software phenomenon has proposed a compound model of innovation, the private-collective model in which private interests are combined with collective interests, as a means to better understand this form of collaborative behavior that results in knowledge creation (ibid). While these open source projects are not electronic networks of practice, there are often electronic networks of practice associated with them. For example, project founders often set up mailing lists for individuals using or developing the specific software code to seek help, to provide information, or to provide new code for others to discuss and test (ibid), and as we will see in the next chapter have been the focus of several studies.

In summary, electronic networks of practice are similar to traditional networks of practice since they are a social space in which individuals working on similar tasks may collaborate and share knowledge. However, there are some considerable differences. Electronic networks of practice are characterized by generalized reciprocity, a high degree of reach, and a low degree of social constraint and shared identity. As a result, while knowledge may be shared in these networks, it tends to be of a much more explicit nature, and potentially of a more novel nature, than that of non-electronic networks of practice. Finally, one considerable difference is that knowledge within electronic networks of practice can be considered to be more of a public good since all interactions between members are generally visible to all members.

2.5 Summary

While this discussion has revealed that there are considerable differences between the various networks of practice, they do have one important aspect in common. Since they are all emergent networks, these various networks are self-organizing and autonomous. Thus, the continued vitality of any network, regardless of type, is dependent upon the willingness of individuals to participate and share knowledge with one another. In summary, this chapter has provided us with a basic understanding of the various networks of practice. In the next chapter, we will review the relevant empirical studies conducted to date, while we return to a comparison of the various types of networks of practice in the final chapter.

CHAPTER THREE

Review of Previous Empirical Studies of Networks of Practice

THIS CHAPTER REVIEWS the set of empirical studies that are relevant to our study on networks of practice in order to develop the research purposes of this thesis. Notice the use of the phrase “relevant to our study on networks of practice” as opposed to “about networks of practice”. To date, the number of studies that focus explicitly on networks of practice is quite limited, especially within certain areas. However, there are several bodies of literature that contain studies relevant to networks of practice (e.g., technology transfer) due to their focus on emergent networks whose main activity is knowledge creation and sharing. In figure 3.1, we present the network of practice matrix in which we provide an overview of the selected bodies of literature from which we draw.

Any review of this degree of breadth is necessarily selective, thus it is important to note a few limitations. First, we focus our review only on studies that rely on empirical fieldwork and not on theoretical articles or studies based on experiments or simulations. This line has been drawn since we are interested in what we “know” about networks of practice as opposed to what we “think we know” about them. In addition, as mentioned above, studies will be primarily limited to those that investigate networks of individuals within and across business firms that emerge as individuals interact on work-related tasks, and thus we will not include studies on networks that are of a more formal nature nor those that emerge due to non-work related interactions, e.g., friendship, common interests, etc. In the few areas of the matrix populated by a higher number of studies, we have selected for the most part only the major academic works of a more reputable quality. Finally, we have chosen not to include the more practitioner-oriented studies since these tend to be less grounded in theory

and less academically rigorous while focusing more on “how to” in order to enlighten practitioners²⁹. In conducting such a review, it is inevitable that justice will not be done to all research, and as a result, some studies will receive too little or no attention.

Figure 3.1 Selected Literatures for Network of Practice Review

		<i>Primary Communication Channels</i>		
		Face-to-face	Mixed	Electronic
<i>Nature of Network of Practice</i>	Co-located Intra-organizational	1. Communities of Practice	∅	∅
	Non-co-located Intra-organizational	∅	2. Social Networks Multinationals R&D Technology Transfer	4. Online Communities
	Inter-organizational	∅	3. Scientific Communities Invisible Colleges R&D/ Technology Transfer Know-how Trading	4. Online Communities

Under each type of network of practice, we present the studies in chronological order based on the date they were published. As mentioned previously, since we are primarily interested in issues of structure and performance, we will pay particular attention to these issues in this review. Thus, at the end of the review of each type of network of practice, we will summarize and discuss issues relating to structure and performance as well as the findings relating to the cognitive aspects within each particular type

²⁹ For discussions on how to establish and build networks of practice, see McDermott (1999a, 1999b), Dixon (2000), Wenger (2000), Wenger et al. (2002), Ackerman et al. (2003). An extensive practitioner-oriented study was conducted by the American Productivity & Quality Center (APQC 2001) on how to build and sustain “communities of practice”. See Kim (2000) for a practical discussion of how to build online communities.

of network of practice³⁰. A table is then provided with the studies organized in chronological order under the three research foci of structure, performance, and cognitive aspects, with findings specifically related to structure and performance highlighted. Finally, at the end of this chapter, we will synthesize this literature review and discuss the research findings. The next chapter, Development of Research Purposes, will then build on the results of this review of empirical studies.

3.1 Studies of Communities of Practice

We begin our review with a look at the literature on communities of practice. As mentioned previously, these studies tend to be ethnographies and case studies of role-based communities in which members have similar jobs or occupations and are co-located within one physical site within the same organization. In addition, some of these do not explicitly label the groups observed as communities of practice since they were conducted prior to the widespread acceptance of the term.

One of the first studies that laid the foundation for the development of communities of practice was conducted by **Lucy Suchman** (1983). In her very exploratory study performed in, 1979, Suchman conducted ethnographic research of two office workers in the accounting office of a large US corporation, paying attention to the actual work performed to accomplish work tasks. Her study began from the observation that the “specification of even the most routine clerical work as a schema of procedures is an unsolved problem in automated systems design”. In her study, Suchman found that the practical action performed by the two workers to actually get their tasks done varied from the procedural specifications for conducting the work. Thus, the primary conclusion of her study is that the “smooth flow” of office procedures is not the work itself, rather it is an outcome around which practitioners orient their work.

Julian Orr (1990, 1996) followed in Suchman’s footsteps by also viewing service work as situated practice, and as mentioned above, Orr’s study

³⁰ While there are many ways to categorize these studies, we have chosen these three since they include the two main aspects in which we are interested: structure and performance. Additionally, we have titled the third category, cognitive aspects, since this category primarily relates to aspects other than structure and performance, such as norms, symbols, identity, and values.

provides a “thick” (see Geertz, 1973) comprehensive description of the way that individuals actually conduct their work³¹. For his doctoral studies, Orr conducted an ethnographic study of Xerox’s service repair technicians by following six technicians of the Silicon Valley District Office on their daily rounds for twelve days. Although Xerox runs an extensive training program and produces a considerable amount of documentation to help technicians conduct their work repairing machines, Orr observed that technicians did not find these formal means to be helpful. Rather, there was “clearly a disparity between the tasks which they are told to accomplish and the means which are said to be adequate to the task. The technicians chose to give the task priority over means to resolve the problems in the field any way they could, apparently believing that management really wanted accomplishment more than strict observation of the prescriptions of work” (1990:15-16). Orr found that war stories, or anecdotes of experiences in which problems and their solutions are described using context and technical detail, are a prominent feature used by the technicians when conducting their work. Additionally, Orr observed that informal meetings such as the breakfasts that technicians attended were valuable fora for discussing work and narrating their war stories.

Lave & Wenger (1991) took somewhat of a different approach than the above two studies and focused their study on the relationship between learning and social situations, and in so doing developed the concept of situated learning. In their frequently cited study that was primarily based on the research of others, they investigated apprenticeship by Liberian tailors (Lave, 1988), Mayan midwives (Jordan, 1989), non-drinking alcoholics (Cain n.d.), butchers in US supermarkets (Marshall, 1972), and U.S. navy quartermasters (Hutchins, 1996). Based on these studies, Lave & Wenger contrasted the traditional dyadic view of learning of a student and teacher with the concept of legitimate peripheral participation within communities of practice. Lave & Wenger describe how apprentices (or newcomers) participate peripherally in a practice, learning from the masters (old-timers) and more experienced individuals (young masters or journeymen) within a community of practice. Thus, structure for Lave & Wenger is more an adaptive outcome of action rather than a precondition within a social system. Touching on structure, they argue that a community of practice has no place designated the “periphery” nor a single

³¹ See Burawoy (1979) for an historical overview and interesting example of anthropology in the workplace.

core or center. In terms of performance, Lave & Wenger propose that full participants of a community of practice are those who have acquired legitimacy as well as the skills, knowledge, and discourse required by the practice. In addition, the power dynamics among individuals in communities of practice are discussed.

Referred to by Lave & Wenger above, **Hutchins** (1991, 1995, 1996) studied socially distributed cognition in an in-depth, impressive study of the work practice of a formally structured navigation team on a U.S. warship. In the above work, Lave & Wenger (1991) view this team as a community of practice. This is exemplified when the team is issued a new officer and the community of practice provides the informal forum for learning since one of the petty officers who is lower in rank yet has more experience supervises the higher ranking officer. As such, this work illustrates how a formal team can develop into a community of practice over time as the team members interact while conducting their tasks.

In another study on distributed cognition, **Scott Cook & Dvora Yanow** (Cook & Yanow, 1993; Yanow, 2000) performed a set of extensive case studies investigating organizational learning³² at three small flute companies near Boston, the most well known being the Powell Flute Company. Each of these companies comprised about 25 individuals, with only one or two individuals not directly involved in flute production. In their study focused on distributed cognition, the important observation is that tacit knowledge is shared and held without being made explicit at the collective level through interactions revolving around the flutes by the group members. This observation is in direct contrast to previous work by Argyris & Schön (1978) who proposed that cognitive maps should be made explicit in order for learning to take place. In revisiting the flute study, Yanow (2000) further argues that some tacit knowledge should not be made explicit and that doing so could at times even be harmful.

One of the studies to first explicitly discuss communities of practice and in an attempt to link them with performance, **Bill Snyder** (1996) wrote his

³² The literature on organizational learning discusses situated learning, and it has recently been argued by some that communities of practice are the appropriate unit of analysis for organizational learning. For discussions and reviews of organizational learning, see Huber (1991), Easterby-Smith, Araujo, & Burgoyne (1998), and Crossan & Guatto (1996).

doctoral thesis on the relationships between organizational learning and organizational performance. He conducted a rigorous case study of two divisions at four regional offices of the US Veterans Benefits Administration (VBA), with offices employing between 100 and 250 individuals. In his study of VBA office workers ranging from staff members and clerks to supervisors, he observed communities of practice of varying strength and effectiveness within the offices as well as intra-organizational distributed networks of practice spanning the offices. Snyder observed that the capacity of office workers to share knowledge and skills was reduced when they belonged to a community of practice whose members did not feel a high level of shared trust and commitment. Looking at the degree to which teams met customer service objectives, Snyder argues that communities of practice are critical to organizational learning activities and as such influence organizational performance through their impact on the creation and sharing of organizational knowledge. Thus, Snyder's results indicate that the levels of trust, respect, and mutual commitment as evidenced in the strength of the relationships among members of a community of practice affect the sharing of knowledge and skills among community of practice members and thus indirectly organizational performance.

In the most extensive study devoted to communities of practice, **Wenger** (1998) observed the learning processes regarding the tasks of filling out claims forms of around 20 co-located insurance claims processors in a US firm. As discussed in Chapter Two, Wenger thoroughly develops the definition of communities of practice, with a focus on discussing the various related cognitive concepts such as practice, meaning, community, learning, identity, and participation. With regard to structure, Wenger elaborates on Lave & Wenger's discussion, stating, "a community of practice is a node of mutual engagement that becomes progressively looser at the periphery, with layers going from core membership to extreme peripherality" (1998: 118). In terms of performance, in Wenger's view, individuals in the community of practice's core are those who have mastered the tasks of claims processing while those in the periphery perform the tasks to a lesser degree the further from the core the individual is. However, beyond this, Wenger offers little discussion on these two areas.

In response to the above work focusing on only a single community of practice at a time, studies have begun to appear recently that focus on the sharing of knowledge between communities of practice. Building on work by Star & Griesemer (1989) on boundary objects, these studies find that the use of language and boundary objects in the form of codified objects, such as artifacts and texts, facilitate the sharing of knowledge that is situated in local practice between communities of practice. In an impressive doctoral study that resulted in an *Organization Science* publication, **Carlile** (1997, 2002) conducted an ethnographic investigation of a small co-located firm (about 300 people) in the US auto supply industry. Carlile focused on understanding how work practice shapes knowledge and the boundaries between practices as well as on identifying the activities or processes that are effective in facilitating collaboration across these boundaries. Based on his observations of collaboration between the sales, design engineering, manufacturing engineering, and production departments, Carlile discusses a pragmatic approach to understanding knowledge sharing processes, proposing that knowledge is localized, embedded, and invested in practice. He observes that knowledge is both a barrier as well as a source of innovation in a product development setting and similar to the next study, he found that the use of boundary objects helped resolve the problems arising when collaborating across community boundaries.

In a second study investigating knowledge sharing, **Bechky** (1999, 2003) performed an award-winning ethnographic study³³ of a US high-technology manufacturing firm for her doctoral studies. In her investigation of knowledge sharing between three co-located functional communities: engineers, technicians, and assemblers, she found that each community had a different understanding of the machines that they were building as well as different languages regarding the machines and their tasks. As a result, misunderstandings in production occurred between these communities. Her findings suggest that knowledge sharing and learning between communities is dependent upon the presence of individuals who speak the various languages of the communities in question and upon individuals keeping communication focused on the concrete. Her study thus indicates that the knowledge of communities of practice can be captured,

³³ 1999 William Newman best dissertation paper award, Academy of Management, 1999 Louis Pondy best dissertation paper award, Organization and Management Theory Division, Academy of Management.

disseminated, and preserved by organizations through the use of boundary objects and brokers.

In yet another doctoral dissertation, **Hara** (2000) conducted a unique ethnographic case study comparing several networks of practice (electronic and face-to-face). Using data from observations, interviews, and document reviews, Hara investigated the sharing and construction of knowledge by lawyers in two public defender offices in Indiana and within an electronic network of practice for all public defenders in the state. The primary contribution of this work is in the area of a community of practice's knowledge. Hara critiques Lave & Wenger's study of apprenticeship by arguing that a community of practice's knowledge is not static, mastered by full participants and only to be learned by newcomers to the community. Rather, Hara suggests that a community's knowledge continuously evolves as members interact with one another and as they come and go. Thus, all members, regardless of their participatory status, continuously engage in a learning process. Additionally, she suggests that a community's knowledge encompasses cultural, practical, and book knowledge. One final finding is that only those lawyers who were physically co-located developed a common identity due to their ability to informally socialize and interact. This was despite the efforts by the public defender's offices to facilitate interaction between non-co-located lawyers through several electronic means, e.g., listserv and other computer conferencing tools. This further supports the importance of face-to-face interactions in the development of communities of practice. We return to Hara's work in the section below on electronic networks of practice.

Gherardi & Nicolini (2000, 2002) further investigated the concept of legitimate peripheral participation in a small ethnographic study of how safety is mastered by novices on an Italian building site. In this study with a slight bend towards practitioners that provides little new insight, these researchers discuss how novices learned the practice of safety through an interactive process of conversing and learning the language that included observing body language, looking and seeing, and doing. Thus, one finding of this study is that for some practices, the ability of a novice to learn the tacit knowledge of the community is dependent upon the novice's co-located physical presence with other community members.

While the above studies primarily focused on understanding the cognitive processes of communities of practice, with the exception of Hutchins (1995) mentioned above, few studies have investigated the impact of the formal organization on the formation of communities of practice in organizations. In another doctoral study, **Schenkel** (2002) conducted an extensive case study of a major Scandinavian construction project involving 137 participants in managerial and support functions. He found that the disciplining elements of ISO 9000 constrained the formation of communities of practice within the project's ten departments ranging between 10 to 30 people; however, they encouraged the formation of a network of practice across the departments.

In the last study on communities of practice to be reviewed, **Schenkel & Teigland** (2002) conducted an exploratory study on the same construction project mentioned above. This study provides mixed evidence for a positive relationship between communities of practice and organizational performance as measured by learning curves.

3.1.1 Discussion of Community of Practice Studies

In summary and as can be seen in table 3.1, the studies to date have provided us with an extensive definition of the cognitive side of communities of practice. Initial studies leading to the development of communities of practice focused on understanding work practices and the social nature and situatedness of learning by individuals. As time progressed, researchers turned their focus more towards the knowledge of a community of practice and how knowledge is shared both within a community of practice as well as between communities of practice. One main observation is that these studies provide support for the importance of physical co-presence in the development of a community of practice. The development of communities of practice is dependent upon the ability of individuals to spontaneously socialize in an informal manner or to unconsciously observe and learn from one another. Thus, while information technologies may facilitate interaction between individuals who are not co-located, they do not provide the same opportunities as co-location does. This inability hampers the development of a common identity and language between individuals and thus the development of a community of practice. A second observation is that the formal organization may impact the boundaries of communities of practice.

Functional boundaries as well as formal procedures affect the ability of individuals to interact with one another by creating boundaries that are either physical or intangible, such as those based on task knowledge. Finally, when knowledge is to be transferred across the boundaries of a community of practice, problems arise due to the situatedness of the knowledge in the local practice. However, the use of boundary objects and brokers who speak the language of the communities in question are useful means of facilitating this transfer.

While we have developed a relatively thorough understanding of the above, there are several areas on which the empirical studies have failed to touch. For example, these studies do little to shed light on the important issues of structure and performance. As can be seen in table 3.1, no studies have specifically focused on structure, and only two have a primary research focus on performance. However, one of these is very exploratory (Schenkel & Teigland) and the other (Snyder) focuses on the indirect link between communities of practice and organizational learning, and not organizational performance. Thus, as for the claims of the general community of practice literature that these networks are linked to organizational learning and performance through incremental innovation in practice or that innovation occurs at the interstices of communities of practice, the empirical studies to date provide little support for these claims.

Furthermore, these studies neglect other important aspects such as community of practice lifecycles, the relationship between communities of practice and management or organizational strategy, and power relationships between members. As mentioned above, Lave & Wenger (1991) discuss power and power relations in their book, yet the majority of the subsequent work on communities of practice including Wenger (1998) has failed to discuss these aspects in depth. Fox (2000) highlights this point and proposes that Foucault's work and actor-network theory (ANT) could complement the community of practice literature by bringing in aspects of power and inequality.

Finally, while most of the studies above are academically rigorous, there are some concerns regarding generalizability. As evidenced above, the number of empirical studies on communities of practice is very limited both in methodology (ethnographies and case studies) and samples (primarily the US and lower level, non-professionals in non-science

professions). Thus, this raises the question of generalizability of community of practice theory to business firms outside of the US or to professionals.

Table 3.1 Selected Studies of Communities of Practice (CP) *

Primary Research Focus	Study	Methods	Sample	Primary Findings
Structure				

Performance				
<i>Relationship between organizational learning and organizational performance</i>	Snyder 1996	Case study: observations, interviews, archival data review	US office workers in two divisions of four offices in US Veterans Benefits Association (100 to 250 employees in each office)	Communities of practice influence organizational performance through impact on organizational knowledge and learning. Sharing of knowledge and skills related to levels of commitment and trust among CP members.
<i>Relationship between community of practice and organizational performance</i>	Schenkel & Teigland 2002	Survey	Major Scandinavian construction project involving 137 managers and support individuals.	Limited support for positive relationship between CPs and learning curve improvement.
Cognitive Aspects				
<i>“Smooth flow” of office procedures</i>	Suchman 1983	Ethnography	Two office workers in accounting office of a large US corporation	“Smooth” office procedures are outcome of actual work conducted by office workers and not reflection of enduring, externally decided procedures.

Primary Research Focus	Study	Methods	Sample	Primary Findings
<i>What is work?</i>	Orr 1990, 1996	Ethnography	Six Xerox service technicians from Silicon Valley	Clear disparity between the work formally defined by the employer and the tasks performed by the technicians to complete their job. War stories of significant importance as diagnostic tool.
<i>Relationship between learning and social situations</i>	Lave & Wenger 1991	Ethnography based primarily on research by others	Small groups of Mayan midwives, Liberian tailors, US non-drinking alcoholics, butchers in US supermarkets, and US navy quartermasters	Learning is a situated activity. Newcomers participate in communities of practice and learn through legitimate peripheral participation (LPP), mastering the knowledge and skills of the community. Structure is more an adaptive outcome of action rather than a precondition within a social system. High performers of practice are full participants of community, having acquired legitimacy as well as the required skills, knowledge, and discourse.
<i>How do people know what they know?</i>	Hutchins 1991, 1995, 1996	Case study	Navigation team on US warship	Cognition is socially distributed. Formal team developed into community of practice over time.
<i>Nature of learning by a collective</i>	Yanow & Cook 1993, Yanow 2000	Case studies	Craftsmen in three small US flute makers (approx. 25 people in each firm)	Tacit knowledge can be held at collective level and need not necessarily be made explicit to be shared within community.

<i>Relationship between learning and social situations</i>	Wenger 1998	Ethnography	Around twenty claims processors co-located in one US company	Learning is a social phenomenon with knowledge as competence gained through participation in a practice through which meaning is experienced. Structure of community of practice consists of core of full participants surrounded by layers of peripheral members. Core members are high performers of CP tasks.
<i>Transfer of knowledge across functional boundaries</i>	Carlile 1997, 2002	Ethnography	Four CPs (sales, design engineering, manufacturing engineering, and production) in US auto supply firm of 300 people in one site	Knowledge is situated in local practice, thus problematic when transferred across functional boundaries. Boundary objects facilitate process.
<i>Transfer of knowledge across functional boundaries</i>	Bechky 1999, 2003	Ethnography	Three CPs (assemblers, engineers, and technicians) in one site of US high technology manufacturer	Language barriers are significant between communities, thus difficulties in transferring knowledge between them. Boundary objects facilitate process by making problems concrete as well as individuals who speak languages of different communities.

<i>Knowledge sharing within a community of practice</i>	Hara 2000	Ethnography	Lawyers in two Public Defender's Offices in Indiana	Community of practice knowledge is not static, thus all members continuously learn through interaction.
<i>Learning of tacit knowledge</i>	Gherardi & Nicolini 2000, 2002	Ethnography	Italian builders on one construction site	LPP involves physical presence due to conversing and learning the language through looking, seeing, and doing.
<i>Management of unexpected deviations in work procedures</i>	Schenkel 2002	Case study involving interviews, survey, and archival data review	Major Scandinavian construction project involving 137 managers and support individuals	Formal organization can influence CP structure. ISO 9000 constrained formation of CPs within construction site but encouraged formation of NP across sites.

* Findings specific to structure and performance are highlighted in bold text.

3.2 Studies of Intra-organizational Distributed Networks of Practice

As mentioned in the previous chapter, intra-organizational distributed networks of practice are networks of emergent relationships of individuals who are distributed across an organization yet who work on similar tasks using a similar base of knowledge. They are networks of individuals who are acquainted with one another, have generally met face-to-face, and communicate through both a mix of communication channels from face-to-face meetings to electronic means. Furthermore, they are to be distinguished from formally mandated teams. Being somewhat more of a challenge to study due to their emergent nature and difficulties in identifying them, there are very few empirical studies of these groups³⁴. However, by broadening our scope in terms of bodies of literature, we find that there are a few studies on intra-organizational networks within the

³⁴ There are several studies for and by practitioners on how to support the creation of intra-organizational networks of practice through various means as described in the above. However, as mentioned we have limited this review to studies that are of an academic nature. See Wenger et al. (2002) for examples of management supported and maintained intra-organizational networks of practice.

innovation, social network, and multinational corporation literature that are worth mentioning³⁵.

The only study of which we are aware that specifically focuses on intra-organizational networks of practice and that is not explicitly practitioner-oriented is by **Hildreth, Kimble, and Wright** (2000). Unfortunately, this study is of a less rigorous academic nature than the previous community of practice studies. These researchers focused on two networks of practice: actuaries and IT support managers within two UK-based multinationals with operations in Europe and Japan. In these cases, they found support for the need for periodic face-to-face meetings to maintain levels of trust and shared identity among network of practice members. In addition, individuals who were separated by greater time distances from the majority of the other members of the network felt themselves to be on the physical periphery of the network. They felt that this physical separation hampered their ability to truly participate in the network. A third finding that echoes the findings in the community of practice literature is that the use of boundary objects in the form of shared documents facilitated the sharing of knowledge between the members.

One practitioner study worth mentioning due to the considerable attention it has received despite its being published in the *IBM Systems Journal* is that by **Lesser & Storck** (2001). These researchers interviewed five to ten members in each of seven communities of practice and intra-organizational distributed networks of practice that were of a more formal nature in US firms (urban services specialists, land and real estate specialists, quality champions in a manufacturer company, research chemists in a pharmaceutical firm, programmers in a software development company, researchers in a specialty chemical company, and project managers in a telecom company). With a focus on performance, they suggest that networks of practice may lead to decreased learning curves for new employees, quicker responses to customers, reduced rework and avoidance of reinventing the wheel, as well as the development of new ideas for products and services.

Within the social network literature, there are three studies worth noting. **Han** (1996) conducted a study that looked at the impact of the formal

³⁵ For reviews of intra-organizational networks, see Krackhardt & Brass (1994), Galaskiewicz (1996), Flap et al. (1998).

organization on the creation of distributed emergent networks. This detailed case study of 76 employees in a large US retail corporation with four hierarchical levels and numerous divisions found that formal organizational boundaries affected the building of intra-organizational relationships. Relationships were found to occur within the divisions as opposed to across divisions and in general, the higher the individual was in the hierarchy, the more relationships the individual had across divisions. In the second study worth noting and as mentioned previously, **Friedkin** (1980) found that the strength of the tie between two individuals had a positive relationship with the degree of overlap between the contact circles of the two individuals. He conducted this case study on scientists in seven biological science departments belonging to the same U.S. university using a questionnaire.

The third social network study is by **Lazega** (2001) who conducted an extensive case study of 71 lawyers in the three offices of a North-Eastern US corporate law partnership. Using data on advice, goodwill (co-workership), and friendship relationships, Lazega found that these relationships resulted in the creation of social niches (similar to intra-organizational networks of practice), or stable quasi-groups that offered members resources at a low cost, a sense of identity and common long-term interests, and the stimulation needed to work together productively. Lazega analyzed in detail aspects of status and social control and found that underperformers were brought back into line through pressure placed on them by other niche members. Additionally, he observed that those lawyers who were informally sought out for advice and for collaboration by others across the firm earned more money for the firm; however, he found no relationship between those who were popular in the friendship networks and individual economic performance.

Within the innovation and technology transfer literature, a series of studies on communication patterns between engineers and applied scientists within R&D operations has been conducted. Reflecting on this research, these studies are relevant to the research on networks of practice despite their being conducted several decades ago. In essence, these studies investigated networks of practice since they focused on knowledge flows through emergent relationships by studying interactions based on technical or

scientific conversations related to work tasks³⁶. These studies began in the 1950s with work by Allen and his doctoral student, Tushman (see e.g., Allen, 1977). Their work is quite impressive in terms of depth and methodology and they are among the few in the networks of practice literatures to incorporate social network techniques. While there are numerous studies performed within this area³⁷, we will only mention the ones most relevant to the research at hand.

Allen's (1977) research focused on the study of 29 R&D project teams, and he conducted network studies in thirteen different laboratories (smallest being 20 professionals, largest being 400 professionals, all US except one European) while **Tushman** (e.g., 1977) conducted an extensive field study of a physically isolated R&D facility of a large U.S. corporation (345 professionals among total of 735 employees and 60 projects in seven divisions). These studies are quite impressive in terms of their data collection methods, with all professionals asked to keep "personal contact records" for one day a week for a number of weeks to create the communication networks. Analysis of the data revealed three types of individuals who were central in the information flows: (1) communication stars: individuals who were most central in these informal communication networks, i.e., were most frequently approached by other colleagues for information, (2) boundary spanners: individuals who spanned both intra- and inter-organizational boundaries, (3) gatekeepers: communication stars who were also inter-organizational boundary spanners.

With regard to the characteristics of these individuals, a significant degree of overlap between individuals who conducted communication star, boundary spanning, and gatekeeper activities was found. Thus, individuals who were communication stars were more likely to be boundary spanners as well as gatekeepers. These individuals tended to occupy higher positions in management levels or were higher technical performers, i.e.,

³⁶ In addition, these works are grounded in the information processing perspective on organizational design. This view argues that individuals are constantly presented with problems accompanied by various environmental and task uncertainties, and in order to deal with these uncertainties, individuals must acquire information. Thus, the information processing literature is similar to that of the network of practice literature since these literatures both view individuals as unable to solve the tasks at hand based only on the knowledge that they have in their head. For a look at the information processing perspective, see Galbraith (1973) and Nadler & Tushman (1988).

³⁷ For a review, see Aloni (1985).

more patents, very active publishers, and longer experience in the laboratory. Thus, these individuals were seen to be more technically competent with a higher level of work-related expertise than less active individuals (Allen & Cohen, 1969; Tushman & Scanlan, 1981).

Another significant finding in this research stream is the relationship between the degree of participation in “intra-organizational distributed networks of practice” by project members and project performance. These researchers found that this relationship was contingent upon the type of project task being performed³⁸. For example, higher performing product development projects whose tasks were more locally defined were more likely to have external project communication dominated by internal boundary spanners, or individuals who spanned intra-organizational boundaries (Tushman & Katz, 1980). On the other hand, research projects, whose tasks were more universally defined, performed better if all members participated in boundary spanning. Thus, this literature argues that when local knowledge is not sufficient to complete the tasks at hand and is of a more local nature, the organizational hierarchy is bypassed by gatekeepers who rise to fill the need (Allen, Tushman, & Lee, 1979).

This research has implications for the network of practice literature since it indicates that there is a relationship between participation in distributed networks of practice, performance, and task knowledge. However, one drawback of this research is that researchers primarily looked *only* at the access of knowledge in the networks and *not the providing* of knowledge by boundary spanners and gatekeepers. In other words, they did not look at knowledge exchange or reciprocal actions. In addition, in the majority of the articles published in the more reputable journals, only ego-centric data are used. In other words, the researchers did not look at the position of the

³⁸ Tushman (1977) defined four types of tasks: (1) basic research: work of a general nature intended to apply to a broad range of applications or to the development of new knowledge about an area, (2) applied research: work involving basic knowledge for the solution of a particular problem. The creation and evaluation of new concepts or components but not development for operational use, (3) development: the combination of existing feasible concepts, perhaps with new knowledge, to provide a distinctly new product or process. The application of known facts and theory to solve a particular problem through exploratory study, design, and testing of new components or systems, and (4) technical service: cost/performance improvement to existing products, processes or systems. Recombination, modification and testing of systems using existing knowledge. Opening new markets for existing products.

project or the individual within the entire intra-organizational distributed network of emergent relationships.

Within the multinational corporation literature, emergent relationships have been found to be a significant coordination mechanism between geographically dispersed divisions. In their review of the literature on coordinating mechanisms in multinationals, **Martinez & Jarillo** (1989) found that researchers have been paying increasing attention to the importance of “informal communication”, defined as informal networks, personal contacts, intra-community visits, meetings, conferences and forums, and transfer of managers, as coordinating mechanisms. Martinez & Jarillo observed that thirty of the eighty-five pieces of research published in books and journals that they reviewed discuss informal communication and that 1976 can be seen as a turning point when researchers enlarged their focus on mechanisms to include more informal mechanisms. However, as evident in the title of Martinez & Jarillo’s work, the focus of these studies is on the integration of activities. Few focused on the sharing of knowledge through these means nor were intra-organizational distributed networks of practice explicitly the focus of the research. Subsequent research has focused on knowledge sharing through these networks within multinationals. However, again the focus has not explicitly been on networks of practice. For example, Tsai & Ghoshal (1998) and Tsai (2002) did not really investigate networks of practice in their study of multinationals since the level of analysis is the multinational unit and not the individual or the network. For example, in the operationalization of these studies, only unit managers were surveyed about their units’ knowledge sharing and social relations (e.g., socializing during events such as company picnics) with other units.

Despite the operationalization within this set of studies, one impressive study worth noting is that by **Morten Hansen** during his doctoral studies. Hansen (1996) built on the work by Allen, Tushman, and others in the technology transfer literature and conducted a study of 120 projects in the R&D operations of a technology-intensive multinational. Using sociometric methods and critiquing the work by Allen and his colleagues, Hansen looked at the position of the project within the firm’s entire project population. Interestingly and which may be questioned, Hansen surveyed only the R&D division managers and project team managers about participation in emergent relationships at the division level and *not at the*

individual level since he argued that the relevant relationships were held at the division level and not at the individual level. Based on a sophisticated analysis of this unit level network, Hansen found a significant relationship between project performance and the position of the project team's division in divisional networks of practice. Project teams whose divisions had weaker ties within these networks of practice were more likely to achieve shorter completion times when the knowledge to be transferred was of a less situated nature (more codified and less tacit). For teams with stronger ties in the network, however, there was a net effect in terms of completion time. Strong ties facilitated the sharing of more situated knowledge for such teams, yet norms of reciprocity meant that the teams were then expected to return the help, thus slowing their completion times.

3.2.1 Discussion of Intra-organizational Distributed Networks of Practice

In summary, there are very few in-depth quality studies specifically focused on intra-organizational distributed networks of practice, and the limited research reviewed here touches only briefly on the areas of structure and performance. The innovation, technology transfer, and multinational literature provides suggestive evidence of a relationship between participation by individuals in intra-organizational distributed networks of practice and performance, yet research suggests that the formal organization impacts the emergence of these relationships across an organization's physical locations. As can be seen in table 3.2, these studies were either conducted twenty to thirty years ago, are of a questionable academic rigor, and/or are not specifically focused on intra-organizational distributed networks of practice. In addition, problems of generalizability surface when we note that the more rigorous studies comprise primarily scientists, researchers, and lawyers in US settings. Interestingly, there are no studies specifically addressing the cognitive aspects of these networks. Thus, despite such claims by researchers that individuals participating in these networks are able to share knowledge and develop a shared identity, values, and language, with positive effects for performance, we have little substantive evidence for these claims.

Table 3.2 Selected Studies of Intra-organizational Distributed Networks of Practice (IANP) *

Primary Research Focus	Study	Methods	Sample	Primary Findings
<i>Structure</i>				
<i>Structure of weak ties</i>	Friedkin 1980	Sociometric survey	Scientists in seven biological departments in US university	The stronger the tie between two individuals, the higher the overlap of their contact circles.
<i>Factors affecting creation of emergent relationships</i>	Han 1996	Sociometric survey	76 employees in large US retail corporation	Formal organizational boundaries affect building of intra-organizational relationships
<i>Collective action among individuals equal in power</i>	Lazega 2001	Case study involving sociometric data	71 lawyers in three offices of US law partnership	Advice, goodwill (co-workership), and friendship relationships create social niches, or stable quasi-groups that offer members resources at a low cost, a sense of identity, common long-term interests, and the stimulation needed to work together productively. Social pressure is applied by others within social niches to maintain individual performance levels. Individuals who most sought out for collaboration and advice by others across the firm earn more money for the firm.

Primary Research Focus	Study	Methods	Sample	Primary Findings
Performance				
<i>Relationship between information flows and project performance</i>	R&D studies, e.g., Allen, Tushman, etc. (1960s, 1970s)	Sociometric surveys	Primarily US R&D laboratories and their projects	Hierarchy bypassed when local knowledge not sufficient for tasks. Project performance dependent upon project task knowledge and number of gatekeepers. Individuals highly involved in IANPs also central in local laboratories. These individuals generally in management positions or highly technically competent and seen as experts.
<i>Knowledge integration across subunits in multiunit firm</i>	Hansen 1996, 1999	Sociometric survey	120 R&D projects within one US multinational	The more central the R&D team in organizational network in terms of team's unit possessing relevant expertise, the easier the network search, and the faster the completion time. Weak network relations slow down projects when knowledge transferred is very complex.

<i>Relationship between networks of practice and creation of organizational value</i>	Lesser & Storck 2001	Interviews	Five to ten members of seven IANPs comprising knowledge workers in a variety of large corporations (majority likely in US)	Support for positive relationship between participation in IANPs and organizational performance. Participation in IANPs results in decreased learning curves for new employees, quicker responses to customers, reduced rework and avoidance of reinventing the wheel, development of new product and service ideas.
Cognitive Aspects -----				

* Findings specific to structure and performance are highlighted in bold text.

3.3 Studies of Inter-organizational Distributed Networks of Practice

Turning now to inter-organizational distributed networks of practice, we find several bodies of relevant empirical studies such as those on scientific communities. While there is a wide body of research on *formal* inter-organizational networks as well as *formal* inter-organizational boundary spanning activity, as noted above, these studies will not be included in this review due to their formal element³⁹. We start our review with some of the relevant studies from the scientific communities before taking a look at some of the major studies performed from the viewpoint of the firm.

3.3.1 Scientific Community Perspective

Until the work by Diana Crane (1972), much of the work investigating scientific communities used bibliographic methods such as references and

³⁹ For a review of inter-organizational networks, see Mizruchi & Galaskiewicz (1994). The literature on formal inter-organizational boundary spanning has its roots in the work by Katz and Kahn (1966) and Kahn et al. (1964) and for reviews of this research, see Van de Ven (1976), Aldrich & Whetten (1981), Galaskiewicz (1985), and Oliver (1990).

citations, with co-citations being one of the most commonly used⁴⁰. However, the use of co-citations is no guarantee that these individuals are interacting with one another. Garfield, Malin, & Small (1978:186) state, “None of the bibliometric linkages [including co-citation analysis] require that social contacts lie behind them, but the existence of strong patterns of coupled documents (clusters) suggests that underlying social factors are at work.” Thus, this review covers only the more important works that actually investigate scientific communities *based on interpersonal interactions* and not those that focus solely on bibliometric means.

Crane (1972) conducted an extensive study of 102 mathematics authors and 221 rural sociology authors in the United States in which she used both bibliometric methods and questionnaires to uncover emergent relationships through sociometric methods. Based on her findings, she proposes that scientists within a research field organize themselves into subgroups of informal networks of personal relationships, or invisible colleges⁴¹ that are characterized by strong ties based on informal collaboration. These invisible colleges are then linked to individuals within other research fields through weak ties by their members, thus facilitating the diffusion of information both to and from each field. A common language based on a similar orientation towards research facilitates communication between individuals from different fields. With regard to performance, Crane suggests that the position of a scientist in the invisible college impacts his or her awareness of existing research as well as how rapidly he or she obtains information. Furthermore, Crane found that productivity in terms of innovations and publications tended to be unevenly distributed, i.e., a small percentage of researchers were responsible for a large percentage of innovations and publications. Finally, Crane argues that invisible colleges have lifecycles, growing and fading depending on the state of the central scientific research problem⁴².

⁴⁰ A co-citation is the citation of two different publications in a third publication and therefore is a special kind of network link between publications A and B. If the author of publication C cites both A and B, the two must be thought to have at least something in common. Such a co-citation implies that the authors of A and B may be studying the same specialty and may be in communication with one another (Lievrouw et al., 1987).

⁴¹ Crane defines an invisible college as a communication network of a subgroup of researchers within a research area (1972: 35).

⁴² The primary contribution of Crane’s study is that she synthesized a more coherent understanding of the social processes that underlie the growth of science. She agrees with Kuhn (1962) in that scientific paradigms do exhibit a lifecycle and at the same time

Following Crane, several researchers have conducted studies within the physical and social sciences focusing on identifying invisible colleges using either bibliometric or sociometric/anthropological methods; however, few have combined them⁴³. In response to this, **Lievrouw, Rogers, Lowe, & Nadel** (1987) conducted an impressive study of invisible colleges among biomedical scientists through a triangulation strategy that involved the analysis of US-funded grants, a literature review, co-citation analysis, questionnaires, and interviews. The 58 researchers in the study were located primarily in the United States and communicated with one another frequently through face-to-face meetings and telephone calls but rarely through written means. The most interesting finding of this research is that the communication network, or social network, among scientists was clearly distinct from the actual content of the work in which they engaged as based on the bibliometric methods. This finding contradicts the widely held assumption that the social structures in science reflect in some way the intellectual structure of the research specialty. Thus, the definition of invisible colleges becomes critical. If we define an invisible college as a social structure of communications, then we arrive at a different picture than if we define an invisible college based on the content of the actual research being performed as evidenced through bibliometric methods.

In an extensive study of the structural dimensions of scientific communities, **Schott** (1988) took the center-periphery model as a starting point and proposed structural analysis as a complement. The center-periphery model was developed in response to the observation that international participation in science is not equally distributed among the participating countries. This model describes the structure of this network as a restricted center that is the primary source of creativity, and as a result, it influences the content and sets the direction that dominates the intellectual work of scientists in the periphery (Schott, 1988)⁴⁴. In this study, Schott analyzed almost two million bibliographic references in the Science Citation Index in order to investigate the underlying regional structure and emergent social structure of scientists. In the overall center-periphery model and consistent with previous research, Schott found the

she concurs with Price (1963) who proposes that the growth of science exhibits a logistic curve.

⁴³ See Lievrouw et al. (1987) for a review.

⁴⁴ For further discussion on the center-periphery model, see Ben-David (1969, 1971), Shils (1972, 1975).

United States as the pervasively influential world center. However, a further investigation of the networks revealed that there were six regional areas within which scientific communities strongly influenced each other. Schott argues that the basis of influence in these regional networks is interpersonal relationships between the scientists, promoted by collegial and educational ties as well as geopolitical ties, such as propinquity and language commonality.

In a recent study of a more limited nature, **Tuire & Erno** (2001) investigated the formal and emergent networks of 104 professors in education at eight Finnish universities using citation counts and sociometric surveys measuring personal contacts. Similar to Lievrouw et al. (1987), these researchers also found two distinct networks: individuals who were central in the collaboration network were not necessarily those who were central in the citation network. In addition, they found that professors were much more likely 1) to exchange knowledge than to collaborate through co-authorship and 2) to exchange knowledge with others in their own university than with others outside their university. Contrary to previous research (e.g., Crane, 1972), these researchers found a relatively thin network of inter-university collaboration with invisible colleges forming *within* universities as opposed to across them. While one explanation may again be the importance of face-to-face, interpersonal relationships, the authors propose that this result may also be due to the nature of education as opposed to the more collaborative nature of the physical sciences, indicating a relationship between structure and the underlying practice knowledge.

On a final note and as mentioned earlier, while epistemic communities within international relations do fall outside the scope of this thesis, they are worth mentioning on a more general level to inform the reader. Researchers have conducted a series of studies on epistemic communities that describe how these communities have been influential in ascertaining national and international policy changes and coordination, e.g., nuclear arms control and protection of stratospheric ozone. Briefly, these studies investigate the processes through which national and international consensus is reached within a given domain of expertise and through which consensual knowledge is diffused. For these studies, see the Winter Issue of *International Organization*, 1992, volume 46.

3.3.2 *Firm Perspective*

Turning from the perspective of the scientific community to that of the firm, **Czepiel** conducted one of the first studies looking at the diffusion of technical knowledge from a sociological perspective as opposed to from a purely rational economic perspective. Investigating the diffusion of a major innovation (the continuous casting process) in the U.S. steel industry, Czepiel conducted highly structured interviews of managerial and technical people in 18 firms. These interviews revealed the existence of a functioning inter-organizational distributed network of practice. This network of practice linked the firms together, and respondents used this network to gather information regarding the decision to implement the innovation despite several barriers to such informal interaction (e.g., great physical distances, competitive industry, avoidance of collusive activity, etc.).

We return now to the technology transfer literature discussed above under intra-organizational distributed networks of practice and find that there are a number of relevant studies to inter-organizational distributed networks of practice. Again based on Tushman's fieldwork, **Allen, Tushman, & Lee** (1979) found evidence of a relationship between project performance and the degree to which project team members communicated with professionals outside of their organization, e.g., researchers in universities, contacts met at conferences, and external technical consultants. For example, basic and general research projects showed higher performance when *all* project members maintained high levels of informal technical communication with these external contacts. However, product development projects exhibited higher performance when external communications were monopolized by one or a few project members, i.e., external gatekeepers. As an explanation, these researchers hypothesize that research tasks are of a more universal nature than development tasks, thus individuals working on research projects can more easily and efficiently communicate across organizational and national boundaries than individuals working on development projects. They base their reasoning on Price's (1965) proposed distinction between science and technology. Science and scientific problems are argued to be universal, thus scientists working within a given specialty work towards the same ends, operate within a common social system (Kuhn, 1962; Crane, 1972) and share a common language and set of methods. Technology, on the other hand, is

argued to be less universal since technological problems are highly localized and defined in terms of the interests, goals, and local culture of organization, thereby reducing the ability of individuals to communicate across national and organizational boundaries. Thus, when individuals communicate with others outside the organization on local problems, outsiders have difficulty fully understanding the nature of the locally defined problem. While both parties may think that the external individual understands the problem, this understanding is usually incomplete and proposed solutions or suggestions are unlikely to match the locally defined solution space, thus resulting in poor performance.

Allen, Tushman, & Lee (1979:703) further defined gatekeepers as “individuals who maintain consistent, ongoing contact outside their organizations, who understand the way in which outsiders differ in perspective from their own organizational colleagues, and who are able to translate between the two systems”. Thus, they argue that gatekeepers are translators, a term borrowed from Katz & Kahn (1966), and as such, they gather knowledge external to the local group and organization, translate this knowledge into the local language and setting, and then share it with appropriate individuals within the local group and organization. In this sense, gatekeepers play a similar role to Wenger’s brokers (1998) through their participation in inter-organizational distributed networks of practice.

While the above work investigated knowledge coming into the firm, researchers found evidence a little over a decade ago that this knowledge flow is not unidirectional. Rather, individuals often participate in two-way knowledge flows in which internal knowledge is traded for external knowledge. **Von Hippel** (1987, 1988) performed one of the first studies investigating this trading, in which he merely documented the phenomenon of informal know-how trading of product and process innovations without investigating the antecedents or outcomes of such trading. Defining know-how trading as the “extensive exchange of proprietary know-how by informal networks” (1987:291), von Hippel interviewed plant managers and other managers by telephone in eleven firms in the US steel minimill industry regarding their trading activity⁴⁵. He found that in the firms

⁴⁵ A precursor of von Hippel’s work was the research by Robert Allen (1983) in which he discussed a phenomenon in the nineteenth-century English steel industry that he called “collective invention”. Allen observed that some firms revealed competitive information, such as new plant designs, to other firms in the industry through informal

studied, only one did not routinely trade any proprietary know-how and this firm was considered to be an outlier in terms of know-how trading by some of the other firms. At the ten firms that did participate, interviewees “emphasized that they were not giving know-how away – they were consciously *trading* information whose value they recognized” (1987:295, italics in original).

Von Hippel (1987) found further anecdotal evidence of this phenomenon when he conducted a series of pilot interviews in several US industries. Results provide suggestive evidence that know-how trading is quite common in some industries, such as aerospace and waferboard manufacturing mills, while essentially absent in others, such as powdered metals fabricators. In addition, his results suggest that this activity ranges from being an accepted norm to being a quasi-covert activity with top management generally not aware or approving of the activity.

In a more extensive study than von Hippel’s, **Schrader** (1991) surveyed by mail 294 technically oriented middle-level managers in 127 firms from the US specialty steel and minimill industry. Schrader finds that these employees make their decisions to trade knowledge based on the economic costs to the firm. He finds that the likelihood that a transfer would occur declined 1) the more the firms were direct competitors, 2) the more difficult it was to access the information from alternative sources, and 3) the more highly valued the information was to the person making the transfer. While roughly 29% of the transfers were between competing firms, Schrader found that often information that was not related to the domain in which the two firms competed was traded or that the information could be acquired from another source relatively easily. As for the reasons underlying the trades, 72% of the respondents expected that their chances of receiving information in return would increase after the trade. Thus, Schrader argues that it is the incremental change in the likelihood of receiving information that is economically beneficial to the firm that is important in determining the benefit to a transfer. Schrader then attempted to link this informal

disclosure and publication in the engineering literature. Von Hippel describes the difference between his and Allen’s findings in the following way: “The essential difference between know-how trading and collective invention is that know-how trading involves an exchange of valuable information between traders which is at the same time kept secret from non-traders. In contrast, collective invention requires that all competitors and potential competitors be given free access to proprietary know-how” (1987: 297).

information exchange to the economic performance of the firms. Managers were asked to evaluate their firm's performance relative to the industry average on a 7-point scale (1 – well below average, 7 well above average) in addition to the firm's general propensity to participate in informal technical information exchange. A positive correlation ($r=0.19$, $p<.001$) was found between the two, providing suggestive evidence that there is a positive relationship between informal know-how trading and firm performance.

Kreiner & Schultz (1993) performed a small study on knowledge sharing in the Danish R&D biotechnology industry. Based on only 16 interviews of researchers and research directors in university and industry, they found that individuals liberally shared knowledge that was even of a confidential nature with others in their personal networks. In addition, they found that successful collaboration between university and industry was often the result of emergent personal relationships.

Perhaps inspired by the work on informal know-how trading, **Macdonald & Williams** (1993) argue that the above research by Allen and colleagues on gatekeepers did not investigate the participation of these individuals in external knowledge *exchange* since these studies merely looked at the gathering of external knowledge through oral communication channels. Thus, these researchers conducted a limited study using a mail survey of 125 individuals working predominantly in science and engineering in the United Kingdom. In this study, they found that individuals who were gatekeepers within their organizations were also more likely to engage in external knowledge trading. These individuals traded knowledge with others with whom they had a personal relationship, and these relationships were characterized by dyadic reciprocity.

In a further extension of their own work, **von Hippel & Schrader** (1996) conducted an interesting study to investigate the possibility of managing knowledge trading. They scoured industry to find an example of such managed trading and found the practice of "oil scouts" in the oil exploration industry. In this example, firms appointed oil scouts to trade geological information on a particular well or area. Management then mandated geologists to use the oil scouts and not to go around them by

using their personal networks even if they felt it to be more effective⁴⁶. However, von Hippel & Schrader found that geologists continued to go around the oil scouts and participate in informal knowledge trading with colleagues at rival firms, even though they knew it was against management's wishes. The argument provided was that the use of oil scouts was ineffective. Since oil scouts were only trained finders of information and not using the information themselves, they were unable to understand the content of the information and thus not effective in their actions.

In the only comparison study, **Appleyard** (1996) investigated the informal knowledge sharing patterns in the steel and the semiconductor industries in Japan and the United States. In her survey of 134 respondents of a non-random sample⁴⁷, she found only a marginal difference in the level of overall knowledge sharing between the two industries. As for Japan vs. the United States, respondents in both the U.S. and Japan rated colleagues in other companies to be the most important sources of external technical information.

Returning to the scientific world, **Liebeskind, Oliver, Zucker, & Brewer** (1996) performed a small study of two US biotechnology firms, looking only at the authors of scholarly publications as a measure of scientific knowledge exchange. This study found that of the total of 503 publications

⁴⁶ In this example, when a geologist in one firm is interested in finding some geological information, an oil scout is supposed to be asked to find this information. In some cases, this information is proprietary and can only be obtained from a rival firm. So, the oil scout may approach a scout from another company and negotiate a trade. In some cases, information is traded. However, in some cases the providing company does not have any information that it immediately wants in return. Often the trade is still concluded with the mutual understanding that the receiving firm "owes" proprietary data of similar value to the providing firm. What is special about this form of trading is that one or two trading intermediaries are placed between the individual or firm desiring the information and the firm or individual holding the information. Traders rarely cheat since their reputation and thus their value and jobs are dependent on their behaving according to the rules. Thus, this trading can be said to be managed since the loss of proprietary information without any form of beneficial return is restricted. Oil scouts are professional traders and thus they should have a deeper understanding of the rules of the trade. A second benefit to the system is that there is a centralization of IOUs that helps to defer the building up of a trade imbalance between firms.

⁴⁷ The author states that the respondents in the sample may be biased towards knowledge sharing due to the selection means, i.e., participating in benchmarking study or industry-related meeting.

during the ten-year period investigated, almost none of the 291 publications that were co-authored by scientists working at different firms was governed by a formal contract or other mechanism between the two firms. This finding indicates that scientists collaborate to a high degree in inter-organizational distributed networks of practice.

Extending Liebeskind's research in a study of a more exploratory nature, **Oliver & Liebeskind** (1998) investigated the interaction between the organizational and individual levels of collaboration within the biotechnology industry. Through reviewing relevant literature and conducting an unspecified number of interviews with scientists, corporate executives, and university technology-transfer officers in Israel and the United States, they propose that exchanges of new scientific knowledge occur in interpersonal relationships while formal inter-organizational arrangements serve to support knowledge commercialization. They found that scientists from the biotechnology firms generally did not collaborate with scientists from other firms but with scientists at research institutions or other universities. In addition, while there was no formal agreement, individuals generally asked management for approval to enter external collaborations. A final finding of interest is that scientists in large pharmaceutical firms participated to a considerably lower level in inter-organizational distributed networks of practice than scientists working in new business firms. The reason provided is that few university-trained scientists choose to work directly for these large firms for fear of being cut off from reciprocal relationships with university researchers due to organizational bureaucracy.

Continuing the work on knowledge exchange, **Isabelle Bouty** (2000) investigated the knowledge exchange decisions of 38 R&D supervisors and researchers in France through a case study analysis involving interviews. In this very thoughtful study, Bouty examined the decisions regarding with whom to exchange resources such as knowledge in informal relationships. First, in contrast to some of the previous studies, she found that individuals only exchanged knowledge that they did not consider to be confidential. Second, individuals exchanged knowledge with others with whom they were mutually acquainted, shared a high level of trust, and whom they did not consider to be a competitor. However, Bouty makes an interesting comment regarding confidentiality, arguing that it is socially constructed. She writes,

“With regard to most resources, though, confidentiality is left to the interpretation of the scientist. This interpretation results from a personal judgment as to the interests of her or his employing firm. It is grounded in a social context and in the scientist’s experience in the laboratory. Thus, as personal judgments can differ between individuals, there can be significant variations in confidentiality appreciation. Specifically, certain “secrets” can be common knowledge in a community, although they officially are confidential. For example, researchers explained: ‘If there is a promising subject, we know that...all the companies are working on it. The research directions are not a taboo subject between us...The global strategy is known...there are open secrets.’” (Bouty, 2000:54).

In more European-based research, **Lissoni** (2001) conducted a unique study of machine firms located in the province of Brescia, Italy that included eight textile machinery firms, ten metalworking machine tool firms, and seven plastic-processing machinery firms. Using data from an unspecified number of interviews with unspecified individuals (e.g., position) at these firms and from a questionnaire of 200 engineers engaged in design, prototyping, and testing activities in the firms, the researcher focused a considerable portion of the study on creating a detailed reproduction of the design and production work-flow for each company in the sample. However, there are some results relevant to our study. First, a surprisingly low percentage of engineers (30%) signaled that they had any kind of relationship (either friendship or technical) with engineers in other firms. Secondly, only 18% of the entire sample indicated that they entered into technical discussions with other firms’ engineers and only 4.5% indicated that they discussed current projects. Based on these results, Lissoni argues that knowledge does not circulate freely throughout the Brescia geographical cluster, rather it circulates within a few smaller communities comprising individuals linked together by ties based on trust and reputation.

One final study worth noting here is that by **Jarvenpaa & Staples** (2001). Although this study does not focus explicitly on networks of practice, it is of particular relevance since the researchers examine attitudes towards

information and knowledge sharing and as such, it complements the above studies on knowledge exchange. Jarvenpaa & Staples (2001) built on the laboratory studies of Constant, Kiesler, & Sproull (1994) in which they found that individuals had different attitudes as to whether they were sharing information or knowledge when defined as expertise. These laboratory studies by Constant et al. suggested that an individual's prosocial attitudes and norms of organizational ownership affect his or her decision to share tangible information; however, the sharing of expertise is influenced by personal benefits. Jarvenpaa & Staples (2001) extended Constant et al.'s study to include contextual factors, such as information culture and task interdependence, in an extensive study of the academic and administrative staff of an Australian and a Canadian university. Using data from 1125 employees (27%) from the Australian university and 810 (26%) from the Canadian university, they investigated attitudes towards information and knowledge sharing internally and with others in an inter-organizational professional task force. They found that the ownership of information and knowledge products that individuals had created was not a zero-sum game in terms of organizational vs. individual property rights. In other words, they argue that self-ownership coexists with organizational ownership, and employees feel that organizations do have rights to the labor of their employees, including their expertise. However, they did find that individuals attached organizational property rights less to information products than they did to their own expertise.

3.3.3 Discussion of Inter-organizational Distributed Networks of Practice Studies

Summarizing the above studies in table 3.3, we find that while the majority focuses on cognitive aspects, there are some relevant studies to structure and performance. The studies on scientific communities focus on structure, and results indicate that while individuals may cite the work of others who may be geographically dispersed, they generally collaborate with others with whom they interact more frequently in face-to-face settings, thus providing further evidence of the importance of face-to-face interactions and propinquity for the building of emergent networks. Additionally, this research suggests that scientific communities are characterized by a core and periphery, with the core influencing the direction of knowledge development and thus the work of those in the periphery. With regard to performance, these studies suggest that performance depends on an

individual's position in the network; however, beyond this, there is little research focused explicitly on structure.

For the studies from the firm perspective, none specifically focuses on structure or uses social network analysis other than the studies by Allen and colleagues. However, these studies examined primarily only the position of the individual researcher within the team and not within the inter-organizational network of practice as well as investigating only knowledge flows into the firm and not out of the firm. Regarding performance, we find a relationship between participation by a firm's members in inter-organizational distributed networks and performance at the firm and project level. Evidence suggests, however, that this relationship may be dependent on the degree to which the task knowledge is local or universal. In higher performing projects in which knowledge is more locally defined, gatekeepers or translators similar to Wenger's brokers facilitate the acquisition of external technical knowledge. However, in projects where knowledge is more universal, higher project performance may be achieved when all project members participate in inter-organizational distributed networks of practice. These performance results should be regarded with some caution since the majority of these studies were conducted thirty years ago focusing only on researchers in R&D operations, and the more recent study (Schrader) is limited, providing only suggestive evidence of a positive relationship between firm performance and knowledge sharing in inter-organizational distributed networks of practice.

An extensive number of these studies do investigate know-how trading and knowledge sharing between members of inter-organizational distributed networks of practice. These studies suggest that knowledge sharing within inter-organizational distributed networks of practice is quite a common occurrence across industries and nations with members of these networks sharing and exchanging valuable knowledge with each other through these emergent channels. However, the management of participation in these networks is difficult, with individuals often making their own decisions to participate and share knowledge without management's consensus or even awareness. Norms of reciprocity tend to dominate the knowledge sharing activities by members of inter-organizational distributed networks of practice, with individuals consciously providing knowledge to others in the expectation that they will receive something in return. With the questionable exception of Bouty, knowledge sharing may even include the

exchange of confidential organizational knowledge. Bouty raises a very interesting point though - confidentiality is socially constructed, and as one of her interviewees even noted, there are “open secrets”. Research by Jarvenpaa & Staples further touches on this aspect of socially constructed confidentiality since they find that the more an individual views their knowledge as his or her personal expertise, the more the individual regards such knowledge as his or her own property and not that of the individual’s organization.

While these studies are of quite an international scope, they are still limited in other areas. First, the vast majority of these studies investigate only researchers, scientists, and engineers at universities or high technology firms, thus providing us with little understanding of inter-organizational distributed networks of practice in non-science based professions or at lower levels of the firm. Second, while we do find a few studies focused on the structural properties of these networks using social network measures, these studies are only based on researchers and scientists and rely heavily on publicly available data. Third and perhaps not too surprising, all of these studies have a quantitative focus in terms of methodology, with data collection occurring primarily through publicly available data or surveys. Finally, we find no investigation of performance at the individual level or the relationship between participation in different networks of practice and performance.

Table 3.3 Selected Studies of Inter-organizational Networks of Practice (IONP) *

Primary Research Focus	Study	Methods	Sample	Primary Findings
<i>Structure</i>				
<i>Growth of scientific knowledge</i>	Crane 1972	Bibliometrics and surveys	102 mathematics authors and 221 rural sociology authors in US	Informal collaboration between individuals within specific research area creates invisible colleges. Individuals well connected in invisible colleges access information rapidly. Invisible colleges have lifecycles.
<i>Structure of scientific communication</i>	Lievrouw et al. 1987	Analysis of US funded grants, literature review, bibliometrics, questionnaires, and interviews	58 biomedical scientists, primarily in the US	Little overlap between emergent networks and citation networks among scientists. Face-to-face meetings and telephone played an important role in collaboration with little use of written means.
<i>Structure of global scientific network vs. regional scientific networks</i>	Schott 1988	Bibliometrics	Two million bibliographic references in the Science Citation Index, global	US center, but six regional areas in which local communities influence each other, thus indicating importance of face-to-face interpersonal relationships between scientists based on propinquity.

Primary Research Focus	Study	Methods	Sample	Primary Findings
<i>Structure of scientific citation vs. collaboration networks</i>	Tuire & Erno 2001	Bibliometrics and surveys	104 professors in education at eight Finnish universities	Collaboration networks and citation networks distinct in structure of individuals and density. Invisible colleges formed within universities as opposed to across them.
Performance				
<i>Relationship between external technical communication and project performance</i>	R&D studies, e.g., Allen, Tushman, etc. (1960s, 1970s)	Case studies with sociometric surveys	Primarily US R&D laboratories and their projects	Universal knowledge more easily communicated across national and organizational boundaries than more locally defined knowledge. Relationship between required task knowledge, number of gatekeepers, and project performance. E.g., higher performing development projects have external communication monopolized by small number of gatekeepers. Gatekeepers similar to Wenger's brokers. These individuals generally in management positions or highly technically competent and seen as experts.

<i>Relationship between know-how trading and firm performance</i>	Schrader 1991	Mail survey	294 technically oriented middle-level managers in US specialty steel and minimill industry	Suggestive evidence of positive link between know-how exchange and firm performance. Individuals base decisions to trade know-how on economic costs to firm. Norm of reciprocity in dyadic relations.
<i>Cognitive Aspects</i>				
<i>Diffusion of technical innovation</i>	Czepiel 1975	Interviews, Social network analysis	Managers and technical people in 18 US steel firms	Decision-makers use IONP to gather knowledge regarding implementation of innovation
<i>External knowledge exchange and knowledge sharing</i>	von Hippel 1987	Telephone interviews	Unspecified number of managers in 11 US steel minimills	Informal know-how trading is norm within minimill industry. Anecdotal evidence that trading and covertness of trading varies across industries.
<i>Informal collaboration between scientific organizations</i>	Kreiner & Schultz 1993	Interviews	16 researchers in Danish R&D biotechnology firms and universities	Liberal trading of confidential know-how. Emergent relationships often led to successful formal collaboration between university and firm.
<i>Participation of gatekeepers in external knowledge exchange</i>	Macdonald & Williams 1993	Mail survey	125 individuals in science and engineering in UK	Gatekeepers participate in dyadic reciprocal knowledge exchange in external networks of practice.

<i>Can external knowledge exchange be managed?</i>	von Hippel & Schrader 1996	Case study	Oil scouts in oil industry	Difficult to manage know-how trading through formal means. Sharing of tacit knowledge dependent on common understanding of work.
<i>Comparison of patterns of external knowledge sharing</i>	Appleyard 1996	Surveys	134 engineers, sales, and quality control individuals in US and Japanese steel and semiconductor industry	Little differences in informal external knowledge sharing between industries. External colleagues most important source of external technical information.
<i>Means with which new biotechnology firms source scientific knowledge</i>	Liebeskind et al. 1996	Bibliometrics	503 publications in two biotechnology firms in US	External collaboration in publications by individuals in firms not governed by formal contract or agreement.
<i>Interaction between individual and organizational levels in external scientific collaboration</i>	Oliver & Liebeskind 1998	Interviews	Scientists, corporate executives, university technology-transfer officers in Israel and US biotech industry	Scientists in biotech firms generally collaborate only with scientists in research institutes or universities and not with individuals in other firms. Collaborations not governed by formal agreement, but subject to informal management approval.
<i>Individual decisions to externally exchange strategic knowledge</i>	Bouty 2000	Case study with interviews	38 R&D supervisors and researchers in France	Three-step decision model to exchange knowledge in inter-organizational distributed network of practice. Confidential know-how not exchanged.

<i>External knowledge sharing in geographically co-located cluster</i>	Lissoni 2001	Interviews and surveys	200 electrical and mechanical engineers in 8 textile machinery firms and their customers, 10 die-casting mold producers, and 7 plastic-processing machinery firms in Italian province	Low percentage of engineers discussed current projects (4.5%) or other technical issues (18%) with other firms' engineers in the province. Knowledge did not circulate freely in the cluster, rather it circulated within a few inter-organizational distributed networks of practice.
<i>Knowledge ownership</i>	Jarvenpaa & Staples 2001	Surveys	1125 employees (27%) from Australian and 810 (26%) from Canadian university	Self-ownership and organizational ownership of knowledge coexist. Personal expertise felt to be more of individual property than tangible information product owned by organization.

** Findings specific to structure and performance are highlighted in bold text.*

3.4 Studies of Electronic Networks of Practice

Before starting this review of the last type of network of practice, it is necessary to note how we have limited this review. Due to the rapid growth of internet usage, we are beginning to see a significant number of impressive studies on online communities. For example, in one of the first large-scale web surveys, Wellman, Quan-Haase, Witte, & Hampton (2001) conducted an extensive study of the impact of the internet and participation in electronic communities on society's social capital through a survey of 39,211 visitors to the National Geographic Society website. While at first glance many of these studies appear relevant to our task at hand, further investigation reveals that the majority of these do not revolve around a specific work practice. Thus, in order to keep the review focused on networks of practice, we do not review studies of online communities in

education, the body of research on Usenet newsgroups more oriented towards social support and self-help (with one exception), or studies looking at the effect of electronic community participation on society. Nor have we included studies looking at the human computer interface aspects of online conversation, such as that of chat rooms⁴⁸, or on internet or media usage in general. Making these delimitations leaves us then with only a handful of studies that are of interest due to their explanatory power regarding electronic networks of practice from a firm's perspective. However, as you will see, some even stretch our definition of an electronic network of practice somewhat. A final point is that due to this small number of studies, we include both intra-organizational and inter-organizational electronic network of practice studies here.

The first study we report is an inspiring study by **Constant, Sproull, & Kiesler** (1996) that has received considerable recognition due to its early appearance and impressive scope. These researchers conducted a study of a broadcast mailing list (i.e., listserv) for the entire employee body of more than 11,000 employees at Tandem Computers, Inc. This mailing list was used for work-related broadcast messages for the entire organization, including announcements from headquarters, industry news, and requests for information. The particular focus of this study was on broadcast requests for information of any kind as long as it was work-related, which were about 30% of all the postings on this list during the six-week research period. As such, this mailing list is on the border of being considered an electronic network of practice since it contained all 11,000 employees and questions could revolve around any form of work practice. However, this study does provide some insights into an intra-organizational electronic network. Using data from surveys sent to message posters (55 information

⁴⁸ Research has found that while different kinds of electronic communities share some characteristics, they may also be distinctive. For example, support groups are distinctive in their use of electronic group membership as a legitimating strategy and in their use of both expertise and personal experience as warrants for advice (Galegher, Sproull, & Kiesler, 1998). For a review of research on electronic communities within the educational field, see Johnson (2001). For a study of 155 cultural newsgroups (e.g., African-American, Pakistan, etc.), see Choi & Danowski (2002). For a study on conversation in chat groups, see Donath, Karahalios, & Viégas (1999). See Lueg & Fisher (2003) for numerous studies looking at online social spaces. For how to manage electronic communities from a practitioner's viewpoint, see Williams & Cothrel (2000). A number of books also focus on building and facilitating electronic communities, for example Kim (2000) and Palloff & Pratt (1999).

seekers and 295 information providers) and text analysis of the postings to the mailing list during the six weeks, the researchers found that people helped others primarily out of organizational commitment and norms of reciprocity and because they enjoyed solving problems and helping others. The researchers determined this mailing list to be effective since message posters received useful technical advice - 49% of the respondents indicated that the replies had solved their problem. As for the relationships between individuals, 81% of the message respondents said that they did not know the message posters at all. In addition, they find that similarity in terms of managerial status, hierarchical level, firm experience, or industry experience does not explain the interactions and that the pattern of interactions is characterized by generalized reciprocity and not dyadic reciprocity. Finally, the usefulness of the replies has no correlation with the number of replies given, thus providing support for Granovetter's (1983) and Burt's (1992) notions that weak ties are useful if they bridge areas of superior resources.

Extending the experiments on information sharing on students by Constant et al. (1994) mentioned above in this chapter to include contextual factors such as information culture and task interdependence, **Jarvenpaa & Staples** (2000) conducted a large study of the determinants of the use of electronic collaborative media (e.g., listservs, email, web-browsers) by individuals in the workplace. Questionnaire responses were collected from 1125 academic and administrative staff (27% response rate of all academic and administrative staff) in an Australian University. Although the questions relating to media usage did not specifically ask whether these collaborative media were used for conducting work-related tasks, they do provide an indication of collaborative media usage for knowledge gathering and sharing with other individuals in intra-organizational and inter-organizational networks of practice. Contrary to expectations, this study found a negative relationship between an open, organic information culture and the use of the collaborative media. Possible explanations put forth by the authors are that in this organization, hierarchy may require more use of the electronic media or that individuals use these media to circumvent the closed information culture to access knowledge that is not freely shared. Another finding of interest is the negative relationship between the use of collaborative media and organizational information ownership, which supports Constant et al.'s (1994) research.

In a well-known study similar to Constant et al. (1996) that is available as an MIT working paper online, **Lakhani & von Hippel** (2000) examined the Apache Usenet discussion group through an analysis of website log data over a four year period and a survey of 366 participants. They found that information providers were relatively concentrated with 50% of the answers provided by the 100 most prolific providers, representing 2% of all providers. In contrast, 24% of the information seekers asked 50% of the questions. They also found that individuals were motivated to share by reciprocity, interest in advancing the community, intrinsic rewards, and increased reputation. Providers strongly disagreed with the statement “it is part of my job”, indicating that helping was indeed discretionary.

In one of the first published studies on inter-organizational electronic networks of practice, **Wasko & Faraj** (2000) conducted a somewhat exploratory study similar to that of Lakhani & von Hippel. They investigated participation in three technical usenet newsgroups (computer language C++, computer objects, and computer database) through an email survey of 342 participants and content analysis of the survey’s open-ended responses. Looking first at participation in general in the community, they found that these communities appeared to have certain norms, such as that individuals only help others who first try to help themselves. Prestige also seems to play a role, with individuals supporting and even attacking each other. Finally, they found suggestive evidence of a negative relationship between network size and its ability to create value for its members. Turning to motivation for participation, Wasko & Faraj found that individuals were motivated by both self-interest and collective interest, where self-interest included both tangible returns (e.g., efficiency in completing work tasks) and intangible returns (e.g., intrinsic satisfaction) and collective interest included care for the community (von Krogh, 1998), prosocial behaviors (e.g., “the right thing to do”), and an interest in advancing the community. However, the most frequent response was reciprocity - that individuals felt that they should give back to the community - thus reflecting generalized as opposed to dyadic reciprocity. These findings further support the view of knowledge as a public good in electronic networks of practice.

Molly Wasko (2001) continued the work from the previous study in her impressive doctoral dissertation on electronic networks of practice. Through interviews, content analysis of messages posted during a two-

month period, and survey data collected from 160 respondents in an inter-organizational electronic network of practice of a US professional legal association, she examined the underlying personal and social factors that predict knowledge contribution in electronic networks of practice. Her results are partially consistent with the previous research mentioned above since she found that people exchanged knowledge with strangers in the electronic network of practice based on the expectation of generating some type of return. Respondents contributing knowledge to the network did not expect to receive tangible returns, rather they were interested in enhancing their reputation in the network as well as reaping other intrinsic returns such as the desire to challenge themselves. In addition, the results revealed that active responders did not behave altruistically, and the only significant difference between responders and non-responders was that responders desired to receive intrinsic returns in the form of enjoyment and challenge. Based on these findings, Wasko argues that knowledge is best characterized as a private good in this context, where people engage in its exchange in order to receive commensurable benefits. However, people are still willing to engage in the provision of public information goods. The implication is that the expectation of returns does not necessarily translate into whether the public good will be provided, but it does seem to have implications for the quality or “helpfulness” of the good. We further develop her thinking in Article 2 of this thesis.

Additionally, through content analysis, Wasko found that this particular electronic network of practice exhibited the norm that individuals only help others who first try to help themselves. Individuals who had “done their homework” and then asked questions almost always received helpful answers. Regarding message content, the majority of postings were knowledge related, had a very low content of socializing, and were respectful and encouraging, with only a very few containing flames or scathing remarks. Finally, knowledgeable members generally corrected postings when appropriate. However, interviews revealed that respondents were of the perception that mentor experts had migrated to their private personal networks for knowledge exchange due to the network being taken over by “newcomers”. One highly skilled and knowledgeable interviewee had stopped participating in the electronic network since “it opens the floodgate for people who are seeking advice” while others had lost interest due to the novice level of the questions (p. 80).

Two very unique studies by **Nonnecke & Preece** (2000, 2003) are also worth reporting since they are the only ones to our knowledge that investigate lurkers in listservs. In a large demographic study (2000), these researchers analyzed 147,946 messages posted during a twelve-week period on 109 health and software support distribution lists. They found that for all the distribution lists, 56% of the listserv members made no postings while 81% made less than two postings per month during the twelve weeks, indicating that “lurkers” made up the vast majority of electronic community participants. However, they also found significant differences in lurker demographics between the two kinds of distribution lists. In a very limited study investigating why lurkers lurk (2003), ten interviews of electronic network participants revealed that lurking was a complex process to understand. A notable finding is that although the interviewees did not publicly participate in the online discussions, they felt a commitment to the network of practice and some even side-posted to provide support to other members. Thus, these researchers propose that lurkers should not be labeled as free-riders since if they were, then they pose the question, “How do online groups survive in the face of almost universal free-riding”. Thus, they suggest that lurkers be labeled non-public participants.

Returning to **Hara’s** (2000) work discussed above, her investigation of the electronic network of practice of lawyers in Indiana produced findings similar to Wasko’s study (2001). Hara found that the more experienced attorneys relied to a higher degree on people and face-to-face interactions than on electronic communications or the electronic network of practice. The electronic network consisted to a high degree of younger, less experienced attorneys, and ties within this network were found to be weaker than within the communities of practices that developed in co-located settings. These findings suggest that there is a relationship between demographics and the participant composition of different networks of practice. One interesting finding is that participation in an electronic network of practice fostered interaction between attorneys in face-to-face settings. Online discussions extended into face-to-face discussions, especially since postings were not anonymous. Finally, Hara’s findings support previous research that electronic networks of practice support the sharing of tacit knowledge to a lower degree than communities of practice.

3.4.1 Discussion of Electronic Networks of Practice Studies

In conclusion, while we find that there is a growing body of research on online communities, there is scant research conducted specifically on electronic networks of practice, be they intra-organizational or inter-organizational. For example, no attention is paid to intra-organizational electronic networks of practice other than Constant et al.'s related study (1996). Interestingly, the two more extensive studies on inter-organizational electronic networks of practice both consist of US lawyers, and the two more exploratory studies consist of only software programmers. Moreover, as seen in table 3.4, there are no studies specifically relating to structure or performance. However, several studies do suggest that interactions between electronic network of practice members are of a generalized and not a dyadic nature. In these studies, researchers have generally investigated individual motivations behind participation and knowledge sharing, revealing that individuals share knowledge with "strangers" due to expectations of returns for themselves (e.g., increased reputation, enjoyment, etc.) as well as for the network (advancing the community). Research by Lakhani & von Hippel further indicates that individuals make discretionary choices regarding their willingness to share knowledge and help others in the network. Additionally, these studies suggest that the lens of collective action with the knowledge of the electronic community as a public good is a useful means of understanding these networks.

Since these inter-organizational electronic networks of practice are conducted in internet space, we know little about the national demographics of these individuals other than that they understand and can write English. However, due to the global reach of the internet, it can be surmised that participants are globally dispersed. Finally, these studies have primarily relied on surveys and content analysis of posted messages.

Table 3.4 Selected Studies of Electronic Networks of Practice (ENP) *

Primary Research Focus	Study	Methods	Sample	Primary Findings
<i>Structure</i>				

<i>Performance</i>				

<i>Cognitive Aspects</i>				
<i>Predictors of usefulness of technical advice provided in mailing list</i>	Constant et al. 1996	Email survey	Mailing list including all 11,000 employees of Tandem Computers. Surveys of 55 information seekers and 291 information providers	Individuals generally strangers. No correlation between demographics and participation. Interactions characterized by generalized reciprocity. Resources of network participants more important than network size in usefulness of network. Individuals provide advice due to organizational commitment, reciprocity, and enjoyment.
<i>Individual factors underlying usage of electronic media</i>	Jarvenpaa & Staples 2000	Mail survey	1125 academic and administrative staff in Australian University	Negative relationship between electronic media use and open, organic information culture and organizational information ownership.

<i>Motivation for helping others and sharing knowledge in open source electronic community</i>	Lakhani & von Hippel 2000	Content analysis and email survey	Four year website log data and 366 participants in the Apache Usenet discussion group	Sharing based on reciprocity, interest in community advancement, intrinsic rewards, and increased reputation. Choice to help others was discretionary. Information providers are relatively concentrated but information seekers are relatively dispersed.
<i>Motivation for helping and sharing knowledge with others in inter-organizational electronic network of practice</i>	Wasko & Faraj 2000	Content analysis of open-ended responses on email survey	342 respondents in three technical usenet newsgroups: computer language C++, computer objects, and computer database	Motives include prosocial behavior, care in community and generalized reciprocity. Support for knowledge as a public good.
<i>Predictors of knowledge contribution in electronic network of practice</i>	Wasko 2001	Mail survey and content analysis	160 respondents and 2,496 messages of an inter-organizational US professional legal association	Share knowledge primarily due to intangible returns (e.g., reputation, enjoyment). Knowledge viewed as both private and public good.
<i>Demographics of lurkers in online communities</i>	Nonnecke & Preece 2000	Content analysis	147, 946 messages on 109 health and software support listservs	Vast majority of members (81%) posted less than 2 messages during 12-week period.
<i>Motivation for lurking</i>	Nonnecke & Preece 2003	Interviews	10 lurkers in US	Lurkers provide support to other network members through side-posting.
<i>Role of information technology in knowledge sharing and construction</i>	Hara 2000	Ethnography	ENP of lawyers in state of Indiana	Participant demography differs between types of network of practice. CPs support sharing of tacit knowledge to higher degree than ENP. ENP instigates interaction between co-located individuals.

* Findings specific to structure and performance are highlighted in bold text.

3.5 Summary of Previous Empirical Studies of Networks of Practice

In summary, we have found and reviewed some fifty studies within or closely related to the network of practice field. We have broadly summarized these studies in table 3.5 according to their findings relating to structure, performance, and cognitive aspects as well as according to methods and samples. We discuss this summary below.

Looking first at methods and samples, we find that researchers have primarily conducted their studies of communities of practice through extensive ethnographies and case studies that often formed the basis of doctoral dissertations and that focused on lower level employees and non-science based professionals located in the United States. Turning to intra-organizational distributed networks of practice, we see that there are very few in-depth quality studies that are specifically focused on these networks. Here we also find a distinct and interesting change in methodology and samples, with researchers primarily using quantitative methods involving questionnaires and sociometric analyses while focusing on professionals such as researchers and lawyers, again within the United States. This choice of methodology and samples is somewhat repeated when we look at the considerable amount of research conducted on inter-organizational networks of practice, with researchers using questionnaires and sociometric analyses to investigate the networks of researchers, scientists, and engineers at universities or high-technology firms. However, contrary to the previous studies, studies of inter-organizational networks of practice are of a more international scope. Turning to the final category, electronic networks of practice, we find that there is a dearth of studies focused on this type of network of practice. Only a handful of these studies are truly focused on electronic networks of practice with the more extensive ones limited in terms of samples, focusing only on software programmers and lawyers who speak English, and methodology, involving primarily surveys and content analysis. As a result, we may clearly question the generalizability of the research within each type of network of practice to other settings. For example, while there is extensive research on communities of practice on non-professionals in the United States, research has failed to show whether we may generalize these results to professionals or to national cultures outside the United States.

Table 3.5 Summary of Selected Empirical Studies

Network of Practice	Struct.	Perf.	Cognitive Aspects	Methods and Samples	Notes (Primarily Relating to Structure and Performance Findings)
<i>Communities of practice</i>	**	**	****	- Ethnographies, case studies - Lower level employees, craftsmen, non-professionals - US oriented	-Studies discuss only impact of formal organization on community of practice formation and very general structural characteristics -No rigorous studies specifically focused on performance
<i>Intra-organizational distributed networks of practice</i>	***	***	**	-Questionnaires with sociometric analyses -R&D researchers and professionals -US oriented	-Studies primarily focused on project performance. More relevant studies on performance and structure mostly performed twenty to thirty years ago and not explicitly on intra-organizational distributed networks of practice.
<i>Inter-organizational distributed networks of practice</i>	*	**	****	-Bibliometrics, case studies, interviews, surveys, social network analysis -Scientists, researchers, engineers -International sites	- Studies focused primarily on project performance. Performance studies of significance conducted only on scientists and researchers and performed thirty years ago. -Structure studies performed only on scientists and researchers
<i>Electronic networks of practice</i>	---	*	***	-Content analysis and surveys -Software programmers and lawyers -English speaking	-Studies primarily on <i>inter</i> -organizational electronic networks of practice -No studies focusing specifically on structure or performance

--- - No relevant findings or studies

* - Limited research of more exploratory or less rigorous nature

*** - Extensive research on one *type* of occupation (e.g., scientists & researchers)

**** - Extensive research on numerous types of occupations

Making broad comparisons of these networks in terms of the research themes in these empirical studies provides us with the ability to easily identify the research gaps and assumptions made within each type of network. First, only the studies on communities of practice have focused considerably more in terms of depth and scope on the cognitive aspects than the other networks of practice in general. Through these studies, we have a deep understanding in terms of identity and knowledge sharing and the importance of physical co-location for communities of practice; however, the lack of ethnographic research on non-co-located networks of practice, be they inter or intra-organizational, limits our understanding of these cognitive elements.

A second area worth noting is that if we take a step back and take a broad look at the field, we find in our review of the empirical studies that researchers generally depart from the assumption either that the individual network member has already made the decision to participate in the network or that individuals are willing to freely share their knowledge with other network of practice members. For example, the community of practice newcomer mutually engages with other members in order to become a full member of the community of practice or the electronic network of practice member has already signed up on the mailing list. However, a few studies on electronic and inter-organizational distributed networks of practice provide evidence that individuals do make discretionary choices regarding the degree to which they participate and share knowledge in a particular network of practice and that they base these decisions on the expectation that they will receive some tangible or intangible benefits in return.

Furthermore, this research provides some interesting perspectives with regard to the knowledge that is shared within these networks. For example, studies on inter-organizational distributed networks of practice suggest that the confidentiality and ownership of knowledge is socially constructed by networks of practice members while studies on electronic networks of practice have opened our eyes to the examination of knowledge and the network using the lens of collective action and public goods. Finally, in general, we find that there really is a dearth of studies on networks of practice from a business firm's point of view with some areas wide open for study, e.g., intra-organizational networks of practice, be they distributed or electronic.

With regard to structure, as can be seen in table 3.6, we find that no research has specifically focused on the structural properties of communities of practice or electronic networks of practice. Looking at research on intra-organizational and inter-organizational distributed networks of practice, we find that the majority of these studies investigate only the structural properties of science-based networks. Additionally, the research by Allen and colleagues was conducted thirty years ago in the pre-internet era. Perhaps this lack of research focusing on structure is not too surprising given the difficulty in tracking these invisible networks. Traditional means of collecting social network data are extremely time consuming and analysis of the data can be quite intensive, not to mention that access to organizations is difficult due to certain ethical and privacy issues. However, based on these findings, we may draw some general conclusions regarding structure in networks of practice. Results suggest that the formal organization may influence the structure of a network of practice, that there is a negative relationship between physical distance between individuals and the creation of emergent relationships due to the importance of face-to-face interactions, that structures are characterized by a core and periphery, and that reciprocity moves from being a dyadic exchange in communities of practice to of a more generalized form in electronic networks of practice.

Table 3.6 Summary of Findings from Selected Empirical Studies Relating to Structure

Primary Research Focus	Study	Methods and Sample	Primary Findings
<i>Communities of Practice</i>			
<i>Relationship between learning and social situations</i>	Lave & Wenger 1991	Ethnography of small groups of Mayan midwives, Liberian tailors, US non-drinking alcoholics, butchers in US supermarkets, and US navy quartermasters	Structure is more an adaptive outcome of action rather than a precondition within a social system.

Primary Research Focus	Study	Methods and Sample	Primary Findings
<i>Relationship between learning and social situations</i>	Wenger 1998	Ethnography of around twenty claims processors co-located in one US company	Structure of community of practice consists of core of full participants surrounded by layers of peripheral members.
<i>Management of unexpected deviations in work procedures</i>	Schenkel 2002	Case study involving interviews, sociometric questionnaire, and archival data review of major Scandinavian construction project involving 137 managers and support individuals	Formal organization can influence CP structure.
<i>Intra-organizational Distributed Networks of Practice</i>			
<i>Structure of weak ties</i>	Friedkin 1980	Sociometric questionnaire of scientists in seven biological departments in US university	The stronger the tie between two individuals, the higher the overlap of their contact circles.
<i>Factors affecting creation of emergent relationships</i>	Han 1996	Sociometric questionnaire of 76 employees in large US retail corporation	Formal organizational boundaries affect building of intra-organizational relationships
<i>Collective action among individuals equal in power</i>	Lazega 2001	Case study involving sociometric data of 71 lawyers in three offices of US law partnership	Relationships based on advice, goodwill (co-workership), and friendship create social niches.

<i>Inter-organizational Distributed Networks of Practice</i>			
<i>Growth of scientific knowledge</i>	Crane 1972	Bibliometrics and surveys of 102 mathematics authors and 221 rural sociology authors in the US	Informal collaboration between individuals within specific research area creates invisible colleges.
<i>Structure of scientific communication</i>	Lievrouw et al. 1987	Analysis of US funded grants, literature review, bibliometrics, questionnaires, and interviews of 58 biomedical scientists, primarily in the US	Little overlap between collaboration networks and citation networks among scientists. Importance of propinquity.
<i>Structure of global scientific network vs. regional scientific networks</i>	Schott 1988	Bibliometrics using two million bibliographic references in the Science Citation Index, global	Importance of face-to-face relationships. Core/periphery structure.
<i>Structure of citation vs. scientific collaboration networks</i>	Tuire & Erno 2001	Bibliometrics and surveys of 104 professors in education at eight Finnish universities	Collaboration networks and citation networks distinct in structure. Importance of face-to-face relationships.
<i>Electronic Networks of Practice</i>			
<i>What predicts usefulness of technical advice provided in mailing list?</i>	Constant et al. 1996	Email survey participants of mailing list including all 11,000 employees of Tandem Computers. Surveys of 55 information seekers and 291 information providers	Interactions characterized by generalized reciprocity.

<i>Motivations for helping others and sharing knowledge in open source electronic community</i>	Lakhani & von Hippel 2000	Content analysis and email survey of four-year website log data and 366 participants in the Apache Usenet discussion group	Information providers are relatively concentrated but information seekers are relatively dispersed.
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Finally, while significant interest in networks of practice is rooted in the belief that there is a positive relationship with performance, as can be seen in table 3.7, we really have very limited support for this relationship, be it on the individual, group, or organizational level. For example, we find that despite considerable claims by community of practice scholars that there is a relationship between communities of practice and performance, we find no rigorous studies other than Snyder's somewhat related study that truly support this relationship at any level. Additionally, most of the studies on intra-organizational and inter-organizational networks of practice that are of a more serious academic nature were conducted thirty years ago and only within a few limited sites. Finally, there are no studies providing any kind of evidence of a relationship with performance within electronic networks of practice nor are there any studies specifically focused on individual performance within any type of network of practice. However, the findings do suggest that an individual's position in a network of practice has an impact on performance.

Table 3.7 Summary of Findings from Selected Empirical Studies Relating to Performance

Primary Research Focus	Study	Methods and Sample	Primary Findings
<i>Communities of Practice</i>			
<i>Relationship between organizational learning and organizational performance</i>	Snyder 1996	Case study: observations, interviews, archival data review of US office workers in two divisions of four offices in US Veterans Benefits Association (100 to 250 employees in each office)	Communities of practice influence organizational performance through impact on organizational knowledge and learning.

<i>Relationship between learning and social situations</i>	Lave & Wenger 1991	Ethnography of small groups of Mayan midwives, Liberian tailors, US non-drinking alcoholics, butchers in US supermarkets, and US navy quartermasters	High performers of practice are full participants of community
<i>Relationship between learning and social situations</i>	Wenger 1998	Ethnography of around twenty claims processors co-located in one US company	Core members are high performers of CP tasks.
<i>Relationship between community of practice and organizational performance</i>	Schenkel & Teigland 2002	Survey of Major Scandinavian construction project involving 137 managers and support individuals.	Limited support for positive relationship between CPs and learning curve improvement.
<i>Intra-organizational Distributed Networks of Practice</i>			
<i>Relationship between information flows and project performance</i>	R&D studies, e.g., Allen, Tushman, etc. (1960s, 1970s)	Case studies with sociometric surveys of primarily US R&D laboratories and their projects	Project performance dependent upon project task knowledge and number of gatekeepers.
<i>Knowledge integration across subunits in multiunit firm</i>	Hansen 1996, 1999	Case study with sociometric surveys of 120 R&D projects within one US multinational	The more central the R&D team in the organizational network in terms of team's unit possessing relevant expertise, the easier the network search, and the faster the completion time.
<i>Collective action among individuals equal in power</i>	Lazega 2001	Case study of 71 lawyers in three offices of US law partnership	Social pressure is applied by others within social niches to maintain individual performance levels. Individuals who are most sought out for collaboration and

			advice by others across the firm earn more money for the firm.
<i>Relationship between networks of practice and creation of organizational value</i>	Lesser & Storck 2001	Interviews of five to ten members of seven IANPs comprised of knowledge workers in a variety of large corporations (majority likely in US)	Support for positive relationship between participation in IANPs and organizational performance.
<i>Inter-organizational Distributed Networks of Practice</i>			
<i>Relationship between external technical communication and project performance</i>	R&D studies, e.g., Allen, Tushman, etc. (1960s, 1970s)	Case studies with sociometric surveys of primarily US R&D laboratories and their projects	Relationship between required task knowledge, number of gatekeepers, and project performance.
<i>Relationship between know-how trading and organizational performance</i>	Schrader 1991	Mail survey of 294 technically oriented middle-level managers in US specialty steel and minimill industry	Suggestive evidence of positive link between external knowledge exchange and firm performance.
<i>Electronic Networks of Practice</i>			

Having reviewed the empirical studies to date, we now move to the next chapter in which we build on the research gaps and assumptions revealed in this review to develop the two research purposes for the empirical studies of this thesis.

CHAPTER FOUR

Development of Research Purposes

IN THIS CHAPTER, we develop the two central research purposes of this thesis. These two research purposes complement previous research since they emerge directly from the gaps revealed in the literature review in the previous chapter: (1) structural dimensions of networks of practice and (2) performance in networks of practice. Additionally, these research purposes serve to fill the gaps in empirical research on intra-organizational distributed networks of practice as well as intra-organizational and inter-organizational electronic networks of practice.

4.1 Research Purpose 1: The Structural Dimensions of Networks of Practice

If we return to our initial discussion of networks of practice in Chapter Two, you will recall that social relationships between individuals are the basis for all networks of practice. For example, it is through interactions with others that novices become full participants and construct their identity in communities of practice and that individuals share knowledge through electronic communities. This is mirrored in the empirical studies presented in the review in Chapter Two in which researchers have focused on investigating social interactions and the related cognitive aspects. However, studying these cognitive aspects provides only a partial understanding of these networks.

In contrast to other areas of the social sciences that have tended to study the “attributes” or the characteristics of individuals, groups, and organizations, researchers within social network analysis have been paying increasing interest to the *relations* between individuals, groups, and organizations within the past few decades. In social network theory, researchers have

found that the interactions between individuals within emergent groups create patterns of relationships that in turn constitute the *structure* of the network (Brass, 1985; Krackhardt & Porter, 1985; Burkhardt & Brass, 1990; Krackhardt, 1991). These relations may then be characterized by a number of important properties such as frequency, stability, transitivity, reciprocity, and multiplexity, and they facilitate the *structural analysis* of social groups (Monge & Contractor 2003)⁴⁹. As stated in Chapter One, structure within social network theory is defined as the presence of regular patterns or regularities in relationships (Wasserman & Faust, 1994) that are represented by networks comprising sets of nodes and sets of ties depicting the interconnections between the nodes (Wellman & Berkowitz, 1988). This definition of structure is distinguished from others in the social sciences since it focuses on the “*concrete* social relations among specific social actors” (Wellman & Berkowitz, 1988:5, italics in original) as opposed to other aspects such as symbols, meanings, norms, values, and role expectations (ibid, Scott, 1998). In addition and as mentioned above, this network definition of structure is in strong contrast to the definition of formal organizational structure that generally refers to the prescribed framework focusing on the differentiation of positions, the formulation of rules and procedures, and prescriptions of authority within an organization (Ranson et al., 1980)⁵⁰.

Within social network theory, individuals and their actions are viewed as interdependent rather than independent, autonomous units since individuals are embedded in networks of relationships (Berkowitz, 1988; Wasserman & Faust, 1994). As indicated above, the fundamental principle then is that pair-wise relationships among individuals link to form networks whose structural characteristics both are the result of dynamic interaction processes and have an effect on individual and group outcomes. At the individual level, due to embeddedness, individuals are involved in multilateral resource interdependencies in which relationships provide access to key resources, such as goodwill, advice and social support, as well as the ability of the individual to influence or be influenced by others (Lazega, 2001). Thus, a person's position in a network may result in both

⁴⁹ For a review of social network concepts and principles, see Monge & Contractor (2003) and Wasserman & Faust (1994).

⁵⁰ As mentioned previously, interest in this formal view of structure has been heavily influenced by Weber (1946), e.g., Hall (1963), Pugh et al. (1968,1969), and Child (1972).

constraints and opportunities for the individual (Burt, 1992). At the group or network level, there is the holistic notion of emergent properties that suggests that at least some properties and outcomes of a social network are a function of its complete structure and are not reducible to either an individual actor or a single link (Degenne & Forsé, 1993). Furthermore, some researchers argue that emergent network structures better explain organizational behavior than formal structures (Bacharach & Lawler, 1980; Krackhardt & Hanson, 1993; Monge & Contractor, 2003).

Social network analysis is then an analytic technique that researchers use to represent the relational data of networks and to investigate the nature and properties of these relations. With the exception of the studies mentioned above, such as Crane's work on scientific communities, the study of lawyers by Lazega, and the studies in R&D such as those by Allen and Hansen, to the best of our knowledge there are few other studies that focus on investigating the structure of networks of practice from a social network perspective. This seems surprising for several reasons. First, as discussed further below, the logic of networks of practice carries with it strong parallels to the structural characteristics of embedded networks. Second, many of the arguments of the network of practice literature are based upon the underlying principle of social network theory: the assumption that individuals are embedded in networks of social interactions that shape their behaviors. Looking at the extensive stream of social network literature, we find that there is a wide range of analytical tools that describe and analyze emergent structures. Thus, an application of social network theory and social network measures to networks of practice would improve both our understanding of and our ability to theorize regarding these emergent networks. Against the background of the above discussion, the first overarching purpose of this thesis is the following:

Research Purpose 1: To describe the structural properties of networks of practice through the application of social network analysis.

This purpose is further broken down into two sub-purposes. Since the studies using social network analysis mentioned above focus on intra-organizational and inter-organizational distributed networks of practice, we have chosen to examine the structures of two networks of practice that have not received any attention to date: a community of practice and an

electronic network of practice. We discuss each of these sub-purposes in turn.

4.1.1 Research Purpose 1a: Structural Dimensions of Communities of Practice

We turn first to the area of communities of practice. With regard to the connection between communities of practice and social networks, we argue in Chapter Two that *every community of practice consists of a network, but not every network forms a community of practice*. If we agree with this, then the question arises as to whether there are specific structural properties that are likely to distinguish a community of practice from other networks. As mentioned above, researchers have begun to look at the various structural aspects of communities of practice, and in particular that of participation levels within communities. However, as far as we have been able to discern, the participation levels as described by the initial proponents of communities of practice, e.g., Lave and Wenger, are the only structural aspects of communities of practice that have been discussed in any significant detail.

Thus, in order to examine the structural properties of communities of practice, we turn to the wide range of extensively used concepts, measures, and techniques offered by social network analysis to find those that are best able to describe communities of practice. We may then synthesize these social network analysis concepts with existing concepts from the community of practice literature to conceptually develop structural properties distinct to communities of practice. These structural properties may then help to detect and analyze communities of practice within organizations, to track their development over time, or to measure their relationship with organizational performance.

In order to fill a second gap in the literature on communities of practice, we take the above one step further by proposing that these distinct community of practice structural properties can be linked to performance. As discussed above, within the field of communities of practice there is a general inherent assumption that communities of practice have a positive impact on organizational performance (c.f. Brown & Duguid, 1991). The general assumption is that as members of a community of practice work together, they improve their practice. Wenger (1998) argues that

communities of practice produce incremental improvements in work practices yet they are not favorable to radical improvements. Similarly, Lave & Wenger (1991) argues that communities are involved in simultaneously producing both practical outcomes for customers as well as learning for members. However, there are few empirical studies that provide evidence of this positive relationship. This lack of empirical research on community of practice performance is understandable since by definition a community of practice is a fluid, emergent informal structure (Brown & Duguid, 1991; Wenger, 1998). As a result, communities of practice are extremely hard to pin down. In addition, there is no agreement as to a performance measure that would capture the community of practice as a whole, again due to their fluid nature (Brown & Duguid, 1991; Wenger, 1998.). However, if we are able to develop the means to detect and analyze communities of practice within organizations through the development of structural properties, then we may be able to investigate the relationship between these structural properties and performance. In summary, through identifying and specifying structural properties of communities of practice, we may then open the door for additional theorizing on both the structural as well as the cognitive aspects of communities of practice as well as for further empirical studies. Thus, Research Purpose 1a is the following:

Research Purpose 1a: To conceptually develop the structural properties of communities of practice and propose a series of relationships between community of practice structural properties and performance.

4.1.2 Research Purpose 1b: Structural Dimensions of Electronic Networks of Practice

The second network of practice that we have chosen to investigate here is that of an electronic network of practice. We extend our reasoning from Research Purpose 1a that we may use social network analysis to help us investigate the structural properties of communities of practice to electronic networks of practice⁵¹. However, we find that we cannot merely apply the

⁵¹ We are not the first to apply social network analysis to online communities; however, to date most of the applications of social network analysis to online communities have focused on *mapping the links* that cross-posted messages establish *between and not*

properties developed for communities of practice in Research Purpose 1a to electronic networks of practice due to the different logics of these networks.

To recapitulate our discussion in Chapter Two, electronic networks of practice are similar to communities of practice in that they are a social space where individuals working on similar tasks self-organize to help each other and share perspectives about their occupational practice or common interest. However, unlike communities of practice and the other kinds of networks of practice where people know each other personally and form dyadic, interpersonal relationships, participants in electronic networks of practice are typically strangers, individuals form weak ties with the entire network instead of with a select few, and interactions generally occur through text-based, asynchronous, computer-mediated communication. Moreover, the differences between an electronic network of practice and the other networks of practice relate to the visibility of the interactions between members. In electronic networks of practice such as those characterized by listserv or bulletin board technologies, the posting of messages is generally open. Thus, once posted, messages are visible to everyone participating in the network. As a result, anyone searching for advice can either post a new question, or in some networks search the archived discussions to reuse knowledge that has already been exchanged between other members.

As we have seen in previous chapters, it has been proposed that theories of public goods and collective action can be modified and expanded to explain knowledge exchange in electronic environments (Fulk, Flanagan, Kalman, Monge, & Ryan, 1996; Monge, Fulk, Kalman, Flanagan, Parnassa, & Rumsey, 1998). Thus, one way of investigating the structural properties of an electronic network of practice is to apply theories of collective action and public goods in our analysis. In the formal language of collective action theory, we argue that the electronic network participants are the

within newsgroups nor do these newsgroups revolve around a work practice (e.g., Donath et al., 1999; Smith, 1999; Sack, 2000; Choi & Danowski, 2002). A cross-posted message is a message that is posted to more than one newsgroup. The “Newsgroups” header of the message displays the names of all the newsgroups to which the message was posted. Reasons for posting to more than one newsgroup may include that the message is relevant to more than one group or the author was unsure as to which newsgroup to post.

interest group or the collective and the public good is the continuous stream of knowledge.

To explain further, public goods are resources from which all individuals in a collective may benefit regardless of whether they have contributed to providing the good, such as a public park or public television (Kollock, 1998). Public goods have two specific characteristics that have implications for their provision and use. First, a public good is a resource that can be provided only if members of a collective contribute towards its provision. It is *non-excludable*, i.e., the good cannot be withheld from any member of the collective, even if he or she does not participate in the production or maintenance of the good (Komorita & Parks, 1995). A second characteristic is known as *non-rival*, meaning that the good is not used up or depleted in its consumption, thus one person's use of the good does not diminish its availability to others in the collective (Shmanske, 1991). Public goods are generally considered to evidence both non-rivalry and non-excludability. Since public goods are not used up in their consumption due to non-rivalry, there is no incentive to add costs by controlling access to the good through exclusion (Musgrave, 1959). However, a connection between the two characteristics of non-rivalry and non-excludability does not necessarily exist: a non-rival good can be excludable while a non-excludable good can be either rival or non-rival (Shmanske, 1991). Thus, true public goods are completely non-excludable and non-rival; however, it is argued that many public goods exhibit these characteristics to varying degrees (Kollock, 1998).

As mentioned above, we follow the suggestions of previous researchers and propose that we view the knowledge of an electronic network of practice as a public good. First, due to the open nature of an electronic network of practice, the network's knowledge is non-excludable. When participants interact in the network, then all members may benefit from their discussion and knowledge sharing, even though they did not contribute to its production through either posting or responding. Second, the knowledge is non-rival since when one person uses the knowledge gained in the network of practice, it still remains available to the other network members.

When knowledge is treated as a public good, then all members participate in supplying the knowledge to the network of practice, thus creating knowledge flows. These flows generate new combinations of existing

knowledge, which results in learning, innovation and new knowledge creation. However, one of the main concepts in theories of collective action and public goods is the social dilemma of the provision of public goods. In other words, the optimal individual decision is to enjoy the public good without contributing anything to its creation or maintenance. In the context of electronic networks of practice, the rational decision by participants of an electronic network of practice would be to free-ride or lurk, merely reading the messages posted by others without contributing to either asking questions or spending time engaging in the online discussions. Yet if all members were to lurk, then there would be no public good produced. This is the social dilemma. Thus, we are interested in investigating the structural properties of an electronic network of practice in order to help us understand the provision of the public good of knowledge, given that individuals are better off not contributing and instead free-riding on the efforts of others. As such, Research Purpose 1b is the following:

Research Purpose 1b: To investigate the structural properties of an electronic network of practice through the application of theories of collective action and public goods.

4.2 Research Purpose 2: Performance and Networks of Practice

In reviewing the network of practice literature, we find that with few exceptions one of the general assumptions is that there is a positive relationship between networks of practice and performance since networks of practice are argued to be the nexus for the sharing and in some cases the creation of valuable individual and group knowledge. Researchers and practitioners alike have been increasingly advocating networks of practice within recent years, and as a result, managers in numerous organizations are attempting to support or even construct various forms of networks of practice within and across their organizations (Wenger et al. 2002; Swan et al. 2002). Similar to the broader set of organizational knowledge management initiatives implemented to enhance performance through knowledge sharing and creation, it seems that the hope of management is that these efforts will positively affect individual behavior in the workplace and thus ultimately drive increases in firm performance (Davenport & Prusak, 1998; Wenger et al., 2002).

However, as revealed in the review of the empirical studies in Chapter Three, there is a dearth of solid academic empirical support for this positive relationship, with researchers paying little systematic attention to the relationship to performance at any level. Several reasons for this can be offered. One potential reason could stem from the assumption that learning leads to improved performance. As discussed in Chapter Two, the original research that resulted in the development of communities of practice was based on situated learning theory in which individuals are argued to learn through participating in a shared activity. Thus, the intuitive benefits of networks of practice may seem to be obvious, thus requiring little support for substantiation. Individuals mutually engage with others participating in the same practice, learning to conduct their work-related tasks, and thus improving their ability to perform their work-related tasks, with the outcome being improved performance for both the individual, the network of practice, and the organization. While this positive relationship to performance may seem intuitive, as we discuss below, previous research suggests, however, that there may be a negative relationship to performance as well (Levitt & March, 1988; Leonard-Barton, 1992).

A second possible explanation for the dearth of empirical study focusing on performance is that defining and measuring performance related to networks of practice is extremely difficult. The ability to develop appropriate performance constructs is hampered by the ethereal and emergent nature of networks of practice; they are, by definition, extremely hard to pin down. Any individual can potentially be involved in numerous networks of practice, varying from an immediate community of practice to a set of internet contacts on the other side of the world. Moreover, the process of defining membership in certain networks of practice apparently takes away their very essence because they thrive on their emergent nature.

One approach that could be used to address these difficulties is to bring the network of practice thinking down to the level of the individual. Rather than attempt to define the various networks of practice within and across a firm's boundaries, we propose that an individual's performance at work is associated with the extent to which he or she is a member of and participates in different networks of practice. Thus, by measuring the patterns of interaction of the individual with various networks of practice, we suggest that we can predict to some degree his or her performance.

In so doing, we contribute to the network of practice literature in an additional way. One common trait of all networks of practice is that by definition they are self-organizing. As a result, their existence and sustainability are dependent upon individual members and their desire to participate and share their knowledge within the network. However, as mentioned above, the empirical studies to date by and large depart from a specific type of network of practice with individuals already having made the decision to participate in the particular network. Furthermore, with the exception of the studies of electronic networks of practice, it is generally assumed that individuals freely share their knowledge with other network of practice members. However, previous research investigating knowledge sharing activity implies that individuals make choices as to whether or not to share their knowledge. In one article, it is even simply put, "To hoard or to share? That is the question" (Boisot & Griffiths, 1999:664). Within this line of questioning, considerable attention has been paid to why individuals help each other and share their knowledge in face-to-face networks (e.g., Thibaut & Kelley, 1959; Schwartz, 1970) as well as in electronic networks of practice (e.g., Constant et al., 1996; Wasko, 2002). Results indicate that individuals base their decisions on potential costs and benefits to knowledge sharing. For example, research by Allen (1977) provides evidence that individuals consider the "cost" of an interaction with another individual before engaging in any interaction. Additionally, as we saw in previous chapters, motivations for knowledge sharing could be based on rational, self-interest or collective interest, or both. For example, the electronic network of practice research provides evidence that individuals tend to share knowledge in the hope of increasing their reputation or advancing the electronic community (Lakhani & von Hippel, 2000). However, while studies have looked at the intangible antecedents to participation within one particular network such as reputation and altruism, researchers have paid scant attention to an individual's participation in a particular network and its effect on individual outcomes such as individual performance. At the individual level, other than the categories of community of practice participation proposed by Wenger (1998), there is little discussion of this relationship.

In addition to this simply put question above, it is obviously not the only question that needs to be asked when discussing knowledge sharing by individuals. Clearly, if there is one general conclusion we can make from the discussion and literature review presented in the previous chapters, it is

that individuals have a large variety of networks of practice within which they may participate: internal vs. external, face-to-face vs. electronic, etc. Previous research further supports the idea that individuals make choices regarding their level of participation in various networks. For example, Wellman & Gulia (1999) suggest that individuals operate with a portfolio of relationships of various degrees of density according to the purpose in belonging to the network. Additionally, although based on only 15 semi-structured interviews of scientists in an inter-organizational consortium, Andrews & Delahaye (2000) found that the respondents (1) deliberately mediated the knowledge acquisition process by deciding from whom they would seek potentially useful knowledge as well as from whom they were willing to accept knowledge and (2) actively deciding with whom they would share their knowledge⁵². As mentioned above, these choices are primarily made based upon individual interests, which are diverse and distributed across individuals. As a result, the process of knowledge sharing among individuals is a rather fragile and uncertain activity (von Krogh, 2002). For example, theories of self-interest propose that individuals make what they believe to be rational choices to acquire personal benefits through maximizing (or satisficing) their gains or minimizing their losses (Monge & Contractor 1997). Thus, individuals acting in this manner feel that there must be some reciprocal rewards for participating in knowledge sharing, such as enjoyment, being challenged, or improved task performance (Wasko & Faraj, 2000).

Research has also found that individuals are motivated by collective interest, which includes “care” (von Krogh, 1998), prosocial behaviors (e.g., “the right thing to do”) and an interest in advancing the collective (Wasko & Faraj, 2000). In the context of networks of practice, then we would argue that individuals make their own decisions as to with whom they would like to interact and share knowledge (and thus in which network of practice to participate) based on the potential returns from these actions to themselves and/or to the network. Thus, individuals may expect that participation in a certain network may result in certain outcomes. While several studies have investigated individual interests in terms of the antecedents to choices to participate within a particular network of practice, (e.g., Lakhani & von Hippel, 2000; Wasko & Faraj, 2000), researchers

⁵² These authors propose a psychosocial filter involving social confidence, perceived credibility, and perceived trustworthiness as a means of understanding the antecedents to these decisions.

have paid scant attention to the relationship between an individual's participation and knowledge sharing in a particular network and individual outcomes such as individual performance. Thus, additional questions to ask are "In which networks do individuals participate and share their knowledge?" and "Does the level of participation in various networks of practice result in different outcomes?"

Tying this back to our above discussion regarding performance, we may then fill these research gaps by specifically focusing on the individual and the relationship between the degree of participation in various networks of practice and his or her individual performance. Thus, our second research purpose becomes the following:

Research Purpose 2: To investigate the relationship between individual participation in various types of networks of practice and individual performance.

In order to fulfill this research purpose, we conduct several studies in which we develop a set of hypotheses relating the participation and knowledge sharing of individuals in various networks of practice and implications for individual performance. Since the focus of this thesis is on networks of practice that are related to work practice within and across business firms, we turn to the knowledge-based view of the firm literature to further help develop our hypotheses⁵³.

The knowledge-based view of the firm (KBV) has developed in response to recent advances in strategic management thought that suggest that knowledge is the most strategically significant resource of the firm (Grant, 1996a,b) and that sustained competitive advantage and superior corporate performance are determined by heterogeneous knowledge bases and capabilities among firms (Eisenhardt & Santos, 2002). Interestingly and not too surprisingly, KBV researchers have yet to reach a consensus in several areas. For example, on the one hand, several proponents such as Grant (1996a,b) view knowledge as a resource while others such as Spender (1996) argue that the firm should be seen as a system of knowing activity rather than a system of applied knowledge bundles that can be moved around the organization (Eisenhardt & Santos, 2002). To date,

⁵³ For a review and discussion of the knowledge-based view of the firm, see Eisenhardt & Santos (2002) or Kaplan, Schenkel, von Krogh, & Weber (2002).

empirical research on the knowledge-based view tends to fall under the former perspective with research focusing on four categories of specific knowledge processes: knowledge sourcing, internal knowledge transfer, external knowledge transfer, and knowledge integration (ibid). The fourth category, knowledge integration, stems from Grant (1996a) who argues that the firm's primary task is to integrate the specialized knowledge of its members⁵⁴ and that competitive advantage results from how effective firms are in performing knowledge integration. As such, much of the research on knowledge integration takes a micro view of interaction, primarily within organizations, and focuses on investigating how the specialized knowledge of individuals is integrated in firms. For example, Eisenhardt (1989b) conducted an inductive study of how top management teams in the computer industry integrated their different functional and personal perspectives to achieve strategic decisions.

Since we also take a micro view of knowledge processes in this thesis, it follows then that we use this lens of knowledge integration in our empirical studies. In his knowledge integration argument, Grant (1996a) posits that the effectiveness of knowledge integration depends upon the efficiency, the scope, and the flexibility of knowledge integration. Efficiency refers to how well the specialized knowledge of a firm's individuals is integrated and is dependent on a common language of discourse developed through frequent interactions between individuals such as that which occurs in communities of practice. The scope of knowledge integration refers to the different types of specialized knowledge being integrated – the more complex the scope, the greater the difficulty for competitors to replicate. Flexibility of integration reflects extending existing capabilities through boundary spanning activities in order to access and reconfigure additional knowledge through both internal and external integration. Sustaining a competitive advantage requires flexibility and the creation of new capabilities by bringing in new knowledge and reconfiguring existing knowledge. Intra-organizational networks of practice promote the internal flexible integration of knowledge across a firm's internal boundaries while

⁵⁴ This is, of course, consistent with other established theories of the firm. Barnard (1938) spoke in terms of conscious, deliberate, and purposeful cooperative action between individuals as the reason for the existence of the firm. He further argued that organizations are cooperative systems that serve to integrate the contributions of individuals. Transaction Cost Economics would also argue that cooperative action can be achieved most efficiently within the firm when the complexities of specifying the contracts between the cooperating parties become too great.

inter-organizational networks of practice provide the means to access knowledge outside of the firm's boundaries in order to enhance external integrative flexibility.

However, this theory of knowledge integration represents a paradox: a focus on the efficiency of integration may hinder flexibility and the ability to create new knowledge and innovations. For example, although it has become widely recognized that participation in communities of practice supports efficient knowledge exchange, learning and incremental innovation, tightly knit communities of practice may lead to the "not invented here" syndrome or the resistance to new ideas not locally developed. In addition, the knowledge in a tightly knit community of practice may be largely redundant. For example, Granovetter (1973, 1983) argues that closely-knit clusters in which individuals are well-acquainted and interact often are characterized by knowledge that is redundant. Knowledge is likely to be quickly shared and commonly known, thus individuals receiving knowledge from someone within the cluster may well already have received this knowledge from someone else. However, weak ties, i.e., characterized by a relatively low involvement of time, emotional intensity, intimacy, and reciprocity, are instrumental to the diffusion of new knowledge. Weak ties provide access to knowledge from people who travel in different circles or engage in different activities. The knowledge they carry is more likely to be novel and not otherwise available. Thus, community of practice interactions may provide little additional knowledge over what an individual may already know, thus impeding the ability to develop new and creative ideas (Granovetter, 1973, 1983). As a result, communities of practice may evolve into core rigidities and competency traps – inappropriate knowledge sets that preserve the status quo and limit new insights, resulting in gaps between the knowledge of the firm and changing market conditions (Levitt & March, 1988; Leonard-Barton, 1992). However, following weak tie theory, knowledge available in distributed networks of practice is more likely to be less redundant due to the weaker nature of the ties in these networks and thus may facilitate flexible knowledge integration.

In addition, Grant's theory focuses primarily on issues of coordination, without referring to issues of "cooperation". This theory then leaves out a key component by assuming that people are willing to share knowledge openly and freely if provided with the structures and opportunities to

interact. However, as seen above, prior research suggests that individuals do not give away their help and advice to others for free (e.g., von Hippel, 1987; Schrader, 1991). Rather, they tend to participate in reciprocal behaviors involving the trading or exchange of knowledge. Furthermore, previous research on boundary spanning activities across a firm's legal boundaries has indicated that this reciprocal behavior may involve "leakage", or the flow of company proprietary knowledge across firm boundaries (Mansfield, 1985; Von Hippel, 1987; Schrader, 1991). Thus, participation in knowledge trading and the resulting potential for informal proprietary knowledge flows across an organization's legal boundaries are of particular strategic interest to management since such activity may impact a firm's competitive advantage. Yet, it is very difficult for firms to manage and evaluate the benefits since it occurs "off the books" with employees generally acting completely on their own with no managerial influence and no documentation of the trade (von Hippel & Schrader, 1996).

In summary, key strategic issues for organizations interested in successfully managing their knowledge resources involve understanding in which networks of practice individuals participate, whether internally or across a firm's legal boundaries and how they access knowledge within these different networks as well as how to balance efficient knowledge integration with demands for flexible integration. Investigating participation and knowledge sharing in various networks of practice should help shed some light on these issues. As a step in this direction and as stated above, our approach then is to bring the level of analysis down to the *individual* level as opposed to focusing on the *organizational level* by investigating the relationships between the participation and knowledge exchange of individuals in various networks of practice and individual performance. It is important to be clear here that our research focus is not on the antecedents of these choices, such as the how or why individuals make certain choices about participation. Rather our interest is focused on the relationship between an individual's participation in various networks of practice once the choice is made and individual performance. Thus, in addition to contributing to the literature on networks of practice by filling the research gap of the relationship between individual performance and network of practice participation, we also hope to contribute to the knowledge-based view of the firm.

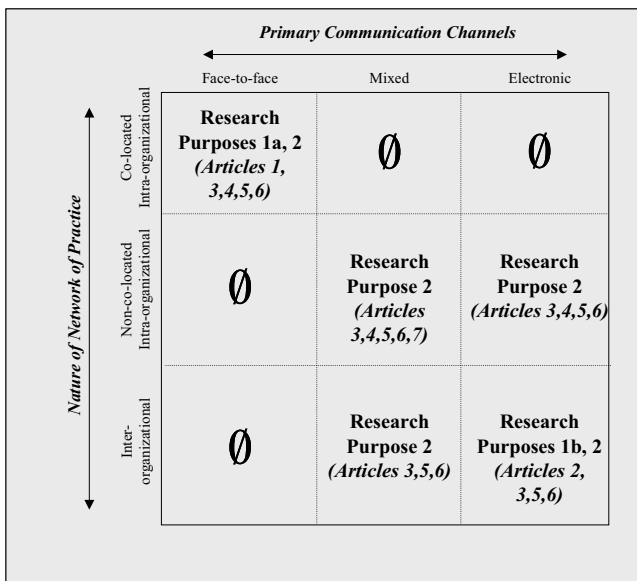
4.3 Summary of Research Purposes

In table 4.1 we present the two research purposes and how they correspond to the seven empirically based articles in Appendix Two. In addition, we present the research purposes and their corresponding articles in the matrix of networks of practice in order to show how they fit into the overall research on networks of practice (figure 4.1). In the next chapter, we will proceed to present the methods and empirical data collections used to fulfill our two research purposes.

Table 4.1 Overview of Research Purposes and Corresponding Articles

Research Purpose	Article
RP1a: To conceptually develop the structural properties of communities of practice and propose a series of relationships between community of practice structural properties and performance	Article 1
RP1b: To investigate the structural properties of an electronic network of practice through the application of theories of collective action and public goods	Article 2
RP2: To investigate the relationship between individual participation in various types of networks of practice and individual outcomes	Articles 3-7

Figure 4.1 Positioning of Research Purposes in Network of Practice Matrix



CHAPTER FIVE

Research Methodology

THIS CHAPTER PRESENTS the research methodology employed in the seven empirical studies. For the purposes of this thesis, we conducted a series of cross-sectional studies using a variety of techniques: surveys, interviews, text analysis, social network analysis, etc. All the studies presented here were conducted in field settings and the empirical basis of this thesis consists of four different research sites: an international contractor consortium in the construction industry in Scandinavia, two multinational consulting firms, and one inter-organizational electronic network of practice whose members are lawyers dispersed across the United States. In order to maximize the relevance of the studies and to enhance the external validity of the findings, research sites were chosen for two reasons: 1) an emphasis on knowledge work and 2) knowledge as the most valuable asset available to these individuals. As mentioned above, the work of the individuals in all of these studies primarily consists of processing, articulating, applying and disseminating knowledge (Wasko, 2001) as opposed to making tangible objects with their hands. Six of the articles presented here are primarily based on quantitative data collected in the form of surveys (from paper to web-based), and one is based on qualitative data gathered in semi-structured interviews. As mentioned, all the studies were conducted using a cross-sectional design. The group of quantitative studies will be discussed first followed by a description of the qualitative study. The chapter concludes with table 5.1 providing an overview of the various research sites and methods used.

5.1 Quantitative Studies

For each of the quantitative studies, an initial qualitative study was conducted that comprised a set of face-to-face interviews in order to

examine the concepts to be used prior to the construction of the survey instrument. In constructing the questionnaires, reviews of previous studies were conducted in order to find existing scales. Where possible, these scales were used or adapted to our purposes. As a result, the questionnaires were based upon a mixture of established scales from the literature and our own measures of constructs relevant for our purposes. Most questions had pre-defined response alternatives based on seven-point Likert scales. Where appropriate, the independent frequency variables were transformed to convert responses from an interval scale to a ratio scale. Moreover, background variables important for each study were collected, e.g., age and experience of respondents. Pilot tests of all instruments were conducted with modifications made to the surveys based on the results of the pilot tests. The format for each questionnaire was consistent across all participants within each study to reduce confounds due to the survey medium. Throughout the data collection processes, individuals were assured that their responses would be kept confidential and that all results would be presented only on an aggregate level. In one of the studies, there was an incentive provided for participation (the second Icon study, Article 6).

5.1.1 Internal Reliability and Validity

When using measuring instruments, there are two important questions to answer according to Kerlinger (1986): (1) what is the *reliability* of the measuring instrument and (2) what is the *validity* of the measuring instrument. Thus, a crucial step prior to testing any theoretical model is the assessment of the accuracy of the measurement model. The goals of assessing the accuracy of the measurement model are to demonstrate that the measures used are valid and that they adequately reflect the underlying theoretical constructs.

Internal Reliability. Research instruments that have a high degree of internal reliability consistently measure what they are intended to measure because they are dependable, stable, consistent, and predictable (Kerlinger, 1986). The degree of precision and the accuracy determine an instrument's reliability and a reliable one is minimally affected by random measurement error. Thus, if the instrument is repeated, it will yield similar results. When constructs are used, an assessment of reliability will indicate how accurate on average a construct created by adding items together will

measure the “true” score of a population⁵⁵. The internal consistency method is often used to determine the reliability of empirical measurements. Individual survey items that make up a theoretical construct are assessed for inter-item reliability, and this evaluation requires multiple items for each construct. In most cases, we used Cronbach’s coefficient Alpha to measure inter-item reliability. Acceptable values of Cronbach’s Alpha for perceptual measures should exceed 0.7 (Nunnally & Bernstein, 1994). Values less than 0.7 imply that the items underlying the construct may be unrelated, or may be measuring more than one construct. With the exception of the first exploratory study at Icon, the alphas (or their equivalent, internal composite reliability, ICR) were above 0.7.

Internal Validity. In addition to inter-item reliability, it is also necessary to assess that the items underlying constructs demonstrate internal validity. One method for assessing convergent and discriminant validity is factor analysis. Factor analysis can be used to determine whether items underlying a theoretical construct have a high degree of correlation among one another compared to their correlation with items underlying other constructs. However, scholars have cautioned the use of this method since naïve and simplistic interpretations of factor analyses may be misleading rather than validating (Carmines & Zeller, 1979). Taking these words into consideration, factor analysis was conducted where appropriate. Results of these analyses showed clean factor separation in most cases. In instances where items did not exhibit adequate loading, these items were dropped from the measurement model and the internal reliability was recalculated. Multi-item constructs were then calculated by taking the average of the items.

For each study below, the sites as well as the methods used are described. However, in order to avoid repetition with the studies, these are not described in great detail here, rather the reader is referred to the relevant study in Appendix Two.

⁵⁵ See Nunnally & Bernstein (1994) for a more elaborate and scholarly discussion of reliability assessment.

5.2 Research Methodology for Research Purpose 1

While the first overarching research purpose is to describe the structures of networks of practice through the application of social network analysis, this purpose is divided into two sub-purposes. Since these sub-purposes focus on two different networks of practice (a community of practice and an electronic network of practice), we collected two different sets of data.

5.2.1 Research Study at Sundlink AB - Article 1

To refresh our memory, Research Purpose 1a is the following:

Research Purpose 1a: To conceptually develop the structural properties of communities of practice and propose a series of relationships between community of practice structural properties and performance

This study is presented in Article 1 and uses data collected from Sundlink Contractors, an international contractor consortium that designed and constructed the Öresund Bridge, a five-mile multi-level bridge connecting Denmark and Sweden, during 1996-2000. The choice of this site presents an interesting opportunity to examine communities of practice based on two factors: a continuous stream of emergent problem situations and the ability to define joint enterprise. The continuous stream of emergent problem situations resulted due to the nature of the project: a highly complex infrastructure project of immense size, stringent quality requirements, well-defined completion time, and harsh environmental conditions.

In terms of defining joint enterprise, Sundlink Contractors utilized a formal quality system based upon ISO 9000, which articulated the work processes and procedures. It is within this quality system that we have defined the joint enterprise for communities of practice in this study (Schenkel, 2002). In particular, we look at the management of "deviations" or situations in which articulated procedures or processes are not followed or articulated objectives are not achieved. The management of deviations requires 1) the use of already existing work methods, 2) a change in existing work methods, or 3) the development of new technical solutions. Thus, examining deviations provides the context for exploring joint enterprise

(management of the deviation within the project), a shared repertoire (the common means/behavior in which the incidents are approached and managed), and mutual engagement (the collaboration of multiple individuals/groups of different and/or the same competencies).

Data were collected through a questionnaire administered during a nine-month period ending in May 1999 as part of a doctoral project (Schenkel, 2002). The data collection occurred mid-way through the project. This time point was chosen in view of evidence that communities of practice do not form at once, but more gradually, based upon recurrent events (Wenger, 1998). Earlier data collection might have preceded the formation of communities of practice. Two types of data were collected: 1) communication patterns in managing deviations, e.g., whom the respondent contacted both within and outside the organization for advice in situations which deviated from prescribed ISO 9000 standards, and 2) socio-demographic information such as age, education, and experience data - all potential factors that can influence the formation and maintenance of communities of practice. The population was delimited by choosing those who were not construction workers, i.e., those who had a managerial or support function. These individuals were excluded from this study in view of their limited role in the actual management of deviation. In total, 137 people of both an operational as well as support character were included in the population and 120 people responded to the questionnaire, resulting in an 87.6% response rate.

For the purposes of this article, we perform three separate analyses to determine to what degree the unit of analysis fulfills the structural properties of a community of practice to illustrate the structural properties of communities of practice. The three units of analysis are 1) the overall project based on relationships between individual project members regardless of department membership, 2) each department based on relationships between the department's individual members, and 3) the overall project based on the aggregated individual relationships between departments. We analyzed the data using SPSS and the UCINET network analysis software package (Borgatti, Everett, & Freeman, 1999) and importing it into Krackplot (Krackhardt, Blythe, & McGrath, 1994), a program used for the graphical analysis of networks.

5.2.2 *Research Study of a US Professional Legal Association - Article 2*

Research Purpose 1b is the following:

Research Purpose 1b: To investigate the structural properties of an electronic network of practice through the application of theories of collective action and public goods.

This study is found in Article 2 and data were collected from a single inter-organizational network of practice of lawyers in a US professional legal association. All association members have access to an electronic network of practice as part of their membership benefits, yet participation is voluntary. This electronic network of practice is supported by “bulletin board” technology, similar to that of Usenet newsgroups where questions and responses are connected in a “thread”, resembling a conversation. During the two months of April and May 2001, there were 2,460 messages posted to the network by 526 unique individuals. (The name of the person posting was included in each message.) Individuals were then chosen to take part in this study based on their electronic network of practice participation, which consisted of posting a message to the network during the two months under investigation. Each participant was then sent an MS Word questionnaire distributed as an email attachment, and 152 valid responses were received for a response rate of 29%. These data were collected as part of a doctoral project (Wasko, 2002).

For this article, we examined all bulletin board messages to determine the identity of the person posting, and the messages were then coded as seeds (the first message in a thread), singletons (seeds without responses), questions, responses, or other. We then built a social network matrix consisting of all 526 participants to determine who was responding to whom, creating a directional, social tie. Building upon Wenger’s categories and based upon the analysis of messages, we created four categories of participants: outsiders (people who posted seeds, but never received a response), seekers (people who posted only questions), periphery (people who posted 10 or less responses) and insiders (people who posted more than 10 responses). Using UCINET software (Borgatti et al., 1999), we analyzed the ego network of each individual to determine centrality in terms of “in degree”, i.e., the number of times other people respond to an individual, and “out degree”, i.e., the number of times an

individual responds to others. Similar to the previous study, we imported the data into Krackplot (Krackhardt et al., 1994) to create a graphical illustration of the network. We then used both the objectively collected message postings as well as survey results to perform our analysis.

5.3 Research Methodology for Research Purpose 2

Restating Research Purpose 2, it is to investigate the relationship between individual participation in various types of networks of practice and individual performance. The five articles, Articles Three to Seven, that address this research purpose resulted from research conducted at two multinational consulting firms, Icon Medialab and Cap Gemini, and three high-technology multinationals: Hewlett-Packard plus two others who wish to remain anonymous. Data were specifically collected for the purposes of this thesis. Before presenting a description of the different research sites and methods, we discuss two methodological issues common to all the articles: operationalization of network of practice participation and measurement of individual performance.

Operationalization of Network of Practice Participation. First, in terms of operationalization, few researchers have attempted to understand the relationship between networks of practice and performance. This is understandable because networks of practice are – by definition extremely hard to pin down. Any individual can potentially be involved in numerous networks of practice, varying from one's immediate workgroup to a set of internet contacts on the other side of the world. Moreover, the process of defining the membership of networks of practice apparently takes away their very essence because they thrive on their emergent nature. Bearing this in mind, it is not surprising that the vast majority of studies specifically focused on networks of practice are ethnographies and qualitative studies rather than quantitative studies using survey instruments. Thus, there are significant methodological challenges in studying communities of practice. The primary concern is that the concept is typically defined in such a way that all emergent interactions, inside or outside the firm, could represent participation in networks of practice. If this broad definition is accepted, then the concept becomes very difficult to research in a rigorous manner because nothing can be excluded. The theory, in other words, cannot be falsified.

However, the approach in these articles is to bring the network of practice thinking down to the level of the individual. Rather than attempt to define the various networks of practice within and across the firm's boundaries, the logic here is that individuals are able to draw from their networks of practice to solve problems they encounter in the course of their work, and that they also contribute back to these networks of practice in a reciprocal manner. By examining the ways in which an individual acquires knowledge to address work-related problems, we will see that some knowledge is gained through access to "codified" sources such as internet websites or company databases, but most is gained through interaction with other people in the firm and outside. The premise, in other words, is that the frequency and quality of the interaction an individual has with specific groups of individuals is a manifestation of the networks of practice in which he or she participates. And the extent to which an individual actively participates in the various networks of practice will *ceteris paribus* be associated with an individual's performance at work. Thus, by measuring the patterns of interaction and knowledge exchange of the individual with various networks of practice and through various media, we argue that we can predict to some degree his or her performance. Thus, while two levels of analysis are of interest in these studies: the individual and the network of practice, the primary unit of analysis, the individual, is appropriately based on the theoretical development of the variables and the proposed causal relationships (Klein, Dansereau, & Hall, 1994).

Measuring interaction between individuals is a multidimensional phenomenon that can be conceptualized and measured across a number of attributes, such as frequency, mode, openness, density, directionality, and so on (Allen, 1977; Tushman, 1977; Jablin, 1979; Gupta & Govindarajan, 1991). In the studies conducted as part of this thesis, we operationalize and measure interaction and knowledge exchange in various types of networks of practice primarily in terms of frequency, with the exception of the second Icon study (Article 6) in which we also capture directionality. However, while we do recognize that this particular operationalization does not adequately capture either the content or the quality of the interaction and knowledge exchange, the notion of frequency of interaction as an indicator of the intensity of the tie between two persons has a long academic tradition (cf. Homans, 1950; Granovetter, 1973), and influential empirical literature (e.g., Allen, 1977; Tushman, 1977) has made effective use of the frequency measure in different settings (Ghoshal, Korine, &

Szulanski, 1994). We follow these studies as well as more recent ones (e.g., Ghoshal et al., 1994) and adopt frequency as our measure of an individual's interaction with other network of practice members. However, in so doing, we acknowledge that we limit ourselves in terms of both the theoretical and normative implications of our findings.

Measurement of Individual Performance. Regarding the second methodological issue, as mentioned above, individual performance is “the most widely studied criterion variable in the organizational behavior and human resource management literatures” (Bommer, Johnson, Rich, Podsakoff, & MacKenzie, 1995: 587). However, measuring performance has proven to be a difficult task. The search for truly reliable, uncontaminated, objective indicators of individual accomplishments within organizations has proven unsuccessful (Campbell et al., 1992), thus, researchers continue to debate the best means by which to measure performance.

Current measurement approaches within organizational behavior and human resource management literature include subjective measures (e.g., self, peer, and supervisor ratings) and “objective” measures that are based on direct measures of countable behaviors or outcomes (e.g., total sales volumes or sales commissions for salespeople). Research has provided evidence that subjective and objective measures are not interchangeable since even the “best” subjective ratings have been found to correlate only to a low degree with “objective” measures (Bommer et al., 1995; Rich, Bommer, MacKenzie, Podsakoff, & Johnson, 1999). Furthermore, in this research, since we have defined individual performance as an individual's actions and not the concrete outcomes of an individual's actions, we are primarily interested in subjective measures. However, researchers are more or less in agreement that perfectly reliable and valid third party performance ratings are unattainable since they are subject to a variety of biases, such as external conditions, the experience of the rater with the job being evaluated, or the ability of the rater to observe the ratee (Borman, 1978; Weekley & Gier, 1989). Studies have shown that the correlations between the various subjective measures tend to be less than “perfect” (see Bommer et al. (1995) and Harris & Schaubroeck (1988) for a discussion). For example, in one meta-analysis, Harris & Schaubroeck (1988) found a correlation of .35 between self-ratings and supervisor ratings.

As for performance measured by self-ratings, a number of previous studies on managers and professionals have found self-reporting measures to be superior to third party measurements (e.g., Heneman, 1974; Wexley, Alexander, Greenawalt, & Couch, 1980). For example, Heneman (1974) found self-rating measures to have less leniency, restriction of range, and halo error than ratings by superiors. Furthermore, a review of the literature on self-rated performance found strong support for their use (Busch & Bush, 1974). However, other researchers argue that self-rated measures are inflated due to egocentric bias (Churchill, Ford, Hartley, & Walker, 1985; Harris & Schaubroeck, 1988). Thus, in summary, there exists no one "best" measure of individual performance.

In each of our studies, we discussed with management which performance measures were possible to collect. In our first study (Article 3-Icon Study 1), we were able to collect both self-reported ratings as well as ratings by the respondents' immediate supervisor. To establish the extent of inter-rater reliability, i.e., the level of agreement on performance between the individual and his/her immediate superior, we used Cohen's Kappa, one of the most widely used measures of inter-rater reliability, which is calculated as follows (see Perreault & Leigh, 1989).

$$K = (F_0 - F_c) / (N - F_c)$$

In this equation, N is the total number of judgments made by each judge, F_0 is the number of judgments on which the judges agree, and F_c is the number of judgments for which agreement is expected by chance. We assumed that if the individual and his/her boss rated performance to within one point they agreed (e.g., one person circles 2, the other circles 3), which means that F_c , the number of agreements by chance, is 38%. On this basis the Cohen's Kappa scores for the two measures of performance examined were 0.55 and 0.63 respectively. Following this analysis, we interviewed a number of individuals about the performance measures. It became clear that in many cases (especially administration and sales), the level of supervision was rather low, and as a result the supervisor or project manager in question was typically not well informed about the individual's performance. However, our results seem to indicate a higher correlation than that generally found in organizations. As discussed above, a meta-analysis across a number of professions found only a moderate correlation of .35 between self and supervisor ratings. The self-supervisor rating

correlation for professional/managerial jobs has been found to be even lower than for that in blue collar/service jobs. One explanation for this lower correlation is that professional/managerial jobs can be argued to be more ambiguous than well-defined blue collar/service jobs (Harris & Schaubroeck, 1988). Thus, since the jobs at Icon fall into the category of professional/managerial jobs, it could be argued that supervisors and individuals at Icon agreed on individual performance to a relatively higher degree. Furthermore, at Cap Gemini, through discussions with management, it became apparent that supervisor ratings or peer ratings would be difficult to obtain due to internal policy. Accordingly, we opted to measure individual performance via self-reporting measures in our studies both at Icon (Articles 3 and 6) and at Cap Gemini (Articles 4 and 5). This choice also facilitated our ability to make comparisons across the studies. Having discussed some of the methodological challenges present in Research Purpose 2, we now turn to the description of the research sites and methods for the respective articles. We begin with Cap Gemini.

5.3.1 Research Studies at Cap Gemini – Articles 4 and 5

The research for Articles 4 and 5 was undertaken in the Nordic operations (Denmark, Finland, Norway, and Sweden) of Cap Gemini and was performed prior to the merger of Cap Gemini and Ernst & Young Consulting. As a result, the company description considers only the Cap Gemini organization. At the time, Cap Gemini was Europe's largest IT services and management consulting company with more than 40 offices and 4,500 employees in the Nordic region alone.

Within the Nordic region, Cap Gemini had numerous networks designed to enhance the company's knowledge management activities. We chose participants in one electronic network of practice, the NCN MS, because it was recognized as a successful, vital conduit of knowledge exchange. This electronic network had 345 members spread across the Nordic countries and the members of this network all worked with applying Microsoft products in their responsibilities with Cap Gemini. This particular population was chosen for the study to ensure that research subjects had access to internal and external sources of information and know-how and had familiarity with using communication technologies that supported information and know-how exchange in electronic networks. In addition, the job responsibilities of the members of the NCN MS electronic network

required a considerable amount of creativity as new problem situations constantly arose due to the rapid pace of change in information technology as well as the diversity among client project demands. This helped ensure that the population chosen for this study had to balance both general job performance and demands for creativity.

Data collection was conducted as an email attachment during January 2000. Previous research has suggested that electronic surveys using scale-type questions are no less valid than paper surveys (Liefeld, 1988). It has also been found that some subjects prefer electronic surveys to paper (Newsted, 1985), and that email responses may even be more valid (Kiesler & Sproull, 1986). We received a total of 83 usable survey responses from the 345 participants with valid email addresses for a response rate of 24%. This “low” response rate could be argued to be higher since research has shown that mailing lists contain a very high percentage of individuals who are members of the electronic network of practice but do not participate (Nonnecke & Preece, 2000). In Article 4, we use correlation analysis to investigate our research questions. In Article 5, we test hypotheses using partial least squares (PLS), and perform two separate analyses independently for each dependent variable (creativity and general performance).

5.3.2 Research Study at Icon Medialab – Articles 3 and 6

The choice of Icon Medialab (Icon) as the second site was motivated due to several reasons. First, in order to conduct a study of individuals’ participation in various networks of practice, including the recently emerging electronic networks of practice, it was necessary to find a firm where a large proportion of the employees were working on a day-to-day basis with the latest internet communication technology. Icon is an internet consulting firm, and as such employees in all functions are not only extremely adept at using new internet-based communication media such as bulletin boards, chatrooms, email, etc. but they also use these to a high degree in their everyday work. A second reason for choosing Icon is that, at the time of this study, it was a medium-sized multinational with offices in several countries and as such had emergent intra-organizational networks of practice. A third reason is that the company encompasses a wide variety of functional competencies, e.g., system architecture, programming, management consulting, art direction, project management, human

computer interface, etc, thus providing the possibility to both compare across functional competencies as well as generalize across these functions.

It should be noted that Icon's largest office was based in Stockholm during the time of the data collection. This was not only convenient, but Stockholm is also quite an opportune location for studying such a firm because Sweden is at the forefront of digital communications technology. The country has one of the highest penetration rates in the world of mobile telephones and internet subscriptions per capita, and Stockholm is a recognized high-technology "cluster". Icon was one of many start-up Internet firms in the area (founded 1996), and it was selected as one of the world's best 350 small companies in 1998 by Forbes (Forbes, 1998). Additionally, Icon is one of the few internet consulting firms established under the IT boom that is still in existence today.

We conducted research at Icon Medialab at two different times since it is the basis of two different studies. The first study took place in the fall of 1998 when the firm comprised 242 employees, and the second study occurred in 2001 when the firm employed 1698 individuals. As evidenced by the difference in the number of employees, Icon experienced an extremely high growth rate during the years between the two studies. Growth in the firm during these years was through greenfield operations as well as acquisition and mergers.

Icon Medialab was founded in March 1996 in response to the rapid growth of the internet. The company's mission is to facilitate the creation of competitive advantage for its customers through the incorporation of the internet in customer operations. Products and services include internet websites, intranets, extranets, and e-commerce solutions. Icon Medialab's clients ranged from the Swedish Postal Service and Compaq to British Petroleum and Volkswagen. By 2001, the company had offices in Europe, the United States, and Asia. At the time of the first study, the company had 242 employees with 46% of these in Sweden. The remaining employees were spread throughout offices of 10-25 employees in Spain, USA, Finland, Denmark, Germany, Belgium, England, and USA. During the second study, the company had 1698 employees in 28 offices across Asia, the US, and Europe.

A strategy of rapid global growth was developed by the founders at the company's inception. One of the means by which Icon hoped to achieve profitable growth was through the reuse of knowledge developed throughout its different projects. In fact, management set a target that more than 50% of all projects should include already proven successful products or services. Thus, Icon Medialab invested heavily in building its structural capital, with the key objectives being to transfer and reuse knowledge complemented with follow-up and reporting.

In addition, Icon Medialab is unique in its representation of a mixture of competencies under the same organizational umbrella. These disciplines include Technology, Design, Usability Engineering, Statistics and Analysis, Media and Entertainment, and Business Strategy, representing the six sides of the "Icon Cube". Thus, Icon Medialab brings together art directors, behavioral scientists, copywriters, journalists, scriptwriters, animators, TV-producers, software programmers, management consultants and web designers, with accounting, personnel, and administration completing the organization.

5.3.2.1 First Icon Study – Article 3

For the first study, we conducted two phases of data collection and analysis. The first phase was conducted in the Stockholm office, in which thirty in-depth field interviews at different levels of the company were held from May 1998 to June 1998. Extensive written material was also collected from the company. The second phase of the data collection during the fall of 1998 involved a postal questionnaire sent to all 242 employees of Icon Medialab at their local offices. Of the 242 questionnaires, 203 usable questionnaires were collected, an 84% response rate. In addition to these individual questionnaires, each of the managing directors of the eight subsidiaries and seven managers at the Stockholm office were asked to complete a questionnaire relating to the performance of the individuals at their office.

We then tested the propositions developed in Article 3 through a series of stepwise regression models. We chose the stepwise approach primarily because of the small sample size and the relatively large number of independent variables. Also, the exploratory nature of the study makes it

appropriate to work with a rather larger number of independent variables than would normally be the case.

5.3.2.2 *Second Icon Study – Article 6*

In order to further address Research Purpose 2, one firm in which we could conduct a social network study designed to investigate the patterns of interactions and participation in networks of practice by all individuals within the firm had to be found. This decision to investigate only one firm is in line with the social network field since the investigation of only one firm is common in network studies (see Marsden, 1990; Hansen, 1996).

In order to conduct social network analysis, a response rate of at least 80% of the individuals in the entire network is required since holes in the network caused by non-respondents can easily distort the results. Additionally, social network data tend to be more challenging to collect than ordinary survey data. It is difficult for social network surveys to be anonymous since the method generally requires identification of each individual. This often presents problems since it is quite common that individuals feel that this type of survey is a breach of their privacy, posing questions about an individual's personal connections such as "With whom do you eat lunch?" Thus, it is not surprising that the majority of sociocentric network studies on individuals tend to be at smaller organizations or within organizational divisions or use some form of publicly available data.

As a result, we needed to find one firm where a high level of access and support could be provided by the company's management. Through the first study at Icon, a good rapport was developed with the company's management, and after consultation with senior management, we were provided access for this study. Since this study is one of the few of its kind, a lengthier description of the data collection is included here.

Although the first study at Icon had been conducted three years prior, it was necessary to conduct a new set of interviews since the focus of the second study included the social network component. Thirty-five interviews were conducted throughout the firm to gain an understanding of the various networks of practice within the firm as well as the different inter-organizational ones in which Icon individuals participated. We

created the survey in English since this is the official company language and designed it as a web-based questionnaire for all employees of Icon Medialab at their local offices. It is important to note here that all employees have access to their own computer and the internet since the majority of the work of all employees across task groups and hierarchical levels is performed using the computer. In addition, management placed few constraints on employees regarding the internal or external use of any form of computer-mediated or other communication channels.

We created this questionnaire in close cooperation with a programmer, a human computer interface specialist, and a project manager on site at Icon Medialab. In essence, the construction of this questionnaire was a mini-internet consulting project and was a large undertaking due to the creation and programming of a special section for the social network data collection. We placed the questionnaire on the company's intranet as well as linked it directly to the company's personnel roster for an up-to-date listing of all active, full-time employees across the company's 26 offices in 16 countries Australasia, Europe, Asia, and North America. Thus, when each individual was responding to the questionnaire, he or she could easily surf through the various offices and names to click on the appropriate individuals with whom he or she communicated on advice-related matters. In this manner, we could collect data on an individual's participation in the various networks of the entire multinational.

We placed a hyperlink to the survey at the top of the company's intranet homepage so that individuals could easily find the survey. In addition, there were hyperlinks to the survey within the introductory email as well as within all reminder emails. Due to the length of the survey, we designed the survey so that when the individual moved from one section to the next, answers were automatically saved in the survey database. In this manner, an individual could leave the survey and return at any time through the intranet link to find his or her previously entered answers. After pilot testing the survey with 15 people in 15 offices, we made several changes to avoid misinterpretations of the questions as well as to remove several technical bugs in the survey that were generally caused by different operating environments. For example, we found that the survey worked very well using Microsoft's Internet Explorer on PCs but not on Macs.

Because our research required the complete network, we had to specify a boundary around it. We used the membership criterion (Marsden, 1990; Wasserman & Faust, 1994:31), thus we included those individuals who were formally employed and active in the organization. Individuals who were currently on leave of absence, working only part-time, or were independent consultants working for the company were eliminated from the respondent pool since their networks would not be comparable to those employees who were actively working full-time for the organization. The resulting number of total potential respondents was 1698.

Since achieving an 80% response rate is difficult in any research situation, several measures were taken. First, all respondents were entered into a drawing for 14 prizes of approximately US \$1600 in total value. Second, several mailings were sent out by email to each individual, including 1) an initial request by email for participation from the CEO of the appropriate office, 2) a request from the researcher by email, 3) a personal follow-up by email two weeks after the first mailing, 4) and if necessary, a second and third personal follow-up by email three weeks after the first mailing. Third, we tried to be responsive to respondents throughout the course of data collection. Once a survey was published on the intranet, we actively monitored our email inbox throughout all waking hours due to the many different time zones represented by the company. Whenever a question or concern came in, we tried to immediately respond to the person sending the mail. In addition, by having our email placed on an individual office's mailing list, we were able to follow any discussions taking place electronically between the unit's employees. In this manner, we were able to immediately answer any questions as well as extinguish or at least dampen any fires that were raised around the survey. As a result, in the course of the project, we sent and received more than 5000 emails, with some of the ones received being of a rather scathing nature due to the sensitive nature of the social network questions. Finally, throughout the data collection process, individuals were assured that their responses would be kept confidential on a secure server at the company's third party intranet host and that results would only be presented in aggregate form.

We received 1439 completed surveys for a response rate of 84.7%, comfortably above the 80% cutoff level. To the best of our knowledge, a survey this comprehensive in global reach is the first of its kind – an intranet-based sociocentric (i.e., network questionnaire administered to all

employees within one organization across the globe). To have performed this survey prior to the advent of internet-based communication would have virtually been impossible. The survey would have been at least 50 pages thick due to the names of all the employees, quite a daunting document to ask people to complete, not to mention the resources that would be needed to spend on both administering the survey around the world and inputting the endless questionnaire and network data into a database.

To analyze this large amount of data collected, we used UCINET software (Borgatti et al., 1999) to create social network measures for each of the individuals. What we thought would be a relatively easy task turned into one that took several months just to get to the point where we could begin analyzing the data. Due to the demands of social network analysis and our research model, we had to ensure that the database only included active, full-time employees. While the database was based on the company's employee roster, we discovered that this list also included the names of individuals who were on leave of absence, worked part-time, or for some other reason were not appropriate for the survey. Thus, the first task was to remove approximately 300 individuals from the database. The next step was to ensure that we had the correct background data for each of the remaining 1698 employees, e.g., hierarchical position, functional competence, etc., and that the information for each of the categories was consistent across the population. While we had programmed the survey to automatically retrieve the individual's title and competence data from the company's intranet, we soon learned that these data were not to be completely trusted. A quick inventory revealed that there were more than 1100 different titles at Icon, and while even though two titles may have been the same across units, the actual task activities of the individuals could still differ across units. Thus, our next task was to return to the organizational data collected from each individual office as well as search the company's intranet and research each and every one of the 1698 individuals in order to determine the correct background data for each one. When these data were finally updated, we created social network measures for each individual before importing them into the questionnaire database. We then analyzed the data through structural equation modeling using the EQS 5.7 software.

5.3.3 *Research at Three High Technology Firms – Article 7*

Since the purpose of this final study strays from the previous four articles and is to explore knowledge dissemination in networks of practice in a multinational setting, we decided to focus on a limited number of MNCs. We based the selection criteria on a number of factors: 1) annual sales greater than USD 15 billion, 2) large, globally dispersed R&D operations, and 3) operating in the high-technology electronics sector. We chose three companies: Hewlett Packard (HP), one other US-based company (A), and one Swedish-based company (B). The latter two are disguised, according to the wishes of the companies.

While explicitly conducted for this thesis, this study diverts from the previous studies and adopts a case research approach to the empirical investigation because of the importance of studying knowledge flow processes in their real-life context (Yin, 1989). This approach is particularly important given our emphasis on studying what *actual* mechanisms are being employed for knowledge dissemination, rather than the mechanisms intended for knowledge dissemination by top management. A secondary reason for choosing a case study approach is that we felt the existing body of literature did not adequately describe the phenomenon under investigation. As stated by Eisenhardt (1989a:548), “There are times when little is known about a phenomenon, current perspectives seem inadequate because they have little empirical substantiation, or they conflict with each other or common sense.....In these situations, theory building from case study research is particularly appropriate.”

At each of these three companies, we conducted ten to twenty-five in-depth field interviews from June 1997 to February 1998 for a total of fifty-five interviews. People at different levels of the company: corporate R&D manager, laboratory manager, project manager, and researcher, were interviewed for one-and-a-half to two hours each. We took several steps to increase the reliability and validity of the results. For example, two interviewers were present at all the interviews that were based on a semi-structured interview guide. Also, each interview was taped and transcribed by one of the interviewers. Immediately following each interview, interviewers discussed individual impressions and differences were resolved. Some written material was also collected from the companies. The data analysis then proceeded through several stages. First, the

interview data were reduced and classified before they were analyzed for commonalities based on knowledge dissemination.

5.4 Summary

As can be seen in table 5.1, the empirical studies involve a wide variety of data collection, and the methods used are quite varied. While all individuals involved in these studies can be defined as knowledge workers, they come from a wide range of occupations, e.g., programmers, lawyers, construction engineers, office administration, etc., and are located across the globe in numerous countries, e.g., the U.S., Singapore, France, Australia, etc. Thus, this approach of using multi-methods and multi-sites has substantial advantages since it allows for the development of a richer understanding of networks of practice and facilitates generalization. We provide an overview of the different research questions, sites, and methods in table 5.1.

Table 5.1 Overview of Research Sites and Methods

Art.	Purpose	Research Site	Methods
1	<i>RP 1a: To conceptually develop the structural properties of communities of practice and propose a series of relationships between community of practice structural properties and performance</i>	-Sundlink, international consortium led by Skanska AB -All individuals in four departments -Construction engineers	-Paper-based survey, n=120 (87.6%) -Social network analysis -Correlation analysis
2	<i>RP 1b: To investigate the structural properties of an electronic network of practice through the application of theories of collective action and public goods</i>	-US professional legal association -All members of association's electronic network of practice -Lawyers	-Bulletin board messages -MS Word survey as email attachment, n=152 (29%) -Text analysis -Social network analysis -Correlation analysis

3	<i>RP 2: To investigate the relationship between individual participation in various types of networks of practice and individual performance</i>	-Icon Medialab -All employees -Nine offices in eight European countries -Variety of professions: management, programming, art direction, etc.	-30 interviews -Paper-based survey, n=203 (84%) -Correlation analysis -Multivariate regression analysis
4	<i>RP2</i>	-Cap Gemini -40 offices in three Nordic countries -All 345 members of the NCN MS electronic network of practice -Programmers	-5 interviews -Html survey as email attachment, n=83 (24%) -Correlation analysis -Text analysis of open-ended survey questions
5	<i>RP2</i>	-Cap Gemini -40 offices in three Nordic countries -All 345 members of the NCN MS electronic network of practice -Programmers	-5 interviews -Html survey as email attachment, n=83 (24%) -Partial least squares analysis
6	<i>RP2</i>	-Icon Medialab -26 offices in 16 countries in Asia, Europe, Australasia, North America -All employees -Variety of professions: management, programming, art direction, etc.	-35 interviews -Internet-based survey, n=1439 (84.7%) -Social network analysis -Correlation analysis -Structural equation modeling
7	<i>RP2</i>	-R&D operations of three high technology multinationals (two European and one US) -Scientific researchers	-55 interviews -Text analysis

5.5 Generalizability

In any research study, the important question that must be asked is to what degree the results from the research can be generalized for a larger group of people than those who participated in the study. As mentioned, all respondents in the studies were conducting knowledge work in

organizations that were knowledge-intensive. In general, it is difficult to assess how representative the findings are for other organizations and networks of practice, especially those that are of a less knowledge-intensive nature. However, it is difficult to generalize the results for the studies that address Research Purpose 1. The study on the community of practice was conducted at only one site, the international construction consortium, and for the study of the electronic network of practice of US lawyers, examination is restricted to one type of electronic network of practice within one industry. However, participants in this study are from multiple organizations, helping to ensure generalizability to networks of practice that span organizational boundaries.

With regard to the studies at the individual level, the ability to generalize across knowledge-intensive organizations is supported to some extent since we find similar trends across the two different organizations studied despite one being a well-established, more conservative, and large multinational and the other a young, medium-sized multinational. In addition, the results from the extensive social network study at Icon are based on responses from employees in different age groups, of different gender, in different hierarchical positions, of different educational backgrounds, in different functional tasks, and from 16 countries across North America, Europe, Australasia, and Asia. Thus, the results can be seen as tentative indications of the relationships between participation in different networks of practice, centrality, and individual performance. Finally, the ability to generalize the results in the last article that was based on case studies is quite limited due to the more exploratory nature of the study.

In summary, although the focus was on individuals exchanging knowledge while conducting knowledge work, networks of practice within organizations as well as across them may have different membership and exchange dynamics. Thus, studies comparing various networks and their network dynamics both within and across firms as well as those publicly available on the internet are suggested.

CHAPTER SIX

Summaries of the Empirical Studies

THIS CHAPTER PROVIDES a summary for each of the seven empirically based articles presented in Appendix Two. For the studies and findings based on qualitative data, we will present a lengthier summary here. However, for those studies based on an analysis of quantitative data, we will present a brief summary of the results and leave the discussion for the next chapter, Discussion and Implications.

Article 1

Theorizing Structural Properties of Communities of Practice: A Social Network Approach

By A. Schenkel, R. Teigland, & S. P. Borgatti

Previous version presented at *Academy of Management*, 2001.

Article 2

The Provision of Online Public Goods: Examining Social Structure in a Network of Practice

By M.M. Wasko & R. Teigland

Nominated runner-up Best Paper ICIS 2002

Previous version published in *The Proceedings of the 23rd International Conference on Information Systems (ICIS)*, Barcelona, Spain, 2002.

Article 3

Communities of Practice in a High-Growth Internet Consultancy: Netovation vs. On-Time Performance

By R. Teigland

Versions published in three books:

In E. L. Lesser, M.A. Fontaine, & J.A. Slusher (eds.), *Knowledge and Communities*, Boston: Butterworth-Heinemann, 2000.

In J. Birkinshaw & P. Hagström (eds.), *The Flexible Firm*, London: Oxford University Press, 2000.

In F. Delmar & P. Davidsson (eds.), *Tillväxtföretagen (High-Growth Firms)*, Stockholm: SNS Förlag, 2001 (in Swedish).

Article 4

Extending Richness with Reach: Participation and Knowledge Exchange in Electronic Networks of Practice

By R. Teigland & M. M. Wasko

To be published in P. Hildreth & C. Kimble (eds.), *Knowledge Networks: Innovation Through Communities of Practice*, London: Idea Group Inc., 2004 (forthcoming).

Previous version published in W.J. Orlikowski, S. Ang, P. Weill, H.C. Krcmar, & J.I. DeGross (eds.), *The Proceedings of the 21st International Conference on Information Systems*, Brisbane, Australia, ICIS, 2000.

Article 5

Integrating Knowledge Through Information Trading: Examining the Impact of Boundary Spanning Communication on Individual Performance

By R. Teigland & M. M. Wasko

Version published in *Decision Sciences*, Special Issue on Knowledge Management, 2003 (forthcoming).

Article 6

Exploring the Relationships Between Network of Practice Participation, Centrality, and Individual Performance in a Multinational Organization

By R. Teigland

Previous version presented at *INSNA – International Network of Social Network Analysts Sunbelt Conference*, 2002.

Article 7

Knowledge Dissemination in Global R&D Operations: An Empirical Study of Multinationals in the High-Technology Industry

By R. Teigland, C.F. Fey, & J.M. Birkinshaw

Published in *Management International Review*, Special Issue on International Management of Technology, 2000, 1.

6.1 Article 1. Theorizing Structural Properties of Communities of Practice: A Social Network Approach

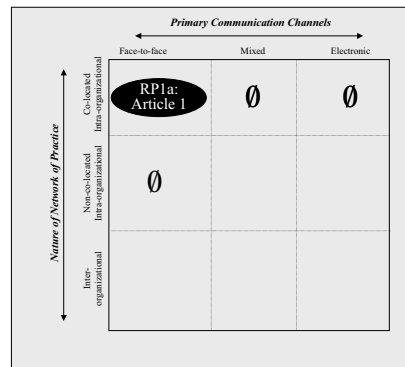
By A. Schenkel, R. Teigland, & S. P. Borgatti

Previous version presented at *Academy of Management*, 2001.

As revealed in the review of empirical studies, research on communities of practice is very biased towards ethnographic research investigating the cognitive aspects of communities of practice within co-located groups of individuals. This literature has concentrated on defining communities of practice, primarily focusing on how communities emerge and operate and often relying on anecdotal accounts as the

basis for theory development. Additionally, researchers have paid little attention to conceptualizing the *structural* properties of communities of practice or the relationship between communities of practice and organizational performance. These gaps in the research seem surprising because on the one hand, there is such a strong relationship between cognition and structure, and on the other hand, the emergent structure has been shown to play a strategic role in organizational outcomes. Thus, this article investigates Research Purpose 1a: to conceptualize the structural properties of a community of practice and propose a series of relationships between community of practice structural properties and performance. Figure 6.1 depicts the positioning of Article 1 within the network of practice matrix.

Figure 6.1 Positioning of Article 1



In this article, concepts are drawn from the social network literature and synthesized with the existing literature on communities of practice. Based upon this synthesis, we propose four structural properties for a community

of practice on the community level (connectedness, graph-theoretic distance, density, and core/periphery structure) and one structural property on the individual level (coreness). These structural properties are presented in table 6.1

1) *Connectedness*. Community of practice researchers see the primary requisite for the development of a community as the mutual engagement among individuals (e.g., Wenger, 1998). As the ethnographic studies have shown, community of practice members engage in a fluid stream of collaboration and narration, helping each other to perform their tasks. For example, Wenger's claims processors talked and interacted at their desks as they worked while Orr's technicians told war stories over breakfast. The result of this interaction is a complex network of social relations and interdependency. Thus, we argue that the extent to which individuals are connected via pair-wise interaction ties is an index of the extent to which they can potentially function as a community of practice. Individuals who are not interacting with others in a group cannot learn the community's practice and thus will not be identified as being members of the community. Therefore, a minimum structural characteristic of a community of practice is that every member has appropriate ties (e.g., advice-giving, trust, etc.) with some if not all other members of the community. In other words, all community members are directly or indirectly connected with each other and there are no isolates. In social network analysis, the maximal set of individuals who are directly or indirectly connected to each other in a network is called a *connected component* (Harary, 1969). Therefore, a community of practice is necessarily located wholly within a single connected component.

2) *Graph-theoretic Distance*. Another fundamental characteristic of communities of practice is the notion of shared repertoire of both a tacit and explicit means of communicating and working that includes language and unarticulated etiquette (Brown & Duguid, 1991; Wenger, 1998). Social network research has studied the diffusion of sharing of ideas and attitudes extensively (Friedkin, 1982; Burt, 1992; Rogers, 1995). A central tenet of this research is the notion that in both diffusion and influence processes, the graph-theoretic distance between nodes in a network dictates the extent to which they are expected to share ideas. The graph-theoretic distance between two nodes is defined as the number of links in the shortest path connecting them. Thus, the greater the graph-theoretic distances

between pairs of group members, the longer it takes for information to flow from one to the other, and the greater the likelihood that what is transmitted arrives too late, too distorted, or fails to arrive at all. Individuals separated by wide distances then tend to develop variations, e.g., in language, values, norms, etc., that are not shared, contrary to the notion of a single community of practice. Thus, we would expect that the average graph-theoretic distance between all pairs of members of a community of practice would be shorter than the average graph-theoretic distance between all pairs of individuals within organizational networks in general.

3) *Density*. Through mutual engagement and the associated cognitive processes, the practice of a community is disseminated and developed. Connectedness is a necessary prerequisite for this development but not sufficient in and of itself since a certain level of density is required. The density of a network measures the degree of cohesion in the group (Blau, 1977) and is defined as the total number of ties divided by the total number of possible ties in the network. A dense network consists of people who are for the most part directly connected to each other, rather than connected through intermediaries. Direct connections are far more powerful in terms of influence and transmitting tacit knowledge. Hence, through a dense network, a community's practice is more evenly disseminated. In social network terms, density is a function of the average number of contacts that each individual possesses, and it is the average number of ties per person divided by $N-1$, where N is the number of individuals in the network. A community of practice should exhibit a higher density than the organizational network in which it is embedded, which is discussed further in Structural Property 4.

4) *Core/periphery Structure*. Community of practice theory distinguishes between communities and constellations (Wenger, 1998). A constellation is a set of different communities of practice (possibly involving overlapping membership) that have different shared repertoires and different joint goals. Groups that have largely different memberships, interacting primarily within-group rather than with members of other groups, and developing separate sets of shared repertoire, can be seen as forming a single constellation, but not a single community of practice. Structurally then, it is obvious that communities of practice do not contain significant subgroupings since such subgroupings would constitute separate, although interlinked, communities of practice.

In social network theory, a network has a core/periphery structure to the extent that it contains no significant subgroups, factions, or cliques except the core itself (Borgatti & Everett, 1999; Everett & Borgatti, 1999). Stated in another way, a network has a core/periphery structure if it “can be partitioned into two sets: a core whose members are densely tied to each other, and a periphery whose members have more ties to core members than to each other” (Everett & Borgatti, 1999: 397.) Network researchers have developed statistical procedures for measuring the extent to which an observed network conforms to a core/periphery structure (Borgatti & Everett, 1999).

Core/periphery structures facilitate the diffusion of information and innovation because they do not contain significant clusters of nodes that are poorly connected to the rest of the network. Consequently, they can be expected to lead to a relatively homogeneous group culture (a shared repertoire) in which most individuals are exposed to new practices and ideas soon after they emerge. In contrast, networks that are divided into cliques or factions work against the establishment of a single community of practice. Different subgroups tend to develop their own norms, beliefs, and practices, which then effectively create separate communities of practice that are loosely connected to each other – i.e., constellations. This in turn implies that communities of practice have a *core/periphery* structure as is described in social network theory.

5) *Coreness*. As described above, Wenger (1998) distinguishes full participation in a community of practice from legitimate peripheral participation and marginal participation, and the distinction between the latter two depends on the legitimacy of the individual. This distinction is fundamentally cognitive rather than structural. Thus, in a network analysis of a set of relations at a single moment, it would be difficult to distinguish between legitimate peripheral participation and marginal participation. However, the difference between these and full participation can be detected by the coreness measures that are produced as a by-product of fitting the core/periphery model (Borgatti & Everett, 1999). Technically, coreness is defined as the principal eigenvector of the network matrix (Bonacich, 1972). In non-mathematical terms, coreness indicates the extent to which a node is located in the center or periphery of a group. Nodes with high coreness are well connected to both core and peripheral members while nodes with low coreness are connected mostly to core

members. Thus, this structural property mimics the position of new apprentices in a community, who initially are connected through a few experienced members who show them the ropes, and who gradually form ties with more and more people. Hence, coreness is the basis for our last structural property.

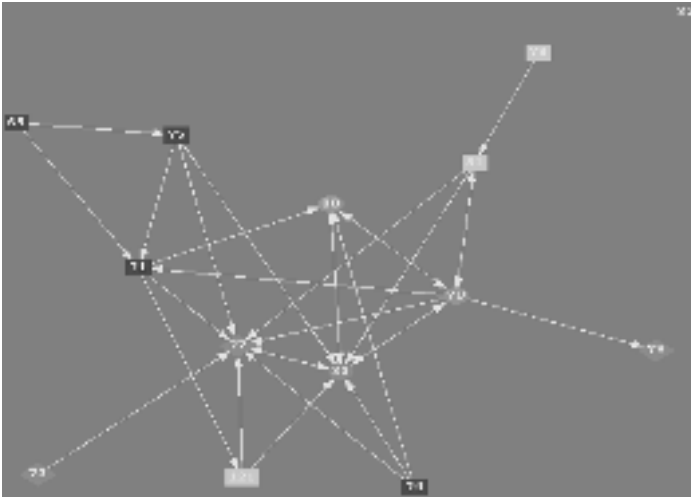
Table 6.1 Structural Properties of Communities of Practice

Structural Property	Description
1. <i>Connectedness</i>	In a community of practice, every member is connected, directly or indirectly, to every other member. That is, a community of practice is contained within a connected component.
2. <i>Graph-theoretic Distance</i>	Relative to organizational networks in general, communities of practice have shorter graph-theoretic distances between all pairs of members.
3. <i>Density</i>	Relative to organizational networks in general, communities of practice have a greater density of ties.
4. <i>Core/periphery Structure</i>	Communities of practice have core/periphery structures rather than clique structures.
5. <i>Coreness</i>	The greater an individual's participation in a community of practice, the greater is his or her coreness score.

To illustrate the structural properties of communities of practice, these properties were applied to the Sundlink bridge project. As described in Chapter Five, data were collected through a paper-based questionnaire. Based on our expectations, we found very weak support for considering the project as a whole to display the structural properties of a community of practice. While the project does fulfill the structural property of coreness, it fulfills the next three structural properties to a very low degree. In particular, there is little support in terms of density that the project network was a community of practice. This may be explained by the physical layout of the project: geographically separated sites and uneven resource allocation that meant that not all the people in the respective departments could interact on a face-to-face basis. This finding thus supports our argument that face-to-face interactions are important for the development of communities of practice and that communities of practice primarily develop within co-located groups of individuals.

We then applied the properties to the five individual departments within the project to determine to what degree these groups of co-located individuals displayed community of practice structural properties. Of the five departments within the project, only the Technical Department shows characteristics of a community of practice (figure 6.2). Despite including individuals with different operative backgrounds, a community of practice appears to have developed within this department during the course of the project. However, none of the other departments displays the structural properties of a community of practice. These findings suggest then that while the formal organization may impact the development of communities of practice, it does not necessarily coincide with them, thus also confirming previous community of practice research.

Figure 6.2 Technical Department



Note: Node shape indicates section membership.

A further analysis at the individual level reveals that coreness is *not* related to age, years of experience in the construction industry, or years of experience in similar duties elsewhere. However, it is significantly related to the number of years in the current position, the level of education, and time spent at the office vs. at the construction site. In addition, within one department, the Technical Department, we find that individual coreness is related to hierarchical position since most of the core individuals are section heads. These findings are all aspects that make sense within the community of practice literature. We would expect the relationship with

tenure in current position because the longer a person participates in a community of practice, the more opportunity there is for building relationships and moving from the periphery (where all newcomers begin) into the core. In terms of education, this may be partly due to management's preference for hiring more educated people for central positions, requiring a high degree of theoretical technical knowledge, but it also may be that more educated people were considered to be more knowledgeable than others and, therefore, more often approached for help. Finally, the negative relationship with time at the construction site also makes sense in light of the community of practice literature since physical proximity and thus face-to-face communication are argued to be important facilitators of mutual engagement.

In addition, we developed three propositions regarding the relationship between community of practice structural properties and performance. At the community level, we propose that knowledge sharing within the community of practice is contingent upon the density and size of the community and that the ability of the community to solve problems is contingent upon the complexity of the problem and the variance in the coreness among the members. Finally, at the individual level, we propose that individuals who have higher coreness scores have a higher degree of individual performance. Individuals with lower coreness scores have less opportunity to gain knowledge from others in the community, resulting in less community-specific knowledge and a more idiosyncratic practice. At the same time, their lack of connection with others makes them less influential and less able to shape the community's practice.

6.2 Article 2. The Provision of Online Public Goods: Examining Social Structure in an Electronic Network of Practice

By M.M. Wasko & R. Teigland

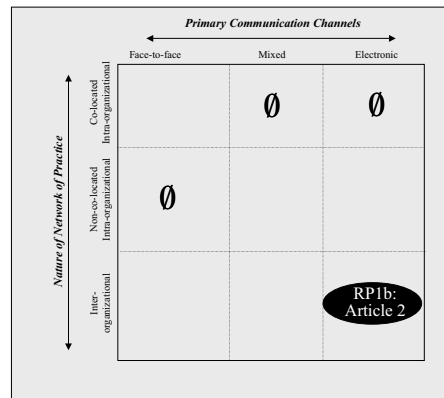
Nominated runner-up Best Paper at ICIS 2002

Previous version published in *The Proceedings of the 23rd International Conference on Information Systems (ICIS)*, Barcelona, Spain, ICIS, 2002.

Electronic networks of practice are similar to communities of practice in that they are a social space where individuals working on similar tasks self-organize to help each other and share perspectives about their occupational practice or common interest. However, unlike communities of practice and the other types of networks of practice where people know each other personally and form dyadic, interpersonal relationships, participants in electronic networks of practice are typically strangers,

individuals form weak ties with the entire network instead of with a select few, and interactions occur through text-based, often asynchronous, computer-mediated communication. More importantly, the differences between an electronic network of practice and the other types of networks of practice relate to the visibility of the interactions between members. In electronic networks of practice, such as those supported by listserv and bulletin board technologies, the ability to post messages is generally open to anyone and once posted, messages are visible to everyone participating in the network. Due to this open nature of this type of network of practice, some researchers have suggested that theories of collective action and

Figure 6.2 Positioning of Article 2



public goods be applied to further our understanding (Steinfield, 1992; Fulk et al., 1996; Kollock & Smith, 1996).

From the viewpoint of the thesis as a whole, this article contributes to our understanding of electronic networks of practice by investigating the structural properties of an electronic network of practice through the application of theories of collective action and public goods. Addressing Research Purpose 2, this article not only fills the gap relating to structural properties of networks of practice, but it also contributes to the body of empirical studies on electronic networks of practice. As we saw in the review of empirical studies on electronic networks of practice, there was a dearth of studies focusing on electronic networks of practice, be they inter-organizational or intra-organizational. Figure 6.3 depicts the positioning of Article 2 within the network of practice matrix.

In order to achieve this purpose, this article builds on the work conducted in Article 1 on structural properties of a community of practice. However, due to the distinct world of online interactions, we found that we had to adapt the structural properties created for communities of practice to electronic networks of practice. The social network measures developed for the community of practice study were partly based on identifying and measuring the *presence* of interaction between two individuals. However, since postings of messages are visible to everyone in an electronic network of practice based on listserv or bulletin board technologies, all members interact automatically with everyone else and are only “one click away” from each other. While variations may occur in electronic network of practice formats, knowledge is generally visible to all other members and is automatically shared with all others. As a result, the measures of connectedness, graph-theoretic distance, and density that were developed for communities of practice are not as relevant in an electronic network of practice setting since individuals are automatically interacting with all other members due to the nature of the electronic network of practice. A different approach is then needed in order to investigate the structural properties of an electronic network of practice.

Thus, heeding the call by previous researchers, we reviewed the literature on collective action and social dilemmas to facilitate the development of a series of structural properties specifically for electronic networks of practice. Through this process, we developed three research questions

relating to the structure and knowledge flows of an electronic network of practice (provided below). We examined these three questions through the analysis of an inter-organizational electronic network of practice of a US professional legal association. The shared practice of this network was US federal law, where participants (lawyers) actively engaged in exchanging legal advice in the electronic network of practice. We collected data through the use of a MS Word questionnaire distributed as an email attachment as well as the text analysis of 2460 messages posted to the network during a two-month period. We examined all electronic network of practice messages to determine the identity of the person posting, and we then coded each one as a seed (the first message in a thread), a singleton (seeds without responses), a question, a response, or other. We then built a social network matrix consisting of all 526 participants to determine who was responding to whom, creating a directed, social tie.

As described in Research Purpose 1b, this study focuses on the production of knowledge as a public good in electronic networks of practice. In the formal language of collective action theory, the network participants are the interest group and the public good is the continuous stream of knowledge produced and jointly held by the network's participants. We argue that the knowledge produced by the electronic network in this study is a public good since it exhibits the characteristic of non-rivalry and non-excludability. A brief summary of the results for each research question is presented.

RQ1. What is the pattern of contribution that produces and sustains the network of practice public good?

The first key issue for examination is the pattern of contributions that creates the public good. In electronic networks of practice, contribution is reflected in the posting of questions and replies that take the form of a conversation. This interaction creates social ties between participants. We define a social tie in an electronic network as the tie created between two individuals when one person responds to another's posting. While it has been argued that social ties are important for collective action, it is less well established as to exactly how and why social ties are important (Marwell & Oliver, 1988). Collective action theory provides three views regarding the pattern of contributions or social ties that is necessary to create the public good: a dense network consisting of direct ties between all

members (Marwell et al., 1988), dyadic reciprocal exchange (Kollock, 1999), and generalized exchange (Fulk et al., 1996).

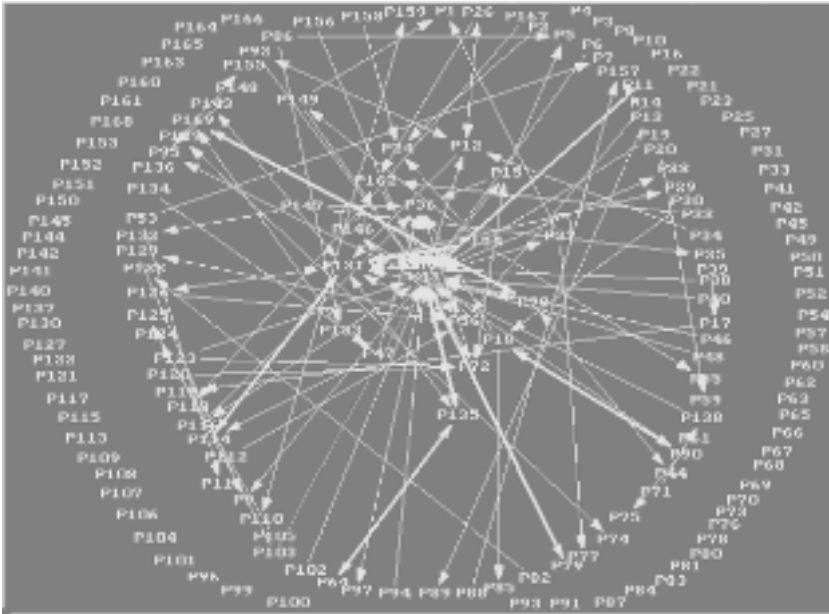
Our results reveal that people do not post an equal number of messages to the electronic network of practice, indicating that members do not participate equally in the provision of the public good. In addition, the knowledge flows in this network of practice are characterized not by dyadic exchange but by patterns of generalized exchange, i.e., one's providing of help is not reciprocated by the recipient, but by a third party. Thus, our results are in line with the work by Fulk et al. (1996).

RQ2: Are networks of practice characterized by a critical mass constituting a core?

Borrowing from nuclear physics, the theory of critical mass argues that a subset of a group may be responsible for making the majority of the contributions to the production and maintenance of the public good (Oliver, Marwell, & Teixeira, 1985). As in Research Question 1, this property is examined by looking at the pattern of social ties. The presence of critical mass is determined by the degree to which ties are centralized or concentrated to a few individuals rather than spread across the entire group. As mentioned above, building upon Wenger's categories of community of practice participation and based upon the analysis of messages, we created four categories of participants: outsiders (people who posted seeds, but never received a response), seekers (people who posted only questions), periphery (people who posted 10 or less responses) and insiders (people who posted more than 10 responses). Using UCINET software (Borgatti, Everett, & Freeman, 1999), we analyzed the ego network of each individual to determine centrality in terms of "in degree", i.e., the number of times other people respond to an individual, and "out degree", i.e., the number of times an individual responds to others. Through this analysis, we found that the network is structured as a star with a critical mass surrounded by peripheral connections emanating outwards. We also performed a component analysis, which revealed that the electronic network of practice is characterized by only one component and not a set of subsets. This indicates that there are no cliques, rather the critical mass actively responds to many unique and overlapping individuals, and the periphery engages in both receiving and providing advice to others. However, contrary to community of practice theory, individuals forming

the critical mass are not tied to one another. Using Krackplot, figure 6.4 shows the network structure of survey respondents (Krackhardt et al., 1994).

Figure 6.4 Structure of Electronic Network of Practice



RQ3: How does the heterogeneity of resources and interests of participants impact network of practice collective action?

A population's heterogeneity of resources and interests is argued to affect collective action and the production of a public good (Olson, 1965; Hardin, 1982; Oliver et al., 1985). The more heterogeneous a group is, the more likely there is a critical mass or subset of members who have a high enough level of resources and/or interests to produce the public good. However, heterogeneity can also hinder collective action even when the mean levels of heterogeneity appear sufficient. As such, the distribution of heterogeneity is important in terms of collective action, i.e., the more positive skew and deviation from the mean, the more likely a critical mass may result (Oliver et al., 1985). Resources include money, time, expertise, energy, and influence (ibid). We examined the importance of resources

and interests by analyzing the correlations between network centrality data and survey measures of resources and interests. Results indicate that interests and resources are not as significant for people who receive help, but they are reasonably good indicators of why people provide knowledge to others. The only significant relationships with receiving help (in degree) are sustainability and challenge, thus those who received help were interested in continuing their electronic network of practice participation and the challenge associated with doing so. The results indicate that longer professional association tenure and higher levels of expertise are associated with *responding to others*. In addition, individuals who were sole practitioners were significantly related to responding to others as were those concerned with enhancing their reputations.

6.3 Article 3. Communities of Practice in a High-Growth Internet Consultancy: Netovation vs. On-Time Performance

By R. Teigland

Versions published:

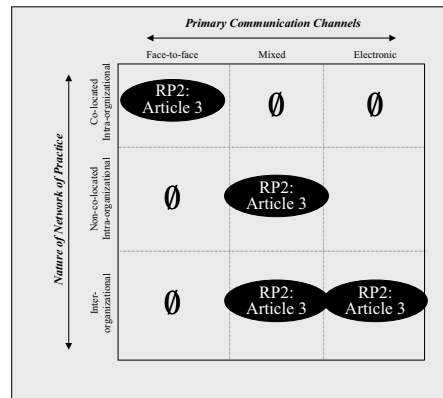
In E. L. Lesser, M.A. Fontaine, & J.A. Slusher (eds.), *Knowledge and Communities*, Boston: Butterworth-Heinemann, 2000.

In J. Birkinshaw & P. Hagström (eds.), *The Flexible Firm*, London: Oxford University Press, 2000.

In F. Delmar & P. Davidsson (eds.), *Tillväxtföretagen (High-Growth Firms)*, Stockholm: SNS Förlag, 2001 (in Swedish).

This article is the first of five that address Research Purpose 2, and it was also the first one conducted in this vein, thus it is of a more exploratory and empirical nature. The findings from the study of the patterns of individual-level knowledge flows at Icon Medialab and the impact of those patterns on individual performance are described. Building on the knowledge-based view of the firm literature, and specifically the work concerned with networks of

Figure 6.5 Positioning of Article 3



practice, we developed a series of propositions linking individual performance to various sources of knowledge. This article is positioned in the network of practice matrix as illustrated in figure 6.5. Research was conducted through interviews and a paper-based questionnaire (203 responses, 84% response rate, in nine offices in eight countries).

The primary intent of this exploratory study is to understand what knowledge sources individuals use in their everyday work in an internet-intensive environment and what role the internet and networks of practice play. The secondary intent is to take this research one step further by linking an individual's knowledge seeking behavior to an individual's work-related performance. In contrast to previous research on individual performance, we break down performance into two components – on-time (efficient) and creativity. On-time performance is defined as the ability to achieve targets and objectives as defined by one's boss or superior. While there are many views of what creativity is, e.g., "the process of using imagination and skill to invent a unique product or thought" (Scott, 1995:66), the definition used in this thesis is the ability to develop innovative solutions to work-related problems in the course of one's work.

Interesting patterns of knowledge seeking activities were revealed through an analysis of the data using stepwise regression analysis and a t-test to compare the means of knowledge source usage. The more technically oriented people, e.g., software programmers and system architects, tended to use external codified sources of information such as internet webpages and electronic networks of practice to a higher degree than non-technically oriented people did when solving work-related problems. Not only were these sources the most frequently used, they were also found to be the most helpful by the technically oriented people. However, non-technically oriented respondents interacted with external people such as customers and friends and with internal distributed networks of practice to a higher degree than technically oriented respondents. Thus, this suggests that the type of knowledge source selected (and thus which network of practice) is dependent on the type of task performed.

Turning to individual performance, taking creativity first, social contact with internal network of practice members outside of work and the use of external codified sources of information (electronic networks of practice and the like) are the significant predictors. These findings are particularly strong when we take a closer look at the technically oriented group. Looking at on-time performance, the use of internal codified sources of information is found to be a positive predictor of on-time performance for the whole sample. However, the use of external codified sources is a *negative* predictor of on-time performance for the technically oriented group. A summary of the findings is presented in table 6.2.

Table 6.2 Results from Stepwise Regression Analysis

Proposition	Creativity		On-time	
	Whole Sample	Tech. Sample	Whole Sample	Tech. Sample
1. Interaction with internal sources (community of practice)				
2. Social contact outside work with community of practice	.17 [†]	.30 [†]		
3. Interaction with external sources (customer, inter-organizational distributed network of practice)				
4. Use of internal codified sources (e.g., intranet)			.23*	.55**
5. Use of external codified sources including electronic networks of practice	.15 [†]	.35*		-.31*

[†] p < .10

* p < .05

** p < .01

*** p < .001

In addition to the above findings, the qualitative data reveal some interesting findings. Based on our interviews, the impression one gets is that technically oriented employees attach great importance to their contacts in their external networks of practice as sources of ideas and as ways of solving tricky problems. Several programmers even stated that they preferred to go first to their internet community or use their external private email list for help instead of asking someone at Icon even if he or she were sitting at the next desk. Several explanations were offered. The first is that by posting a question in an open inter-organizational electronic network of practice, people are not obligated to help. Instead those who want to help can do so in a voluntary fashion. By reaching out to the electronic community for help, one does not disturb a colleague at work who has his or her own schedule and deadlines to meet. Another reason is that people can access a much broader source of expertise than at their own company. In many instances, individuals claimed that there was no “critical mass” internally, especially when discussing the intranet, within Icon. However, this critical mass could be found in inter-organizational electronic communities. Members of inter-organizational electronic communities work at different types of companies all over the world, yet they work on the same type of problem. Thus, interviewees were of the opinion that participation in an electronic network of practice enabled them

to gain access to the latest thinking within their field, especially since the change of pace within the internet consulting industry is so rapid.

To turn the discussion to the second independent variable, social contact outside of work, we found in our interviews that individuals became members of tightly knit communities of practice through extensive social contact outside of work. During this social contact, these individuals discuss the difficult problems encountered during the day, the responses received from the electronic community, and how they then attempted to solve their problems. The latest solutions or tips from both the outside communities and one's own work are passed between the members of the community. In this manner, these community members socially construct their world through the narration of stories, turning incoherent data into coherent knowledge. This enables them to gain insights into the work they are performing, allowing them to be more creative in their daily work. What is interesting here then is the combination of the interaction with an individual's external network of practice with an individual's internal network of practice. As ideas cross community boundaries, resulting in the cross-fertilization of communities, knowledge is combined and placed within the company's local context to foster creativity.

In terms of achieving on-time performance, a very different picture emerges. Here, the use of internal codified sources of information is a positive predictor of on-time performance, while the use of external codified sources is a *negative* predictor. This is entirely in keeping with intuitive expectations. Building relationships with external communities and creating unique or "elegant" solutions on the basis of those relationships works well when creativity is the objective, but it is a strong negative when on-time delivery matters. Gathering knowledge from the outside takes time because either the sources must be located or one must wait for someone to volunteer help. And once the knowledge or help is received, it must be assimilated into the context of both the problem and the company's way of doing things. As interviewees indicated, this may take considerable time depending on the complexity of the knowledge and the problem.

In addition, we found that reciprocity within these inter-organizational electronic communities is necessary in order to become a true member. In other words, to be able to ask the other internet community members for

help, one must prove that one also gives back to the network through providing help to others when asked. This returning of help then results in the individual performing work for others outside the company. This then takes away time from the individual's internal responsibilities, potentially leading then to poor on-time performance.

We also investigated the high use of internet webpages and electronic communities and found that prestige is a significant factor in their use. Several interviewees commented that some individuals feared making mistakes or making themselves look stupid by asking others at Icon for help. So, they turned to the internet where "no one knows if you're a monkey". Another aspect is that interviewees viewed membership in closed or invitation-only internet communities as being prestigious. In addition, interviewees indicated that some programmers were under a form of social pressure from their external network to help fellow members solve their difficult problems, often attempting to "show off" in front of the others. This was found to lead to conflicting goals or loyalty for the programmers. Creating a "cool" solution or trying to impress a global community through solving another external member's difficult problem leads to longer hours worked, using unnecessary resources as well as causing delays in product delivery to the customer. However, it is this participation in external networks of practice that leads to the cross-fertilization of networks that then fosters creativity, an important factor in the creation of a firm's competitive advantage.

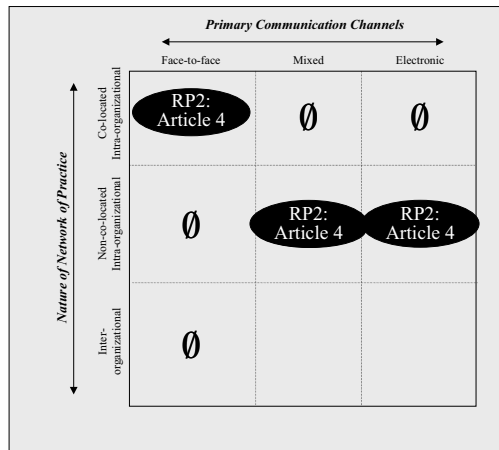
6.4 Article 4. Extending Richness with Reach: Participation and Knowledge Exchange in Electronic Networks of Practice

By. R. Teigland & M. M. Wasko

To be published in P. Hildreth & C. Kimble (eds.), *Knowledge Networks: Innovation Through Communities of Practice*, London: Idea Group Inc., 2004 (forthcoming).

This article continues along the same lines as Article 3. However, it digs more deeply into investigating an *intra-organizational electronic network of practice* since we know much less about these networks of practice compared to traditional, face-to-face communities of practice within organizations. Thus, the goal of this article is to examine knowledge exchange in an intra-organizational electronic

Figure 6.6 Positioning of Article 4



network of practice as well as the relationship that this participation has with individual performance. In this study, individual performance is measured with a focus on creativity. The research site is Cap Gemini Nordic, and we collected data from software programmers through the use of interviews and an html questionnaire linked to an SQL database sent as an email attachment. In addition to survey measures, participants also provided insights by responding to open-ended questions about their participation in the electronic network of practice. Figure 6.6 provides the positioning of this article on the network of practice matrix.

In particular, we examine the relationships between knowledge acquisition and knowledge contribution, electronic network of practice tenure and participation, individual performance, and reliance on co-located coworkers

(indicating community of practice participation). Our results indicate that higher levels of participation and tenure in the intra-organizational electronic network of practice are associated with both acquiring knowledge from participation in the network of practice and contributing knowledge to other network members. In addition, both knowledge acquisition from and knowledge contribution to the electronic network of practice are positively related to individual performance. However, tenure in the electronic network of practice is not associated with higher rates of participation or with individual performance. Finally, the results show that individuals who relied on their co-located colleagues for help or advice with their work tasks reported no associations with participation, knowledge acquisition, or knowledge contribution. In fact, the survey results indicate that *reliance on co-located colleagues is associated with lower levels of self-reported individual performance*. These results are summarized in table 6.3.

Table 6.3 Quantitative Results from Survey

	Scale Range	Mean	Std. Dev.	Cronbach's Alpha	1	2	3	4	5
1. Intra-organizational Electronic Network of Practice Participation Level	1-7	2.3	0.82	n/a					
2. Intra-organizational Electronic Network of Participation Tenure	1-50	10.81	11.64	n/a	.06				
3. Knowledge Acquisition	1-7	3.62	1.75	0.95	.52**	.29*			
4. Knowledge Contribution	1-7	2.34	1.57	0.85	.59**	.23*	.52**		
5. Co-located Coworkers (Indicating Community of Practice Participation)	0-3.71	2.99	1.05	n/a	.04	.06	.02	.08	
6. Individual Performance	1-7	4.30	1.29	0.82	.41**	.13	.24*	.57**	-.24*

* Significant at the $p < .05$ level, two-tailed

** Significant at the $p < .01$ level, two-tailed

In addition, an analysis of the open-ended survey questions suggests that electronic networks of practice are a valuable *complement* to communities of practice. Individuals indicated that the electronic community was an excellent means of improving their own level of technical competence and

that they learned through their participation by receiving help and information related to their work tasks. Additionally, they felt that participation enabled them to keep current with technical developments as well as to know who was actively working in different areas. In response to the question as to why individuals help others on the community, the answers provided included a norm of reciprocity and corporate responsibility. We also asked whether participation had helped improve their work performance. Of the respondents, 62% replied that the community had helped them. We find two categories of answers. First, participation greatly improves the speed with which participants are able to solve their problems. Second, individuals are able to learn and receive new insights from the community. Thus, learning in a network of practice appears to be on a broader, more general level (learning about new areas and topics within the practice) while previous research provides evidence that learning in a community of practice may be of a deeper, more specific type (learning how to apply the new area to one's specific task).

6.5 Article 5. Integrating Knowledge through Information Trading: Examining the Impact of Boundary Spanning Communication on Individual Performance

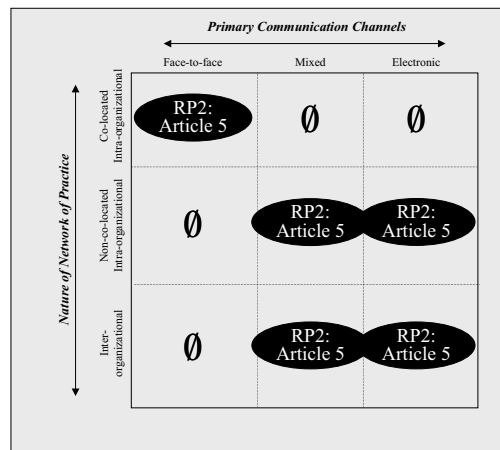
By R. Teigland & M. M. Wasko

Version published in *Decision Sciences*, Special Issue on Knowledge Management, 2003 (forthcoming).

This article takes the research conducted in the previous two articles one step further by grounding it in the knowledge-based view of the firm, and in particular Grant's theory of knowledge integration. The goal of this article is to examine whether individual performance in terms of efficient or creative performance varies as a result of participation and knowledge exchange in internal and external networks of practice. Specifically, we developed a series of hypotheses relating to

the efficiency of integration, the internal flexibility of integration, and the external flexibility of integration that predict the relationships between an individual's participation in various networks of practice, internal and external knowledge exchange, and individual performance. Thus, we examine whether individual performance is related to participation and knowledge exchange in 1) communities of practice, 2) intra-organizational distributed networks of practice, 3) intra-organizational electronic networks of practice, 4) inter-organizational distributed networks of practice, and 5) inter-organizational electronic networks of practice. As such, this article addresses Research Purpose 2, and it is positioned in the network of practice matrix as depicted in figure 6.7. The research site is the intra-organizational electronic network of practice of 345 programmers within

Figure 6.7 Positioning of Article 5



the Nordic operations of Cap Gemini. As mentioned, we collected data through the use of interviews and an html questionnaire linked to an SQL database sent as an email attachment.

Results from the PLS analysis are provided in table 6.4. There is evidence that a high reliance by individual on communities of practice as sources of help results in lower levels of creativity. This suggests that the knowledge of an individual's local community of practice may be largely redundant and that the use of this local knowledge, although efficient due to a shared practice, does not appear to positively impact individual performance. On the other hand, participation in intra-organizational distributed networks of practice enhances creativity as evidenced by the positive relationship between internal knowledge trading and both efficient performance and creativity. Individuals participating in internal distributed networks of practice are able to act as bridges between local communities of practice, accessing non-redundant knowledge from other locations and integrating it with knowledge of their own. Contrary to expectations, we found that external knowledge trading has no direct relationship to individual performance. Rather it affects creativity and general performance indirectly through its influence on internal knowledge trading.

Table 6.4 Results of PLS Analysis

	Internal Knowledge Trading⁵⁶	External Knowledge Trading⁵⁷	Creativity	Efficient Perform.⁵⁸
1. Co-located Coworkers (Indicating Communities of Practice Participation)			-.20*	-.15
2. Non-co-located Coworkers (Indicating Intra-organizational Distributed Network of Practice Participation)	.24**			
3. Intra-organizational Electronic Networks of Practice Participation	.26**			
4. Internal Knowledge Trading			.54**	.28*
5. Contacts at Other Firms (Indicating Inter-organizational Distributed Network of Practice Participation)		.45**		
6. Inter-organizational Electronic Networks of Practice Participation		-.06		
7. External Knowledge Trading	.45**		.09	.17
R ²	.44	.20	.38	.17

* p < .05, two-tailed test

** p < .01, two-tailed test

⁵⁶ Label has been changed from Internal Information Trading to Internal Knowledge Trading to reflect the choice of terminology in this thesis.

⁵⁷ Label has been changed from External Information Trading to External Knowledge Trading to reflect the choice of terminology in this thesis.

⁵⁸ Label has been changed from General Performance to Efficient Performance to reflect the choice of terminology in this thesis.

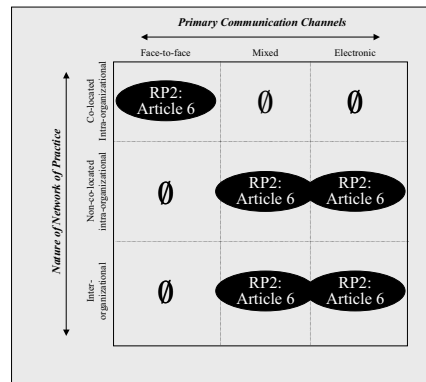
6.6 Article 6. Exploring the Relationships Between Network of Practice Participation, Centrality, and Individual Performance in a Multinational Organization

By R. Teigland

Previous version presented at *INSNA – International Network of Social Network Analysts Sunbelt Conference, 2002.*

This article further extends the research on the relationships between participation in various networks of practice and individual performance by introducing the social network measure of centrality. We tested the model developed in this article using questionnaire and social network data collected from Icon Medialab after the company had grown to 1698 employees spread across 28 offices in Europe, the US, and Australasia, and Asia. As such, it addresses Research Purpose 2, and it is positioned in the network of practice matrix as depicted in figure 6.8.

Figure 6.8 Positioning of Article 6



This article combines Grant's theory of knowledge integration, Hansen's (1996) work on knowledge integration in multinationals, and networks of practice and social network theory. Similar to the previous article, we developed a series of hypotheses relating to the efficiency of integration, the internal flexibility of integration, the external flexibility of integration, and human capital that predict the relationships between an individual's use of various types of knowledge sources (networks of practice and codified knowledge sources), internal and external knowledge exchange, firm network of practice centrality, and individual performance (creativity and efficient performance). In addition, we hypothesize that these relationships

differ for three different task groups depending upon the tasks performed: Commercial and Support Group, System and Software Group, and Design Group.

Based on the matrix of social network data of all 1698 individuals, we calculated a measure of overall intra-organizational network of practice centrality for each individual in the firm, i.e., the degree to which an individual is central in the network of the firm's entire set of intra-organizational networks of practice (be they communities of practice or distributed networks of practice). We then analyzed the data including this centrality measure as well as other measures using structural equation modeling. We discuss the results for the entire sample and each of the three task groups below; however, a lengthier discussion of the results for the whole sample as well as the task groups is presented in Article 6 in Appendix Two.

Our results provide insight into the literature on networks of practice and knowledge integration at the individual level of the firm. While we did not find any support for the hypotheses relating to the use of internal codified sources, we did find strong or moderate support for several of the hypotheses involving the participation in internal and external networks of practice, as well as the two human capital variables of education and experience. What is also interesting is the fact that we see such different results for the two different dependent performance variables as well as for the relationships for each of the three task groups.

Efficiency of Integration. Looking at internal codified sources, contrary to expectations, we did not find any significant relationship between the use of these and either creative or efficient performance for the sample as a whole. As for participation in networks of practice, we found the level of interaction with co-located coworkers as a predictor of efficient performance. This is in keeping with our *a priori* expectations. A high degree of personal interaction with other members of one's communities of practice who share the same language should be a highly efficient source of knowledge. However, we did not expect to find a positive relationship between interaction with co-located coworkers and creative performance. Based on theories of weak ties, we had predicted a negative relationship since it was expected that the knowledge of an individual's community of practice is largely redundant, thus hampering the creation of new ideas.

Internal Flexibility of Integration. We found support for the relationship between overall intra-organizational network of practice centrality and creative performance. Thus, our results suggest that *efficient* performance is dependent upon the ability of an individual to reuse existing local knowledge without having to tap into the firm's global knowledge base. However, the relationship between overall network of practice centrality and *creative* performance supports theory that individuals participating to a high degree in intra-organizational distributed networks of practice are acting as brokers, indicating that flexible knowledge integration is the result of the recombination of knowledge found throughout the firm's geographically dispersed communities of practice.

In terms of the drivers of overall intra-organizational network of practice centrality, we did find the expected positive relationships between internal knowledge exchange and centrality. Mutual engagement involving the exchange of knowledge with one's community of practice leads to overall network of practice centrality in the firm. This finding is in line with community of practice theory that argues that movement into a central position within a community is dependent upon mutual engagement between the individual and others in the community and that this movement is jointly determined. However, contrary to expectations, we also find a *direct* relationship between participation in intra-organizational distributed networks of practice and centrality. This finding is unexpected since we argued that internal knowledge exchange should fully mediate this relationship. Our findings thus indicate that a central position in the firm's networks of practice is only partially dependent upon the individual's participation in exchange relationships of sharing and receiving knowledge with others both locally as well as in other locations. Thus, in this study, interactions with distributed network of practice members are not dependent upon knowledge exchange relationships to the same degree as interactions with community of practice members.

External Flexibility of Integration. Turning to external integrative flexibility and the use of external knowledge sources, our results support our hypotheses. The use of external knowledge sources does not have a direct impact on an individual's performance. Rather it affects creative performance indirectly through its influence on internal knowledge exchange and network of practice centrality. In addition to the hypothesized relationships, we also found a *direct negative* relationship

between the use of external knowledge sources and network of practice centrality. Thus, those individuals who merely used external knowledge sources to a high degree but did not integrate this knowledge with that of others through internal knowledge exchange remained on the outskirts of the firm and by implication achieved lower levels of creative performance.

Differences among Task Groups. Finally, we found considerable differences in the relationships among the variables across the three task groups. As for the System and Software Group, this group is in strong contrast to the other two groups of employees in this organization. This group shows a very high degree of dependency on the use of external knowledge sources and participation in inter-organizational networks of practice. While for the entire sample as a whole, a negative relationship between the use of external knowledge sources and network of practice centrality is found, this relationship is positive for the System and Software Group. In addition, the use of internal codified sources leads to a lower degree of creative performance. One explanation for this finding may be linked to the nature of the system and software development field. The pace of change may be so fast within this field that in order for individuals to keep pace with development, they must rely to a high degree on the use of external knowledge sources. Knowledge within the firm may quickly become irrelevant and the reuse of internal knowledge may hamper individuals' ability to develop and implement new solutions and processes. These findings are in line with the argument that system and software engineering and design is similar to non-software R&D such as that researched by Allen and colleagues (Hauptman, 1986). One explanation may be that software engineers working with the same programming language may easily communicate and share knowledge with others in inter-organizational networks of practice due to the more universal nature of the programming language. As a result, external knowledge used by the System and Software Group does not need to be absorbed through the combination with internal knowledge accessed in knowledge exchange to the same degree as the external knowledge used by the Commercial and Support Group and Design Group.

These findings then provide evidence that the dynamics of knowledge sharing among network of practice members within and across firms may be dependent upon the nature of the underlying practice knowledge. More

detail on the individual task group patterns can be found in Article 6 in Appendix Two.

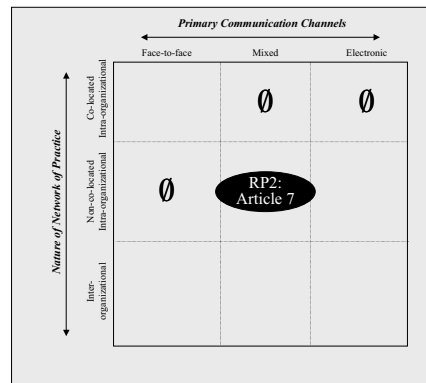
6.7 Article 7. Knowledge Dissemination in Global R&D Operations: An Empirical Study of Multinationals in the High Technology Industry

By R. Teigland, C. Fey, & J. Birkinshaw

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While this article is the last of the seven empirical studies of this thesis, it is actually the first study that was conducted. This research laid the groundwork for networks of practice as the central theme in this thesis. The focus of this introductory research is on an applied question: *How are MNCs managing the knowledge flows in their global R&D operations?* While this research did not set out to explicitly investigate networks of practice, results revealed that intra-organizational networks of practice were one of the primary mechanisms that facilitated knowledge sharing in the companies investigated. In addition, we found some interesting results regarding performance at the firm level. Thus, while this article does not explicitly address Research Purpose 2 on the relationship between participation in networks of practice and individual performance, it does serve to fill the second research gap of performance identified in the review of the empirical studies. Thus, we report this article under Research Purpose 2, and figure 6.9 illustrates how this article is positioned in the network of practice matrix.

Figure 6.9 Positioning of Article 7



The basic challenge to the management of multinational corporations (MNCs) is one of maintaining the responsiveness of individual units to the opportunities and demands of their local environment while at the same time capturing the latent benefits that a large, global network can confer.

To create a sustainable competitive advantage, knowledge, it is argued, must be created at a quick pace while it is simultaneously transferred and applied throughout the MNC's global operations (Bartlett & Ghoshal, 1989; Hedlund & Nonaka, 1993; Doz & Hamel, 1997). Coordination across units prevents the duplication of effort while at the same time ensuring the fastest time to market with a product that customers want. However, globally dispersed networks of R&D units create significant managerial challenges to MNCs. The task of efficiently making use of R&D knowledge becomes more difficult as many MNCs continue to expand their global R&D operations, and thereby increase the number of geographically dispersed locations, employees, functions, and external partners. Both the complexity of the network and the differences in language and culture lead to significant challenges. Thus, as mentioned above, the focus of this study is on an applied question: *How are MNCs managing the knowledge flows in their global R&D operations?* The question is descriptive, but it builds on our *a priori* expectation that most firms would like to see an increase in both the volume and quality of knowledge flows between and within R&D units. To address the research question, we conducted case studies within three high technology MNCs.

One key finding in this research is that although management spent considerable time and financial resources on implementing information-technology mechanisms for individual researchers to use in their everyday knowledge sourcing activities, the researchers used these to a very limited extent. Rather *they preferred to use their intra-organizational distributed networks of practice* to search for knowledge for help with work tasks.

Several means of facilitating the development of networks of practice across the companies were also found. For example, one company had implemented an advanced form of groupware that was a virtual workspace, enabling researchers in a network of practice to easily share information, collaborate on documents, and connect with fellow researchers throughout the organization through such means as bulletin boards and calendars. Of interest is that there was no central authority or administration for the system since it was run and maintained by the network. Individual researchers determined their own level of participation and could designate what level of security they desired for the information that they entered, e.g., "write-only" or "read-only" access. In addition, there were some

grass-roots efforts such as technology conferences or technology interest groups.

We also found that the level of encouragement from management to participate in intra-organizational distributed networks of practice differed across the companies investigated from no support to full support with resources. Of the three companies, we found that Hewlett-Packard had the most active intra-organizational networks of practice. This seems to be due to management's support for these networks through the providing of resources and by allowing them to be of a grass roots nature. People who were interested in a technology or a subject were free to participate in meetings of distributed individuals working on the same kind of task across the organization. Other means focused on increasing the level of participation in intra-organizational network of practice included personnel rotation and cross-laboratory projects. Finally, Hewlett-Packard appeared to have the highest level of shared identity, language, and values of the three companies due to management's extensive efforts.

Regarding Research Purpose 2 and the relationship between intra-organizational networks of practice and firm performance, we found support for this relationship. We assessed the three companies on six factors related to R&D performance, e.g., number of articles published, time to market, and impact of R&D on emergence of successful products. Hewlett-Packard had the most balanced performance assessment and on no measure did they score the lowest. This finding follows logically from our assessment that Hewlett-Packard had the highest level of internal knowledge sharing that was supported by the company's considerable efforts to encourage participation in intra-organizational networks of practice and to create a shared identity, language, and values across the organization. Company A, which had the lowest degree of performance, exhibited the lowest degree of intra-organizational network of practice participation and shared identity across the organization. Employees appeared to identify more with their local unit than with the company as a whole and this led to the feeling of fiefdoms within the company. There was a high level of "not-invented-here" as evidenced by the resistance to ideas coming from outside the division due to the strong feelings of local identity. This was exemplified by the finding that each unit had developed its own knowledge sharing tools and was resistant to adopting tools from other units. In addition, individuals at Company A were less interested in

spending time helping others from other units, and they exhibited a higher degree of “knowledge equals power”.

CHAPTER SEVEN

Discussion and Implications

THIS CHAPTER DISCUSSES and interprets the results from the seven empirical studies conducted and is divided into five sections. First, the main findings from the empirical studies are synthesized, and the theoretical implications of the major findings are then discussed in terms of the network of practice and knowledge-based view of the firm literatures. Third, the practical implications of the major findings are highlighted and explored. A section on limitations and suggestions for how the results from this study can be expanded in future settings is presented. The chapter then ends with the dissertation study conclusion. As mentioned previously, the empirical studies in their article format are attached in Appendix Two.

7.1 Synthesis of Main Findings

The overarching goal of this dissertation is to improve our understanding of networks of practice from a business firm's perspective and in particular to investigate structure and performance in networks of practice within and between firms. As such, we will discuss the findings for each of two research purposes in turn. It is important to note that the findings of the individual studies are not directly comparable due to differences in methodology; however, we feel that we can make an additional contribution to the literature by attempting to synthesize the results.

7.1.1 Research Purpose 1: Describing Structural Dimensions

The first research purpose of this thesis is to describe the structural properties of networks of practice through the application of social network analysis. The principal idea behind this research purpose is that the development of a set of structural properties would facilitate the analysis and further theorizing of networks of practice. Clearly, any set of structural

properties is not sufficient in itself as an indicator of the presence of a network of practice; however, we argue that certain structural properties do need to be fulfilled in order for a specific network of practice to develop.

In order to investigate this question, two polar forms of networks of practice were analyzed: an intra-organizational community of practice and an inter-organizational electronic network of practice. When conducting exploratory research, it is suggested that cases representing opposite situations should be selected. Eisenhardt (1989a: 537) states, "...it makes sense to choose cases such as extreme situations and polar types". Eisenhardt's statement is relevant to this research since the identification of similarities between the two networks facilitates the ability to generalize beyond these two cases, despite the two studies not being directly comparable. Below is a discussion focused on comparing these two studies.

In order to address Research Purpose 1a, we reviewed the social network literature for appropriate measures that could be applied to communities of practice. Five measures focusing on the presence and frequency of interaction were selected that then created the basis for five structural properties for communities of practice: connectedness, graph-theoretic distance, density, core/periphery, and individual coreness. The primary idea behind the selection of these measures is that we argue that they are the necessary, but not sufficient, conditions that need to be fulfilled in order for a community of practice to be present. The underlying assumption in the community of practice literature is that through dyadic, frequent interaction individuals develop a shared identity, language, norms, and values revolving around a joint enterprise. Thus, the more the network is characterized by a dense network of individuals directly tied to one another with a central core of individuals surrounded by peripheral members, the more likely the network is a community of practice and thus will have a high degree of sharing and incremental innovation of the community's knowledge.

We then applied these measures to a large construction project in Article 1. Results are compatible with the argument that the formal organization does affect the structure of communities of practice within the organization; however, the two are not completely aligned. In this organization, individuals were geographically separated as defined by the organization's

departments, and the organization constrained the availability of resources for individuals to meet face-to-face between departments. Results indicate that individuals tended to form relationships only with others who were generally within the same department; however, each department did not form a community of practice, despite the small number of members. In addition, individuals who were in the core of the organization's network of practice were those who were *physically present* in their respective departments to a higher degree. These findings are compatible with the previous cognitive arguments (Orr, 1996; Wenger, 1998) that communities of practice are based on face-to-face interactions and as such generally consist of individuals who are co-located and not distributed. In addition, our results are in line with theories of legitimate peripheral participation (Lave & Wenger, 1991) since individuals who had the highest coreness scores had a higher degree of professional and network expertise. Finally, we developed a series of propositions relating various community of practice structural properties to performance as an area for further research.

When we turned our attention to Research Purpose 1b and electronic networks of practice in Article 2, we found that the properties developed for communities of practice in Article 1 could be directly applied to electronic networks of practice. As mentioned, the social network measures developed for the community of practice study are partly based on identifying and measuring the *presence* of interaction between two individuals. However, in electronic networks of practice that are based on bulletin board or listserv technologies, postings of messages are automatically visible to everyone in the electronic network. As such, all members interact *de facto* with everyone else. Thus, the measures of connectedness, graph-theoretic distance, and density that we developed for communities of practice could not be applied directly to these forms of electronic networks of practice, implying that a different approach is necessary to investigate the structural properties of an electronic network of practice.

As the literature review revealed, previous research on online communications suggests that theories of collective action and public goods could be an appropriate lens for our research purpose (Fulk et al., 1996; Monge et al., 1998). Thus, we developed a set of three research questions investigating the application of these theories to electronic networks of practice and their structural properties. We examined an inter-

organizational electronic network of practice (listserv) of US lawyers. Through the investigation of these research questions, we found support for the application of collective action and public goods theories to electronic networks of practice. First, we found that the members of the collective, the electronic network of practice, did not participate equally in the production of the public good and that interactions were characterized by a pattern of generalized reciprocity as opposed to one of a dyadic nature. This finding is in line with work by Ekeh (1974) and Fulk et al. (1996). Second, adapting Wenger's (1998) categories of participation, we found that the overall structure of the electronic network of practice was characterized by a group of individuals who formed the critical mass that was primarily responsible for the production of the public good. The critical mass was then surrounded by a periphery of individuals who participated to a lower degree. However, when we applied the core/periphery measure that was developed for communities of practice, we found that the electronic network was *not characterized by a central core of individuals closely connected to each other* as in a community of practice. Second, we performed a component analysis, which revealed that this electronic network of practice was characterized by only one component and not a set of subsets, indicating that this electronic network did not have multiple cliques. Thus, while our findings are compatible with critical mass theory (Oliver et al., 1985), we find that Wenger's model of participation categories needs to be amended when applied to electronic networks of practice.

Additionally, we examined the characteristics of the network members in terms of heterogeneity of resources and interests. We found a high degree of overall heterogeneity among the members, and in particular we found that those who responded to a higher degree to others, and thus contributed to the production of the public good, had a higher degree of resources (professional and network expertise) and a higher level of interests (sole practitioners and professional and social motives). These findings are compatible with the work of Olson (1965), Hardin (1982), and Oliver et al. (1985) who postulate that the heterogeneity of resources and interests of a population affects collective action. One of the more interesting findings is that which is in line with Hardin's argument, namely that individuals who lack private alternatives are those who have a high interest level in the production of the public good (1982). In this electronic network of practice, individuals who responded more often were more likely to be sole

practitioners and thus were less likely to have private alternatives for professional discussion than a lawyer in a partnership law firm. The electronic network of practice provided them then with important social space for the development of their practice knowledge.

Applying our thinking on collective action and public goods back to the community of practice study in Article 1, it is an interesting exercise to consider whether knowledge within this community of practice exhibits characteristics of a public good, even though this was not the express purpose of our research in this study. First, we find that knowledge is by its nature non-rival. Production of a community of practice's knowledge requires the same amount of input regardless of the number of community members who will use it, and the use of this knowledge does not diminish the availability of it to other members of the community. However, previous research does not support the argument that a community of practice's knowledge is non-excludable to all members (Lave & Wenger, 1991). In a community of practice, knowledge entails a tacit component that is learned through legitimate peripheral participation without being made explicit. Due to the nature of interactions primarily being dyadic within communities of practice, this knowledge is shared through one individual interacting with another in face-to-face interactions. Thus, only in the smallest of communities of practice could knowledge potentially be non-excludable due to the physical restraints regarding the number of dyadic interactions and relationships any one individual may have. Additionally, as discussed, degrees of participation within a community of practice are jointly determined by the members, with some individuals moving towards the core while others are unable to move despite their desire to do so. Thus, only individuals who are full members of a community of practice have potential access to all the community's knowledge.

Building on our results of the community of practice study in Article 1, we may then test the non-excludability of knowledge. If knowledge were non-excludable in a community of practice, then the density of a community of practice should be 100%, indicating that all individuals are interacting with all the others. In this manner, individuals could not be excluded, in principle, from the knowledge produced by others in the community. However, when the density is less than 100%, individuals are not directly tied to all the others and as such those acting as intermediaries can choose

to restrict the flow of knowledge, thus making the knowledge excludable to others. Applying this thinking to the patterns of interaction within the Technical Department, the construction project department that fulfilled the structural properties of a community of practice, we find that the density is only 27.5%, a far cry from 100%, despite the department comprising fewer than 15 individuals. Thus, we find suggestive evidence that knowledge is not non-excludable in this community of practice and thus is less of a public good in a community of practice than in an electronic network of practice.

Summary. Based on the above findings, we can now make some conclusions regarding the examination of the structural properties of networks of practice using social network analysis. First, our results suggest that a common set of structural properties cannot be applied across the board to all types of networks of practice. This in turn implies that a generic set of social network measures cannot be applied to all networks of practice. Rather, the relevant structural properties and corresponding social network measures of a particular type of network of practice appear to be dependent on the primary communication channels used by the network of practice. The more a network of practice depends on electronic communication channels such as bulletin boards or listservs in which all interactions are visible to all network members, the more connected members are. Thus, the network is denser and the distance between members decreases in terms of simple structural interactions, implying that the network's knowledge increasingly develops characteristics of a public good.

The one structural property that we do find to be common across the two networks of practice studied is the core/periphery property, thus providing support for community of practice theory (Lave & Wenger, 1991; Wenger, 1998) and inter-organizational network of practice theory (e.g., Schott, 1988). In both studies, we found a clear core surrounded by peripheral members, with the core individuals exhibiting a higher degree of professional and network expertise than the peripheral members who surrounded them. Thus, our findings suggest that these core individuals are influential in sharing knowledge with all members and in teaching novices "how to get the job done". However, as mentioned, we did still find a difference in this structural property across the networks of practice

studied. Individuals within the core are not tied closely together in the electronic network of practice as they are in the community of practice.

Finally, we find support for viewing knowledge as a public good and the application of collective action to electronic networks of practice as suggested by (Fulk et al., 1996; Monge et al., 1998). In addition, we find partial support for applying these theories to other types of networks of practice such as communities of practice.

These findings regarding structural properties thus suggest that the patterns and dynamics of interactions and knowledge sharing among members vary across the different types of networks of practice. In addition, these findings have practical implications. To be more specific, our findings have several implications for one of the central debates of networks of practice as to whether they can be constructed and managed by management. For example, our findings regarding the relationship between the heterogeneity of resources and interests of individuals and critical mass required for the creation of the public good suggest that the likelihood that a network of practice develops and is sustained is dependent upon the underlying constellation of individuals in terms of their resources and interests. Thus, this implies that management may be able to successfully support the development and sustainability of a network of practice by ensuring a high degree of variance among the related resources and interests of individual network members. We return to both the theoretical and practical implications from these findings in the next section on implications after we discuss our findings from Research Purpose 2.

7.1.2 Research Purpose 2: Individual Performance

The second research purpose is to investigate the relationship between individual participation in various types of networks of practice and individual performance. As we found in the literature review, there are few empirical studies that focus directly on this relationship. In addition, the literature on the various networks of practice adopts the point of departure that the individual has already decided to participate in the network of practice in focus, and the general assumption is that the individual aspires to be a full member of that network. However, as previous research has indicated, individuals can make discretionary choices regarding with whom they interact (Allen, 1977) and share knowledge

(Andrews & Delahaye, 2000), thus affecting the degree to which they participate in various networks of practice.

To address this purpose, we conducted four studies in which we developed a series of hypotheses grounded in the network of practice, knowledge-based view of the firm, and social network literatures that predicted the relationships between participation in various networks and individual performance. Each of the studies contained a slightly different model; however, they all investigated participation in various networks of practice with individual performance as the dependent variable. The reason these models differed are two-fold. First, the models were adapted to the research site and the particular research questions of the study. Second, with each study, we advanced our thinking based on both our previous findings and on the work of other researchers. For example, the first Icon study (Article 3) serves primarily as an exploratory study while the second Icon study (Article 6) presents a considerably more extensive model. Additionally, there are significant differences between the samples of respondents. Cap Gemini respondents are all programmers located in the Nordic countries while the respondents at Icon Medialab in the first study come from a wide variety of functional backgrounds and were located in nine offices spread across Europe and in the second study come from 28 offices across Europe, the United States, Asia, and Australasia. We discuss and synthesize the findings from these four studies below.

Results from these four studies clearly indicate that individuals participate to varying degrees in different types of networks of practice. Some individuals participate only in communities of practice, while others participate to a high degree in both inter-organizational electronic networks of practice and communities of practice. We also find that an individual's level of participation in various types of networks of practice is related to his or her individual self-reported performance. While there is some variation in the findings among the studies, some clear trends do emerge. The first relates to participation in communities of practice.

7.1.2.1 Communities of Practice

Community of practice theory suggests that members participate in the sharing and transfer of valuable individual and group tacit knowledge, and thus we would expect that individuals who participate to a high degree in a

community of practice would exhibit a higher degree of *efficient* performance. The theory of weak ties (Granovetter, 1973) further suggests that the knowledge in communities of practice is largely redundant due to their closely-knit structures, providing little additional information over what an individual may already know. Thus, a high degree of participation and knowledge sharing in a community of practice would most likely impede the ability of an individual to develop new and creative ideas, resulting in a negative relationship between community of practice participation and *creative* performance. We find mixed support for these relationships. The research at Cap Gemini revealed that individuals who participate to a higher degree in communities of practice report lower levels of creativity; however, we found a different set of results at Icon Medialab in Article 6. Here we found that individuals who participated to a higher degree in communities of practice had both a higher degree of efficient and creative performance. While the relationship to efficient performance is in line with our a priori expectations, we did not expect to find a positive relationship between community of practice participation and creative performance at Icon.

One explanation for this finding at Icon may be due to the differences between the two research sites. In the Cap Gemini study, individuals in the same physical site were from one functional discipline, software programming. Thus, when individuals discussed with others in their communities of practice, knowledge was more likely to be redundant since they shared the same general functional competence. However, due to the organization of Icon as described above, the knowledge within communities of practice at this company may have been less redundant. At Icon, individuals within one physical location comprised several functional disciplines, e.g., management consulting, programming, design, human-computer interaction, etc., with individuals from a variety of functions generally sitting next to each other in open environments. As a result, communities of practice at Icon were more likely to incorporate more than one functional competence. Since flexible integration involves integrating existing knowledge in new patterns, the ability to achieve flexible integration should increase when the number of different areas of functional knowledge to be integrated increases due to a higher number of potential combinations. Thus, one explanation for the difference in our results could be that at Icon the more an individual participates in communities of practice, the more likely they include individuals from a

variety of functional areas, thus potentially decreasing the level of knowledge redundancy, which then positively impacts creative performance.

7.1.2.2 Intra-organizational Distributed Networks of Practice

Looking at participation in intra-organizational distributed networks of practice, the literature suggests that individuals in these networks share the same organizational language and code of behavior and are faced with similar issues related to their knowledge tasks, supporting integrative efficiency and thus general performance (Brown & Duguid, 1991; Wenger, 1998). In addition, the combination and recombination of firm-specific knowledge that is physically dispersed across the organization may facilitate integrative flexibility and thus creative performance since these acquaintances are more likely than community of practice members to have important knowledge that is non-redundant (Granovetter, 1973). However, due to less frequent patterns of interaction and lower intensities of social pressure found in distributed networks of practice, members may be less willing or committed to exchange knowledge without some type of return (Blau, 1964). We would expect then that the relationship between participation in intra-organizational distributed networks of practice and individual performance would be mediated by internal knowledge exchange. We found support for this at Cap Gemini where the relationship between participation in intra-organizational distributed networks of practice and performance was mediated by internal knowledge exchange. In the second study at Icon, we further developed our model to include a measure of network of practice centrality. Basing our argument on previous social network research, we argued that an individual's centrality in a firm's networks of practice mediates the relationship between knowledge exchange and creative performance. The results from the Icon study support these relationships.

These results then suggest that individuals who participate in a *reciprocal exchange* of knowledge and help within intra-organizational distributed networks of practice are more likely to become central individuals within the firm's networks of practice. These central individuals play the role of brokers (Wenger, 1998) and, as mentioned previously, we may compare them to boundary spanners in the technology transfer literature (Tushman & Scanlan, 1981). Theory suggests that a central or broker position in the

networks of practice of a firm is *jointly* determined by the other members of the networks of practice and the individual (Lave & Wenger, 1991). In other words, just because an individual wishes to become a central individual does not necessarily guarantee the individual such participation status. Our results are in line with this, suggesting that individuals also need to behave reciprocally and provide knowledge in exchange to other members of their networks of practice to achieve central status. Additionally, through their central position and collaboration with others in distributed networks of practice, brokers are able to gather knowledge and advice more efficiently and effectively from areas across the firm to fit their own local needs than individuals in less central positions, thus positively impacting individual performance.

While the findings regarding performance from the Cap Gemini and Icon studies do differ somewhat, they do support the relationship between participation in intra-organizational distributed networks of practice and individual performance. Through these distributed networks of practice, individuals gain access to knowledge that may be reconfigured efficiently to fit their local needs, resulting in more efficient performance (Cap Gemini only), or they may gain access to new knowledge and innovative ideas that they integrate with their own, resulting in more creative performance (both Cap Gemini and Icon).

One explanation for the different results relating to efficient performance may be due to the type of knowledge within the different samples. Cap Gemini programmers are working primarily with software codes and as a result may share a somewhat universal language, thus facilitating their ability to communicate and share knowledge more efficiently across organizational boundaries. Previous research on electronic networks of practice of programmers has revealed that a large portion of communication within these networks involves the transmission of blocks of code (Wasko & Faraj, 1999). Furthermore, interviews in the first study at Icon reported here indicated that blocks of code gathered by individuals through their participation in distributed and electronic networks of practice could easily be “cut and pasted” into their local work. As a result, we may surmise that knowledge gathered by the Cap Gemini programmers from distant locations through participation in intra-organizational networks of practice may be easily absorbed locally and thus, positively impact efficient performance.

Individuals at Icon, on the other hand, are working with a variety of functional types of knowledge, e.g., human-computer interface, art design, programming, etc., and these different functional types of knowledge may be more local than universal. Explanations provided in interviews at Icon were that the usage of the internet by end-users differed across countries, thus limiting the degree to which front-end solutions developed in one office could be efficiently “cut and pasted” between offices in different countries. Rather, at Icon individuals needed to spend time and effort translating and absorbing knowledge accessed through participation in intra-organizational distributed networks of practice to fit their local situations. Thus, we would expect that participation in intra-organizational distributed networks of practice would not positively impact an individual’s efficient performance.

Regarding creative performance at both Icon and Cap Gemini, we found support that participation in intra-organizational distributed networks of practice provides individuals with access to unique or non-redundant knowledge, thus facilitating their ability to create new knowledge through flexible knowledge integration and thereby increasing their ability to achieve creative performance.

7.1.2.3 Inter-organizational Distributed Networks of Practice

Again we find differing results; however, they all support a positive relationship between participation in inter-organizational networks of practice and individual performance. Extending the model developed in the first Icon study (Article 3), we introduced the measures of internal and external knowledge exchange in the Cap Gemini study based on research in the technology transfer literature (Article 5), arguing that external knowledge exchange mediates the relationship between participation in inter-organizational distributed networks of practice and performance. However, contrary to expectations, we found that participation in inter-organizational distributed networks of practice did not impact an individual’s performance through external knowledge exchange. Rather our findings suggest that external network participation and knowledge exchange affect creative performance *indirectly* through influencing internal knowledge exchange. One explanation may be that individuals involved in external trading are performing gatekeeper activities similar to those investigated in the research conducted in R&D operations by Allen

(1977) and others. Thus, these individuals may not be applying this externally gained knowledge to their own tasks, which would affect their own performance, as much as they are transmitting it to others within the organization who have a specific need for this knowledge. A second explanation may be that the knowledge acquired outside the firm may be so novel that it must be combined with internal knowledge in order to be applied in the firm's context. This explanation is further supported by the findings at Icon in which individuals who reported higher degrees of creative performance were those who gathered knowledge through participation in inter-organizational electronic communities and then discussed these ideas with members of their communities of practice.

In the second Icon study, as mentioned above, we further developed our model by incorporating the measure of network of practice centrality based on the social network literature. We argued that the relationship between network of practice participation and creative performance would be further mediated by network of practice centrality. We found support for this relationship, and interestingly, we also found a *direct negative* relationship between participation in inter-organizational networks of practice and centrality at Icon Medialab. Thus, those individuals who interacted and shared knowledge with others outside the firm to a high degree but did not integrate this knowledge with firm knowledge through internal knowledge exchange remained on the periphery of the firm's networks and by implication achieved lower levels of creative performance.

7.1.2.4 *Electronic Networks of Practice*

In the first Icon study (Article 3), we found a direct *positive* relationship between participation in inter-organizational electronic networks of practice and creative performance, however, a direct *negative* relationship to efficient performance for the technically oriented individuals. As discussed in Article 3, interviews provided several explanations for this negative relationship, such as norms of reciprocity, the nature of knowledge being shared, and individual professional motivations.

Based on previous research (Thibaut & Kelley, 1959; Blau, 1964; Orlikowski, 1996), we extended our first Icon research and predicted that participation in both internal and external electronic networks of practice

would be mediated by knowledge exchange. Our findings at Cap Gemini support internal knowledge exchange in intra-organizational electronic networks, and thus are compatible with previous research that norms of reciprocity are critical for sustaining knowledge exchange in electronic discussion networks (Lakhani & von Hippel, 2000; Wasko & Faraj, 2000). However, contrary to expectations, we found *no* relationship between participation in inter-organizational electronic networks and external knowledge exchange. Thus, it seems that individuals are more likely to engage in knowledge exchange with others through electronic networks with whom they have a common bond, such as organizational membership. We further discuss these differences in the following section on theoretical implications.

7.1.2.5 Differences across Task Groups

Finally, the Icon studies revealed that there were differences in the general patterns of participation in the various types of networks of practice and their relationship to individual performance depending upon the task being performed by the individual. For example, in the first Icon study (Article 3), we found that the technically oriented individuals made greater use of external knowledge sources, such as electronic networks of practice, than their commercially oriented counterparts, *especially* when solving difficult problems. And as mentioned, a high degree of participation in inter-organizational electronic networks of practice was negatively related to on-time performance whereas this relationship was not found for the entire sample.

In the second Icon study (Article 6), we found different patterns across the three task groups in the relationships between participation in the various networks of practice and performance. In particular, the System and Software Development Group (SSW) was in strong contrast to the other two groups of individuals, the Design Group and the Commercial and Support Group, since SSW individuals exhibited a higher degree of participation in external networks of practice. For example, the Design Group exhibited a *direct positive* relationship between participation in a community of practice and creative and efficient performance while the SSW Group exhibited no direct relationship between these. Additionally, while a *negative* relationship between participation in inter-organizational networks of practice (both distributed and electronic) and network of

practice centrality was found for the entire sample as a whole, this relationship was *positive* for the SSW Core.

As mentioned previously, one explanation for these findings may be linked to the nature of the knowledge of the different groups. The pace of change may be so fast within the system and software field that individuals must rely to a high degree on the use of external knowledge sources to keep pace with development. Knowledge within the firm may quickly become out of date and the reuse of this “old” knowledge may hamper the ability to develop and implement new solutions and processes. In addition, a second explanation may be due to the more universal nature of system and software knowledge; external knowledge used by the SSW Group may not need to be translated before it is combined with internal knowledge through knowledge exchange to the same degree as the external knowledge gathered by the Commercial and Support Group and Design Group.

7.1.2.6 Participation in Networks of Practice and Firm Performance

Finally, while not the express purpose, the study of the three high-technology multinationals investigating how MNCs manage knowledge flows in their global R&D operations (Article 7) provides tentative evidence of a positive relationship between participation of individuals in a firm’s intra-organizational distributed network of practice and firm performance.

Summary. Our empirical studies reveal a significant relationship between an individual’s participation in various types of networks of practice and individual performance. On the one hand, we find that efficient performance has a direct, positive relationship to participation in communities of practice, yet too much participation in communities of practice comprising members sharing the same functional expertise may lead to a lower degree of creative performance. On the other hand, participation in intra-organizational distributed networks of practice and inter-organizational networks of practice, be they electronic or distributed, has a positive relationship to creative performance. However, our results also reveal that knowledge exchange and centrality are important mediators in the relationship between participation in networks of practice and creative performance. Further investigation of these performance relationships revealed significant differences between groups of individuals

based on their tasks, indicating that the dynamics of knowledge sharing within the various networks of practice is contingent upon the underlying practice knowledge. We discuss the practical and theoretical implications of these findings in the next section.

7.2 Theoretical Implications

As stated in Chapter One, the overarching goal of this thesis is to improve our understanding of networks of practice from a business firm's perspective, and our approach has been to bring together a number of related theories that can inform our understanding of both *individual-level behaviors and network-level activities* as opposed to the *organizational level*. In this manner, we may then propose implications relevant to the network of practice literature. Additionally, our intention is to apply our thinking and findings back to the level of the firm so that we may then contribute to the extant literature on the knowledge-based view of the firm. We discuss these two areas in turn.

7.2.1 Networks of Practice

Chapters Two and Three, in which the literature and the relevant empirical studies were reviewed, provided a point of departure for this thesis, leaving us with an understanding of the current "state of affairs" of the network of practice field. To structure our discussion, we developed a network of practice matrix, mapping the various types of networks onto this matrix based on the primary communication channels and nature of the network of practice. The review of empirical studies conducted to date on the various kinds of networks of practice revealed that in general there is a dearth of studies within all areas of the network of practice matrix. Additionally, we found that the majority of studies explicitly focused on networks of practice have investigated the cognitive aspects of communities of practice. Thus, we identified structural properties of networks of practice as well as the relationship between networks of practice and performance as two significant gaps in the research. A third gap is that there are an extremely limited number of studies focusing on intra-organizational distributed networks of practice and electronic networks of practice. Thus, this review exposes that "what we think we know" is considerably more than "what we know" regarding networks of practice.

The set of seven empirical studies presented in this thesis helps to fill these research gaps as well as support previous thinking regarding networks of practice. Regarding the structural dimensions of networks of practice, our studies show that the synthesis of social network concepts and methods with the network of practice literature greatly facilitates the ability to uncover these “invisible” networks. Thus, this research opens the door for additional theorizing and empirical studies on the structural properties of various networks of practice. For example, we may use structural properties to help detect and analyze networks of practice, to track their development over time, or to measure their relationship to performance.

These findings regarding structural properties also reveal that the patterns and dynamics of interactions and knowledge sharing among members vary across the different types of networks of practice. Due to the close relationship between structural and cognitive dimensions, we suggest that this then implies that the cognitive dimensions also vary across networks of practice. For example, results from our study of the electronic network of practice (Article 2) call into question whether or not participation in an electronic network of practice is jointly determined as it is in a community of practice. Due to the nature of the media in an electronic network of practice, individuals can post and respond to others to the degree they desire regardless of whether other individuals are interested in interacting in a relationship with the individual posting the messages. Other differences revealed relate to the reach and reciprocity of various networks. Comparing the two studies (Articles 1 and 2), we find that reach is much more extensive and that reciprocity is of a general nature in the electronic network of practice. In addition, we provide support for applying theories of collective action and public goods to electronic networks of practice and suggest that these may also be applied to other types of network of practice to facilitate our understanding of them.

In the second set of studies (Articles 3 to 7), we focus on the research gap concerning the relationship between participation in various types of networks of practice and performance. Our results suggest that this relationship is not only contingent upon the strength of the tie but also upon the redundancy of the knowledge in the network at hand. Our findings suggest that the strong ties of communities of practice have a positive impact on members' *efficient* performance. However, the redundancy of the knowledge in terms of functional competencies in the community of

practice impacts members' *creative* performance. Thus, the more a community of practice is characterized by a diversity of functional competencies, the more likely that the community of practice is able to develop more creative solutions through the recombination of these diverse competencies. However, for communities of practice characterized by the same functional competency, there is greater likelihood that this community of practice may turn into a competency trap or core rigidity (Levitt & March, 1988; Leonard-Barton, 1992) unless members of this community of practice also participate in distributed or electronic networks of practice in which they may access non-redundant knowledge.

Thus, not only are our findings compatible with Granovetter's theory of strong ties, but they also provide suggestive evidence for social resources theory (e.g., Lin, Ensel, & Vaughn, 1981). Social resources theory focuses on the nature of the embedded resources in a network and argues that it is not the weakness of the tie per se that conveys advantage, rather it is the likelihood that the tie reaches someone with the required resource. We modify this to our findings by arguing that it is not the strength of the tie per se within the network that affects creative performance, but it is the composition of the network in terms of the diversity of knowledge competencies that it comprises.

Additionally, we find some indication that the degree to which the network's practice knowledge is of a more universal nature and less embedded in a local practice is an important aspect in the dynamics of networks of practice. Our results suggest that practice knowledge that generally is of a more universal nature, such as software programming, may be shared more effectively by individuals participating in distributed and electronic networks of practice than knowledge of a less universal nature, such as the design knowledge of the art directors at Icon. This is evidenced by the finding that the technically oriented individuals used external electronic media including electronic networks of practice to a higher degree than their commercially or support-oriented counterparts at Icon, especially when solving difficult problems. In addition, further evidence is found at Cap Gemini where programmers who participated to a higher degree in distributed and electronic networks of practice exhibited a higher degree of efficient performance. These findings are in line with previous research within the technology transfer literature in which it was hypothesized that individuals conducting tasks of a more universal nature

could communicate more effectively across organizational boundaries than individuals conducting tasks of a less universal nature (Allen, Tushman, & Lee, 1979).

Our findings also imply that other cognitive dimensions such as norms of reciprocity and trust differ across the various types of networks of practice. For example, we do not find a relationship between participation in inter-organizational *electronic* networks of practice and external knowledge exchange. However, we do find a relationship between participation in inter-organizational *distributed* networks of practice and external knowledge exchange. One explanation may be found by looking at the relationship between the ability to establish reciprocal exchange and various communication channels. Building reciprocal relationships with individuals in inter-organizational electronic networks may be more difficult since members generally have not met each other face-to-face and have little social influence over one another due to the voluntary and anonymous nature of the exchange. In addition, when reciprocity occurs in these networks it is typically of a general and not a dyadic nature (Kollock, 1999). In order for an individual to give to the network, there must be a level of trust across the network members that ensures other network members will “pay back” when requested. Achieving this level of trust and reciprocity may require a more complex process than one-on-one, face-to-face relationships.

Our empirical studies also indicate that it may be easier to build trust and achieve a norm of reciprocity in intra-organizational electronic networks than in inter-organizational ones. This may be because individuals within these networks have a common organizational tie and are thus working for the greater good of the company (Constant et al., 1996). However, there are other aspects to consider. Intra-organizational networks may be more stable in terms of participation, membership, and identification of participants. It is also possible that individuals are not as anonymous as they are in inter-organizational networks. Finally, misbehavior in an intra-organizational electronic network may be more easily “punished” and carry tangible deterrents, while positive behaviors may be rewarded through increases in status and reputation in the organization. As a result, intra-organizational electronic networks may be able to better control their boundaries and member behavior, resulting in more effective knowledge flows.

Our findings also support taking a *differentiated* view of networks of practice over a unitary one. The rationale for taking a unitary view of networks of practice may be meaningful in that networks of practice may be described as structures that foster knowledge sharing and learning within business firms. However, we find that imposing unitary views on networks of practice masks possible heterogeneity along two dimensions. Through our ability to contrast the findings from the series of seven empirical studies in this thesis, we have uncovered differences in networks of practice along two dimensions: 1) the type of the network and 2) the underlying practice. First, in general if we look at the findings related to performance and structure, we find significant differences across the various types of networks of practice. For example, knowledge sharing in communities of practice is positively related to general performance while knowledge sharing in intra-organizational distributed networks of practice is positively related to creative performance. Additionally, communities of practice are characterized by a more restricted reach and dyadic reciprocity than electronic networks of practice. Secondly, by conducting the analyses on the different task groups within the Icon studies, we find that networks of practice may differ based on the knowledge that is the basis for the network's practice. For example, as we see in table 7.1, the drivers of network of practice centrality are different for each of the three task groups in the second Icon study (Article 6), with participation in external networks of practice as a *positive* driver of network of practice centrality for the System and Software Group but a *negative* driver for the Commercial and Support Group. Additionally, in the first Icon study (Article 3) we found that the technically oriented individuals (e.g., system architects and software programmers) attached greater importance to their contacts in external networks, often turning first to individuals in *inter-organizational* networks of practice for help. Our analysis also revealed that the technically oriented employees rated *external* sources of knowledge as more helpful than the non-technically oriented employees did. One of the explanations for these differences offered in the qualitative data was that external sources provided a broader source of expertise and access to the latest thinking within the field, which was especially important for technically oriented employees due to the fast pace of technological change. Thus, these findings suggest that unitary views assuming common characteristics across different networks of practice risk losing their power in explaining interesting outcomes.

Table 7.1 Drivers of Network of Practice Centrality at Icon (Article 6)

Drivers of Network of Practice Centrality	Task Group		
	System and Software	Commercial and Support	Design
1. Use of internal codified sources, e.g., intranet			Positive
2. Participation in intra-organizational distributed networks of practice		Positive	
3. Internal knowledge exchange	Positive	Positive	
4. Participation in inter-organizational distributed and electronic networks of practice	Positive	<i>Negative</i>	

However, taking a differentiated view of networks of practice leads to a different way of thinking about these emergent networks. For example, instead of taking a unitary view of networks of practice in firms such as Icon Medialab that comprise numerous competence groups, a more refined approach would be to study networks of practice within each competence group. In this manner, variations related to structure, performance, and cognitive aspects may be uncovered. Furthermore and as mentioned below under practical implications, this thinking implies that generic efforts to support networks of practice across competence groups in a firm may be unsuccessful due to their inability to meet the specific needs of the network of practice within each group.

Additionally, while we have chosen not to investigate the antecedents of network of practice participation decisions in this thesis, we may further speculate that the above differences in patterns may be due to underlying differences in individual personal characteristics. In other words, choices to participate in different networks of practice may partly depend on an individual's personality type or even their education or previous training. For example, at the risk of broadly generalizing, we may speculate that individuals such as those who conduct commercial tasks in sales may be more likely to choose to communicate to a higher degree via face-to-face interactions with individuals outside the firm whom they know due to sales training or perhaps even a more extrovert personality while software

programmers may be more likely to choose to work with anonymous others in inter-organizational electronic networks of practice due to programming training or a more introvert personality. Research within the technology transfer literature supports this idea. For example, based on their research in a U.S. military R&D lab, Taylor & Utterback (1975) are of the opinion that a person becomes a gatekeeper partly based on personal inclination. Furthermore, Taylor (1975) speculated that individuals in R&D working on basic and applied research tasks are more likely to communicate with others outside their project team than those working on product development tasks since researchers are generally trained to seek help from others as opposed to attempting to solve problems based on their own resources, as technicians generally are trained to do.

Our findings also contribute to several of the debates within the network of practice literature. A review of the studies to date as well as the empirical findings from the studies in this thesis provide support for the frequency of face-to-face interactions as being a determining factor in the type of network that emerges. Thus, as indicated in our definition of communities of practice, we argue that these networks only emerge within groups of individuals whose primary communication channel is frequent face-to-face interactions and as a result are more likely to develop among groups of individuals who are co-located.

A second debate is whether innovation occurs within communities of practice or at their interstices. While the level of analysis is at the individual, our findings provide suggestive evidence for both sides of the argument. We propose that the likelihood of innovation occurring within communities of practice depends upon the degree of the heterogeneity of the backgrounds of the community of practice's members. We also find suggestive evidence for the second argument that innovation occurs at the interstices of communities of practice through brokers as evidenced by the creative performance of individuals participating in networks of practice that span internal and external organizational boundaries. However, we also find suggestive evidence that communities of practice may evolve into core rigidities and competency traps (Levitt & March, 1988; Leonard-Barton, 1992) as evidenced by the negative relationship between creative performance and participation in communities of practice.

A final contribution to the network of practice literature is that by conducting a set of seven empirical studies and including them in this thesis helps to advance our understanding of networks of practice to a greater degree than if these studies were conducted as separate works by different authors. Having conducted these complementary studies personally helps to analyze and compare the findings based on deeper insights, thus providing a more complete view of networks of practice. In order to facilitate future work on networks of practice, in table 7.1 we propose our own definitions of the various networks of practice based on the understanding that we have developed in this thesis. Additionally, we present a summary of the characteristics of the various networks of practice in table 7.2.

Table 7.2 Definitions of the Various Types of Networks of Practice

Network of Practice	Definition
<i>Community of practice</i>	An emergent group of a limited number of individuals contextually bound through close face-to-face interactions in the pursuit of a common enterprise
<i>Intra-organizational distributed network of practice</i>	An emergent group of an unlimited number of dispersed organizational members working on similar tasks using a similar competence who are generally acquainted with one another through dyadic relationships
<i>Intra-organizational electronic network of practice</i>	An emergent group of an unlimited number of dispersed organizational members working on similar tasks using a similar competence whose communication channel is purely internet-based
<i>Inter-organizational distributed network of practice</i>	An emergent group of an unlimited number of dispersed individuals regardless of organizational affiliation working on similar tasks using a similar competence who are generally acquainted with one another through dyadic relationships
<i>Inter-organizational electronic network of practice</i>	An emergent group of an unlimited number of dispersed individuals regardless of organizational affiliation working on similar tasks using a similar competence whose communication channel is purely internet-based

Table 7.3 Characteristics of the Various Types of Networks of Practice

Characteristic	Communities of Practice	Intra-organizational Networks of Practice	Inter-organizational Networks of Practice	Electronic Networks of Practice *
Location of members	Co-located	Both co-located and distributed	Distributed	Distributed
Primary communication channels	Face-to-face	Mixed face to face, electronic and other forms of communication such as news letters	Mixed face to face, electronic and other forms of communication such as news letters	Computer-mediated, threaded messages
Membership	Restricted, locally bounded	Somewhat restricted since bounded by personal relationships	Somewhat restricted since bounded by personal relationships	Open
Size / reach	Limited to same time, same place interaction	No limitations but generally smaller due to dependency on personal relationships	No limitations but generally smaller due to dependency on personal relationships	No limitations
Participation	Limited to co-location and shared practice	Open and based on shared interest in practice	Open and based on shared interest in practice	Open and based on shared interest in practice
Nature of interaction	Jointly determined, visible social and status cues	Partly jointly determined, partly filtered social and status cues	Partly jointly determined, partly filtered social and status cues	Individually determined, filtered social and status cues
Identity	High degree of shared identity, language, norms, values	Medium to medium-high degree of shared identity, language, norms, values	Medium to medium-low degree of shared identity, language, norms, values	Low degree of shared identity, language, norms, values
Restraint on behavior	High	Medium	Medium	Low

Characteristic	Communities of Practice	Intra-organizational Networks of Practice	Inter-organizational Networks of Practice	Electronic Networks of Practice *
Strength of member ties	Strong ties based on personal relationships and shared experiences, and a common history	Weak ties based on affiliation in the practice	Weak ties based on affiliation in the practice	Weak ties based on online interaction
Knowledge	High redundancy and high level of shared tacit knowledge. Characteristics of private good	Medium to medium-high redundancy and medium to medium-high level of shared tacit knowledge. Both private and public good characteristics.	Medium to medium-low redundancy and medium to medium-low level of shared tacit knowledge. Both private and public good characteristics	Low redundancy and low level of shared tacit knowledge. Public good characteristics.
Structural characteristics	High degree of connectedness. Individuals of critical mass tied to one another. Direct reciprocity	Medium degree of connectedness. Individuals of critical mass tied to one another. Both direct and generalized reciprocity	Medium degree of connectedness. Individuals of critical mass tied to one another. Both direct and generalized reciprocity	High degree of connectedness. Individuals of critical mass not tied to one another. Generalized reciprocity
Performance	High degree of efficient but generally low degree of creative	Low degree of efficient but high degree of creative	Low degree of efficient but high degree of creative	Low degree of efficient but high degree of creative

Note: We have combined intra-organizational and inter-organizational electronic networks of practice in one category. Clearly there are differences between the two, e.g., an intra-organizational electronic network of practice's membership is limited to the total number of employees in an organization. However, the primary purpose of this table is to show the differences between the four major types of networks of practice, hence we have combined the types of electronic networks of practice.

7.2.2 The Knowledge-based View of the Firm

Observed by Grant (1996), theories of the firm are conceptualizations of business enterprises that explain and predict structure and behavior. While our research has not explicitly been aimed at understanding firm theories, as mentioned in Chapter One, our intent in this thesis is to apply our thinking and empirical findings on networks of practice on both *individual-level behaviors and network-level activities* back to the level of the firm such that we may then contribute to the extant literature on the knowledge-based view of the firm.

7.2.2.1 Grant's Theory of Knowledge Integration

As mentioned under Research Purpose 2, a common theme in empirical research on the knowledge-based view of the firm focuses on knowledge integration. As Grant argues (1996a), the firm's primary task is to integrate the specialized knowledge of multiple individuals – through various coordination mechanisms such as rules, sequencing and routines. In addition, a high degree of team interdependence involving group problem-solving and decision-making is required. Competitive advantage results then from how effective firms are in integrating the specialized knowledge of their members, and Grant proposes that this effectiveness depends upon the efficiency, the scope, and the flexibility of knowledge integration. Our research is compatible with Grant's arguments of efficient and flexible knowledge integration since our findings indicate that participation and knowledge access in various types of networks of practice impact individual performance in different ways. For example, we found at Cap Gemini that those individuals who participated to a high degree in communities of practice exhibited a low degree of creative performance; however, those who participated in intra-organizational distributed and electronic networks of practice exhibited a high degree of creative performance.

However, as mentioned in Chapter Four, Grant's theory focuses primarily on issues of coordination (structuring to enhance the effectiveness of knowledge integration), without referring to issues of "cooperation". As such, this theory leaves out a key component by assuming that people are willing to share knowledge openly and freely without expecting anything in return if provided with the structures/opportunities. Our empirical studies suggest otherwise. Both our quantitative and qualitative findings indicate that this view of the firm as a knowledge integrator should be further developed by incorporating a dimension of cooperation. Norms of reciprocity and expectations of returns for knowledge sharing appear to be key factors of participation and knowledge access in all types of networks of practice. Thus, in order for an individual to access

knowledge from members in a network of practice, our results indicate that he or she must be willing to provide knowledge in return.

7.2.2.2 The Firm as a Social Community and Community of Communities

In addition to the above and in connection with the growing interest in networks of practice, there is also a significant body of literature arguing that a distinctive feature of the firm is its capacity for enabling the transfer of tacit knowledge (Kogut & Zander, 1992, 1996). Kogut & Zander (1992:384) write, "In our view, the central competitive dimension of what firms know how to do is to create and transfer knowledge efficiently within an organizational context." These authors further argue that the firm should be understood as a social community, writing "We suggest that organizations are social communities in which individual and social expertise is transformed into economically useful products and services by the application of a set of higher-order organizing principles. Firms exist because they provide a social community of voluntaristic action structured by organizing principles that are not reducible to individuals" (1992:384). The main idea is that firms are communities within which the transfer and combination of knowledge are facilitated through a shared common stock of knowledge, shared coding schemes, and a shared language. Costs of communication are lower between the firm's members due to a shared identity, which also results in shared organizing principles reflected in the firm's explicit and tacit rules of coordination and which influences the direction of search and learning (Kogut & Zander, 1996). Thus, firms are more efficient vehicles than the market in their transfer of tacit knowledge and in their ability to coordinate the combination of varieties of functional expertise.

Further proponents of this knowledge-based view of the firm are Brown & Duguid (1991, 1998), who argue that the firm should be seen as a community of communities. They write, "most formal organizations are not single communities of practice, but, rather, hybrid groups of overlapping and interdependent communities" (1998:97). While interest in these views of the firm continues to grow, with the exception of studies such as that by Zander & Kogut (1995), there are interestingly few empirical studies investigating these views. However, our findings are both compatible with and suggest further areas for development within this view.

Support. First, our findings are compatible with the view of the firm as a social community and a community of communities (figure 7.1). At the local level, we find that individuals are members of communities of practice, with a high degree of participation in these communities leading to a high degree of efficient and, in some circumstances, creative performance. Individuals within these local

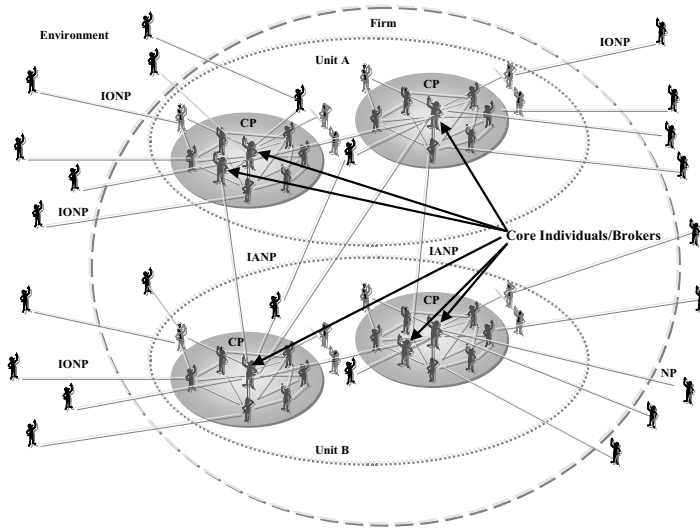
communities may then also be members of intra-organizational distributed and electronic networks of practice. Individuals participating to a high degree in these networks serve as brokers, bridging local communities of practice through exchanging, transferring, and translating knowledge between them. Theory suggests that the transfer of knowledge between these individuals is facilitated by a shared common stock of knowledge, language, and norms, and that new knowledge is created through the combination of local knowledge with less redundant distant knowledge within the firm. Our studies provide suggestive evidence of this since we found that those individuals who participated to a higher degree in intra-organizational distributed networks of practice exhibited a higher degree of creative performance.

In addition, Brown & Duguid (2000) view the firm as being interconnected with other firms through their members' participation in inter-organizational networks of practice that tie together individuals from a variety of external organizations. Our results are compatible since we find that individuals regularly tap into external sources of knowledge through participation in inter-organizational networks of practice to get their work done. In the first Icon study, we even found that the production-oriented technically oriented people made greater use of external sources of knowledge than their commercially oriented counterparts, *especially* when solving difficult problems. Thus, in knowledge-intensive firms such as Icon and Cap Gemini, employees are able to communicate across external organizational boundaries with others working on similar problems and as a result, access new knowledge and ideas.

Within these views of the firm, proponents argue that one source of innovation lies in the interface between a firm and its environment (Brown & Duguid, 1991) and that the creation of new knowledge occurs through the combination of novel external knowledge with internal knowledge (Kogut & Zander, 1992). In line with this, we find in our quantitative results that the access of external knowledge through participation in inter-organizational networks of practice does not have a direct impact on an individual's creative performance. Rather, it affects performance indirectly through its influence on internal knowledge exchange. Thus, our findings suggest that individuals combine externally gathered knowledge with their own as well as with knowledge obtained within the firm through participation in intra-organizational networks of practice. Additionally, as our qualitative findings from the first Icon study (Article 3) suggest, this external knowledge may need to be translated in order to adapt and combine it for the firm's specific use.

Figure 7.1 The Firm as a Social Community and Community of Communities

IONP: Inter-organizational network of practice
 IANP: Intra-organizational network of practice
 CP: Community of practice



Finally, the view of the firm as a social community also argues that performance differences among firms partly arise due to the ability of firms to transfer knowledge within their boundaries due to shared coding schemes, shared values, shared identity, and higher organizing principles (Kogut & Zander, 1992). We found suggestive evidence for this claim in our final study that focused on the R&D operations of three multinationals. In this study, we observed that the highest performing firm, Hewlett-Packard, is the one that exhibited a higher degree of shared identity by members across the firm's geographically distant operations as well as higher levels of knowledge sharing between members of intra-organizational distributed networks of practice.

Areas for Development. In addition, our findings also indicate some areas for further development in the field. First, at the individual level, our studies indicate that the issue of an individual's membership in the firm should be considered. Within networks of practice, one of the primary themes in both the research on networks of practice to date as well as in our empirical studies is the degree to which an individual is a member of a particular network of practice. If you recall, Wenger (1998) proposes that there are different levels of

participation within a community of practice: full participation (insider), peripherality, marginality, and full non-participation (outsider). In order for an individual to obtain access to the community and its knowledge, it is necessary for the individual to become an “insider”. This occurs through a process of legitimization through mutual engagement, collaboration, and storytelling, during which the individual learns the values and the informal and technical language of the community, while most importantly, how to function as a community member (Lave & Wenger, 1991). Insiders are full members at the core of the community, having fully mastered the community language as well as the community rules and how to use them. They know such things as who is involved with what activities and what is needed to become a full member of the community, and they are able to perform the practice in a more effective means than those in the periphery.

However, the traditional perspective on organizational membership in the literature views membership as a binary state⁵⁹. Yet if the firm is to be viewed as a social community, then we should be able to apply this network of practice thinking regarding membership as well to the firm. The argument then would be that individuals are “members” of a firm to differing degrees, as a function of their time in the firm, their participation in mutual engagement and collaboration with other firm members, their ability to master the language and norms of the firm, their degree of shared identity, and even their desire to become a full member of the firm. Individuals who are insiders in the firm due to their having fully mastered the firm’s practice, language, and rules and how to use them would be found at the core of the firm. We may then hypothesize that the degree to which an individual is a member of the firm and in the core of the firm’s entire network of internal networks of practice will be associated with a higher degree of individual performance. What this implicitly argues then is that

⁵⁹ Building on Weber, several researchers see individuals as being either members or non-members of formal organizations (Scott, 1998). Aldrich (1979: 221) writes, “The minimal defining characteristic of a formal organization is the distinction made between members and nonmembers, with an organization existing to the extent that entry into and exit out of the organization are limited. Some persons are admitted, while others are excluded.” Following Weber (1947: 140), organizational membership is then defined in the following way: “A party to a closed social relationship will be called a ‘member’.” This perspective holds that organizational authorities control the entry and exit into and from an organization and set the conditions for member entry and exit. In addition, authorities control “wages or salaries, hours of work, amount of work expected, and the allocation of a member’s organizational time” (Aldrich, 1979: 222). Thus, in this view, individuals are either a member or a non-member. Individuals employed by a firm are members since the firm’s authorities have admitted them under certain entry conditions, and those who are not employed are non-members.

full firm members will have mastered the practice of the firm through mutual engagement and collaboration (as predicted by theory) and will benefit through superior performance, whereas individuals who are less firm-like in their behavior and do not collaborate with others in the firm will have inferior performance. If such a hypothesis is not supported, then we have evidence that mutual engagement, collaboration, and membership are *not* valuable to performance, which would throw into doubt the overlying argument that we see the firm as a social community.

While it may seem strange to claim that some people are more “members” of a firm than others, not only is this view consistent with network of practice theory, but it is also entirely consistent with the concept of fuzzy logic. Fuzzy set theory, introduced by Lofti Zadeh in the 1960s, implements classes or groupings of data whose boundaries are not sharply defined, i.e., fuzzy. In this manner, fuzzy set theory deliberately blurs the rules of logic that insist that categories are unambiguously applied and that there is an “excluded middle” between something being and not being the case. The benefit of applying fuzzy techniques is the strength in solving real-world problems, which inevitably entail some degree of imprecision (Battelle, 1997). While we do not propose that there is a direct correspondence between the use of the concept in mathematics and our application here, we do feel that this concept may improve our understanding of the membership of individuals in firms. In addition, this is not the first time that this term has been used in the management literature. Hagström (2000) used this term to describe the networks of a firm’s relationships that fall between market-type and legal firm relationships.

The results from our extensive social network study of the entire body of employees at Icon in 26 offices in 16 countries (n=1698, Article 6) are compatible with this view of the firm as a social community with individuals exhibiting different degrees of firm “membership”. First, we find that individuals who participate to a higher degree in communities of practice within Icon’s subsidiaries and thus are full members of the local practice exhibit a higher degree of individual performance. We also find that individuals who participate in mutual engagement, collaboration, and knowledge exchange with others throughout the firm to a higher degree are those who are in the core of the firm’s internal networks of practice (network of practice centrality), and these individuals also have a higher degree of creative performance. Finally, we find a *direct negative* relationship between participation in inter-organizational networks of practice and centrality. Thus, those individuals who merely access knowledge externally to a higher degree but do not combine this knowledge with that of others through participation in the firm’s networks of practice

remain on the outskirts of the firm and by implication achieve lower levels of creative performance.

Another area for further consideration that is related to firm membership regards the individual motivations of firm members. Kogut & Zander view the firm as a “social community of voluntaristic action”, arguing that the “assumption of the selfish motives of individuals resulting in shirking and dishonesty is not a necessary premise in our argument” (1992: 384). Thus, if we understand the argument correctly, their view is based upon the assumption that individuals within a firm are generally willing to collaborate and share their knowledge with one another. Applying our thinking from theories of public goods and collective action, the implicit underlying assumption then is that the firm should be viewed as a collective with the knowledge produced by the firm as a public good. However, as our literature review on electronic networks of practice revealed, previous studies indicate that individuals make choices regarding their willingness to share with others based on the expected payoffs. Research on electronic networks of practice, an organization that is perhaps closer to being a collective with knowledge as a public good than a traditional business firm, provides evidence that individuals are motivated not only by collective interest (e.g., interest in advancing the community) but also by self-interest (e.g., enjoyment, increased reputation) (Lakhani & von Hippel, 2000; Wasko & Faraj, 2002). Our study of an electronic network of practice (Article 2) reveals that those individuals who are the most willing to participate through sharing their knowledge and thus in the core of the network are motivated by self-interest since they are concerned with enhancing their own reputations. However, those individuals who ask others for help are motivated by collective interest since they view their participation as a means to sustain the network.

Applying this thinking to the firm, we would then expect that firm members make choices regarding their participation and willingness to share with others within the firm based on expected individual and collective payoffs. However, since individuals also may participate in inter-organizational networks of practice, the indication is that individuals weigh payoffs from internal participation with payoffs from external participation. In some cases, as indicated in the first Icon study (Article 3), external payoffs may even outweigh internal payoffs. For example, in the qualitative data we found that individuals chose to leak the firm’s proprietary knowledge to individuals in other firms in return for a self-benefit of increased reputation or a collective benefit of advancing the professional community. As a result and in line with our argument above, some individuals may then choose to be lesser members of the firm than others due to higher expected returns from external participation.

Finally, in addition to individual motivations to participation and knowledge sharing, community of practice theory would argue that participation in the firm is jointly determined. Thus, although some individuals desire to become full members of the firm through choices to participate and share their knowledge with others within the firm, they may not be allowed to do so by other individuals within the firm. Thus, the individuals found in the periphery in the second Icon study (Article 6) may not all be there by choice. Some of these individuals may be there because they are not allowed into the firm by other firm members. Thus, the only available sources for help may be external ones.

Following from the above, our findings also suggest then that the boundaries of the firm in knowledge-intensive companies such as Icon and Cap Gemini are less rigid than traditional theory would imply, with individuals tapping regularly into informal external sources of knowledge. While the knowledge-based view argues that a firm's boundaries provide a demarcation in identity with members of a firm attaching meaning to their firm membership and having a shared identity (Kogut, 2000), we may further suggest that this may be expanded. First, drawing from the network of practice literature, this shared identity implies that the boundaries of the firm are not only determined by the willingness of an individual to share with others in the firm but also by the ability, or rather the inability, of the individual to use externally accessed knowledge within the firm's local context and practice. In other words, individuals develop a shared identity due to their willingness to interact and share with others in the firm and as a result are less able to apply external knowledge than internal knowledge in their work. However, building on the above discussion of varying degrees of membership and community of practice theory, we suggest that a firm may be characterized by a core of individuals with a higher degree of shared identity surrounded by rings of individuals with decreasing degrees of shared identity. The more an individual chooses or is "restricted" to participate in external networks of practice while participating less in the firm's networks of practice, the more likely this individual may have a lower degree of shared firm identity but a higher degree of shared external identity. In some cases, an individual may even have a higher degree of shared external identity than firm identity. Seen in this light, we propose then that a firm's boundaries in addition to its members are fuzzy as well.

This speculation regarding firm boundaries and membership also has implications when discussing the hybrid form of organization. Most arguments concerning the hybrid organization think of the hybrid in terms of contractual relationships between two parties that are usually at the organization level, e.g., joint venture, alliance between two companies, etc. (Williamson, 1991).

However, our results indicate that hybrids can occur at the individual level as well, with some individuals falling somewhere between full-scale firm members and independent contractors. Thus, it could be hypothesized that this individual behavior makes some “hybrid” organizational form likely - in which individuals are still members of firms, but they also exhibit certain market-like behaviors.

A second area for development within the knowledge-based view of the firm relates to our findings regarding the structural properties of networks of practice. If we view the firm as a social community and community of communities, then building on our findings from Research Purpose 1, we may develop a set of appropriate structural properties. For example, we would expect to see within the firm as a whole a similar constellation to that of various types of networks of practice: a core of full members surrounded by rings of peripheral members and perhaps even non-participants. Other properties involving measures such as density, graph-theoretic distance, and connectedness could then be developed to help determine the degree to which knowledge sharing is occurring across the firm or language, values, and norms are potentially shared. These structural properties could then facilitate further theorizing within the knowledge-based view of the firm or facilitate a means to compare firms on various dimensions.

7.2.2.3 Absorptive Capacity

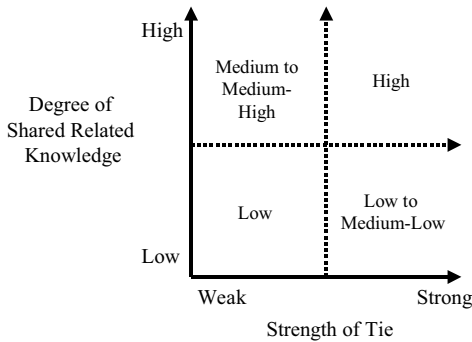
On a final note, our results are also in line with absorptive capacity theory by Cohen & Levinthal (1990). Absorptive capacity has been defined as the ability of a firm to recognize the value of new, external knowledge; assimilate it; and apply it to commercial ends. The authors argue that a firm’s absorptive capacity is dependent upon the absorptive capacities of its individual members and is not only a factor of the firm’s direct interface with the environment, but it also is a factor of the firm’s ability to transfer knowledge from the point of entry to throughout the firm. Furthermore, in order to assimilate and use new knowledge, individuals and the firm need to have prior related knowledge.

Our findings further suggest that absorptive capacity and performance are enhanced by the combination of new knowledge with existing knowledge that crosses intra-organizational boundaries through individuals participating in knowledge exchange within intra-organizational distributed networks of practice. Our individual performance findings further indicate that knowledge coming from outside the firm cannot be easily transferred into and applied to any immediate solution inside the firm. Rather, external knowledge accessed by individuals through participation in inter-organizational networks of practice must be translated to the firm’s local context and practice through a high degree

of personal interaction and knowledge exchange through internal networks of practice.

Finally, we further suggest that we may borrow from the work on absorptive capacity by proposing that ties between individuals can be characterized by their *absorptiveness*. We feel that the dimension of strength does not adequately reflect the ability to absorb knowledge through a tie. Thus, we propose that the characteristic of absorptiveness is based on two dimensions of ties: strength and the degree of shared related knowledge. In other words, if a tie between individuals is characterized by a high degree of absorptiveness, then the individuals may easily assimilate and use knowledge shared through the tie due to a high degree of shared related knowledge as well as a high degree of strength. An example of this is individuals who are members of the same community of practice. However, a medium to medium-high level of absorptiveness may still be achieved through ties that are weak, contrary to what social network theory might suggest. For example, in an inter-organizational electronic network of practice for programmers working with C++, a member may have a weak tie with other members in the network of practice since he participates primarily through lurking. However, the individual could still be able to rather effectively absorb knowledge accessed in this electronic network of practice for use in his work due to a high degree of absorptiveness stemming from extensive prior experience in C++. At the same time, this individual may have a series of strong ties with other individuals who have a low level of prior related knowledge, e.g., colleagues from another department with whom one eats lunch, thus the ability to absorb relevant knowledge through these ties is low to medium-low. Lastly, ties that are both weak as well as characterized by a low degree of prior related knowledge have a low degree of absorptiveness, e.g., colleagues in another department located in another location. We illustrate our thinking in Figure 7.2.

In summary, our research makes several contributions not only to the network of practice literature but also to the knowledge-based view of the firm. In addition to these theoretical implications, there is also a set of practical implications, which is the subject of the next section.

Figure 7.2 Absorptiveness of Ties

7.3 Implications for Practice

7.3.1 Knowledge Management

One of the primary implications of the results from our research is for the field of knowledge management. Our findings indicate that organizations concerned with knowledge management may need to rethink their knowledge management strategies. First, what is to be made of the high use of external knowledge sources? To date, knowledge management systems have focused on leveraging knowledge *within* the organization. In some instances, these systems may also include other organizations (sometimes referred to as extranets), yet these other organizations fall within the realm of the organization's formal task environment. However, as our studies reveal, informal external sources are used highly by individuals in addition to having a positive influence on creative performance and in some cases a negative influence on efficient performance. A challenge then for management is whether knowledge management systems should be developed that facilitate the use of external sources. At Icon, interviews with technically oriented individuals group reveal that these individuals prefer going outside the organization to external electronic communities to asking others within Icon for help. Not only could more answers be found to their questions, but also the speed with which answers were given was much faster than using internal knowledge sources.

Second, what do we make of the result that different patterns of knowledge sourcing and participation in networks of practice are associated with different performance outcomes? With the rapid development of the ease of use of the

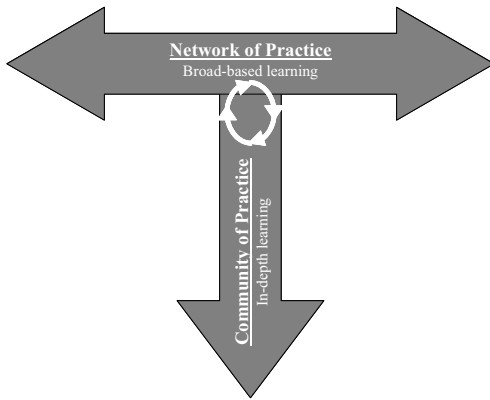
internet (e.g., smart agents, more specialized discussion forums) and the increasing ability of individuals to use the internet to communicate with others in their external networks of practice, this media is expected to become a much more helpful knowledge source. While the use of external sources and participation in inter-organizational networks of practice has a positive relationship to creative performance, we find, however, that it is participation in communities of practice that leads to superior efficient performance. The question then becomes how to balance the use of external networks of practice with internal ones to ensure a productive ratio of creativity to efficient performance. One suggestion is that knowledge management systems could be aimed at facilitating a balance between efficient and creative performance that matches a company's competitive strategy. As we find here, knowledge integration patterns differ depending upon which type of performance is the objective. In some organizations, a focus on efficient performance through systems that promote local communication may be the objective while in others a focus on creative performance through systems that promote the development of inter-organizational networks of practice may be the objective.

In addition, this research shows that implementing generic knowledge management strategies across an organization may not prove successful. As we observed, the technically oriented individuals at Icon differed significantly both in their use of various knowledge sources and the relationship to individual performance and centrality. These differences imply that knowledge management systems tailored to each group of employees based on its practice knowledge may be more successful. For example, for groups such as the System and Software Group, a system focused on the use of external knowledge sources as well as internal ones may be a better use of a firm's resources than a system that only focuses on internal ones.

This research also indicates that internal knowledge management systems may be more successful if they focus on linking individuals together as opposed to focusing on knowledge repositories. Results are in line with previous research, suggesting that individuals prefer to communicate with others when searching for knowledge. These results then suggest an important new use of internet-based communication technologies to support knowledge management. Rather than using technology to replace traditional knowledge management techniques, such as creating document repositories, management may need to think of non-traditional ways to leverage these new technologies for improved knowledge flows within and across the firm, by leveraging networks that support the exchange of advice and ideas between individuals.

Our findings also suggest some practical implications for the development and maintenance of electronic networks of practice. First, our study indicates that electronic networks of practice do not need equal member participation, but rather they can be sustained through the collective actions of a small percentage of members who form a critical mass. This critical mass is able to provide the public good through generalized exchange of advice and solutions. These individuals are often concerned with enhancing their reputations in the network, thus technology that supports identifiers of individuals may be more likely to succeed than systems where participation is anonymous. In addition, we found that those most likely to develop the critical mass were tenured experts in their area, but may not have easy access to other interested individuals. Thus, unlike communities of practice that require face-to-face interaction, electronic networks of practice transcend traditional barriers to knowledge exchange through the creation of knowledge as a communal public good, available to all members of the collective.

Finally, our research findings suggest that intra-organizational distributed networks of practice are a valuable *complement* to traditional face-to-face communities of practice. Learning in a distributed or electronic network of practice appears to be on a broader, more general level (i.e., learning about new areas and topics within the practice) while learning in a community of practice may be of a deeper, more specific type (i.e., learning how to apply the new area to one's specific task). This distinction may be characterized by a "T" format as shown in figure 7.3. We argue that in order to improve an organization's ability to efficiently integrate knowledge while simultaneously creating new knowledge through flexible knowledge integration, organizations should focus on sponsoring *both* traditional communities of practice and distributed and electronic networks of practice as well as stimulating the *interaction* between the two. Through the active participation of organizational members in both communities and networks, these organizational forms become integrated, thus resulting in the exchange and recombination of existing knowledge to create competitive advantage. In addition, the integration of these two may serve as a defense mechanism against the "not-invented-here" syndrome, core rigidities, and competency traps.

Figure 7.3 T-based Network of Practice Learning

7.3.2 Participation in Inter-organizational Networks of Practice

Just as individuals have a certain degree of commitment to their organizations, they also have a degree of commitment to their profession or occupation as several researchers have noted (e.g., Saxenian, 1996; Brown & Duguid, 2001). In some professions, the degree of commitment to the profession can be so strong that the norms of the profession even transcend the norms of the organizations that employ the individuals. Members of professions can be separated by great distances and still see themselves as part of the same professional group. Academics have long been examples of individuals with a strong degree of commitment to their profession (Pickering & King, 1995).

The implication from our results is that individuals may then hold multiple identities, as Kogut & Zander (1996) posit. On the one hand, individuals belong to their firm, while on the other, they may belong to a professional network outside the firm, as evidenced through the high participation in inter-organizational networks of practice. Thus, an individual may be faced with competing allegiances and conflicting objectives. This can be best described through our qualitative findings from the first study at Icon in which it was found that these conflicting identities were strong within Icon, primarily among the programmers. While programmers were inspired by management to make Icon the world's best company, they were, however, pressured by their external internet communities to produce the latest "cool" solution. In addition, programmers were under social pressure from their external networks to help

fellow members solve their difficult problems, often attempting to “show off” in front of the others. This was found to lead to conflicting goals for the programmers: best company vs. best function.

One result of this participation in inter-organizational networks of practice is that individuals may spend too much time “working for” their external network. The first Icon study revealed that individuals who spent time working with others in electronic communities were more likely to have a poor level of efficient performance. Interviews with some of these individuals revealed that they often were so busy helping others outside of Icon or striving to create elegant or “bleeding edge” solutions to impress others in their external networks of practice that they were unable to focus on finishing their own tasks according to management’s objectives. Furthermore, it appeared that these individuals had considerable “power” over management. This power resulted from management’s inability to understand in detail what their employees were doing since they were unable to keep up with the rapid pace of technological development. Thus, management often did not know whether employees were working on necessary value-adding activities or were spending time trying to impress their peers. One manager summarized this situation with reference to the software programmers, “Programmers take us (management) hostage. We never know whether they’re working on extra bells and whistles to impress their buddies or whether it’s really a value-adding activity for the customer.” For some individuals, the payoffs may be greater from developing the “latest and coolest” solution than from completing their work on time and to their supervisor’s requests.

The second challenge is more of a threat to a firm’s competitive advantage – the trading of proprietary know-how or information. The development of the internet has greatly facilitated the degree by which proprietary information can be traded between companies without management’s knowledge. In many cases, management is completely unaware that its employees are engaging in this behavior. The decision whether to transmit proprietary knowledge is placed within the hands of the individual. If an individual is trying to enhance his or her identity in the external network, then he or she may leak this proprietary knowledge without receiving anything of value for the company in return. However, the results of this research seem to provide contrary evidence, that external knowledge exchange is beneficial for the firm, although indirectly through the recombination with existing knowledge. This indirect relationship also implies that while an individual may trade away “proprietary” knowledge, the ability of a rival firm to turn this into an innovation lies in its ability to integrate it with its own existing knowledge bases in the firm.

Third, while some organizations have attempted to stop the cross boundary flow of knowledge within these inter-organizational network, these attempts may be counterproductive (Brown & Duguid, 2001). Attempting to block participation in inter-organizational networks of practice may only lead to increased loyalty to the external network and decreased loyalty to the organization and potentially a negative effect on individual performance. And as noted above, these flows are two-way, generally characterized by an equal exchange of knowledge. Thus, cutting off flows to outside of the firm will more than likely risk cutting off flows into the firm (Saxenian, 1996; Brown & Duguid, 2001). Interviews at Icon conducted considerably after data collection in the second study revealed as well that after management focused on increasing the development of solutions through internal knowledge gathering and reducing participation in external networks of practice, the level of creative solutions and the ability to compete dropped in addition to a number of high performers leaving the firm.

Finally, one implication of this research is that when management hires a person, management is also “hiring” the employee’s external network as well. Thus, management must consider the potential employee’s external network and how active the individual is in this network. If the person is very active in this external network, then the individual’s time may be spent on external activities. As indicated here, individuals who participate to a high degree only in external knowledge exchange and not in internal exchange, are less central in the firm and may exhibit a lower degree of efficient performance. Another aspect to consider is which individuals are included in the potential employee’s network and what value these individuals may provide to the organization through external knowledge exchange.

As a result, it can be suspected that individuals will most likely have to balance their participation in the firm with their participation in external networks. In some cases, individuals may feel that their relationship with their employer is subordinate to their relationship with their outside network. They may feel that they can always get another job through their network and they may take their network with them no matter where they work. Thus, this leads us to question whether the internet is creating a second professional environment *external* to the company that now can compete with and displace the professional environment of the company. The success of an individual may no longer be tied solely to his or her performance within a company. In one sense we are beginning to see this already in Silicon Valley where individuals claim that they work for “the Valley” and not for any one particular company (Saxenian, 1996). As these external professional groups grow, they may become potential rivals to managerial control if the profession has a higher influence than the organization

on the individual. This may occur when the individual has a higher degree of commitment or loyalty to the profession than to his or her organization. In addition, the professional group to which an individual belongs may have a strong code of norms and values that management has difficulty in influencing (Pickering & King, 1995).

7.3.3 Brokers

This research has also provided evidence that management should pay considerable attention to developing an understanding of who the brokers are in the organization since they are of considerable importance to the firm. Brokers are influential in the future of the firm since they are one of the primary determinants in the direction of the firm's knowledge development. Due to their central position in the firm's intra-organizational networks, brokers wield power over resources. As a result, they influence the organization's knowledge flows between firm units and the knowledge sourcing processes of other individuals. Brokers provide their own knowledge or provide pointers to relevant experts in the firm or even outside the firm when others from across the organization come to them for help. Additionally, they are critical in determining which external knowledge is combined with which internal knowledge due to participation in knowledge exchange. While most individuals throughout the firm participate in some kind of external knowledge exchange, it is easier for brokers to trade away the firm's more valuable knowledge since they have greater access to the firm's more valuable resources and critical knowledge due to their position. Decisions to trade and the ability to obtain valuable external knowledge are based on their own judgment. Finally, brokers may also influence the degree to which other individuals become true firm members. In summary, since knowledge is argued to be the most valuable resource of the firm (Kogut & Zander, 1992; Grant, 1996a,b, Nahapiet & Ghoshal, 1998), brokers are critical to the firm's knowledge integration processes and the ability to create sustainable competitive advantage.

7.3.4 Achieving the Balance

Thus, one challenge for management is to achieve the appropriate balance of participation in inter-organizational and intra-organizational networks of practice by firm members to facilitate the optimal mix of efficiency and creativity. While we have not specifically studied how this might be achieved, we provide here some areas for consideration by management. One suggestion is that management might focus on aligning the balance of participation in internal and external networks of practice with the company's competitive

strategy. For example, if the firm is pursuing more of a knowledge creation than a knowledge reuse strategy (Hansen, Nohria, & Tierney, 1999), then encouragement of participation in external networks of practice over internal ones may facilitate creativity and access to the latest solutions. However, if the firm's strategic focus is on knowledge reuse, then too much external participation may lead to an inefficient use of resources. Additionally, as we noted above, taking a generic view of networks of practice throughout the competence groups in the firm may lead to poor results, indicating that the appropriate balance may also need to be reconsidered for each competence group.

Furthermore, if there is one takeaway from this research for managers, it is that efforts to "control" participation and knowledge sharing in various networks of practice by firm members will more than likely be fruitless or even counter-productive. For example, in the studies in the literature review as well as those performed for this thesis, we found that individuals participated in external networks of practice and consciously traded company secrets with others in competitive firms despite it being against company policy. Thus, one means of achieving the appropriate participation levels in the different networks of practice may be for management to interview potential employees regarding their problem-solving and knowledge-gathering behaviors during recruiting and to select those whose problem-solving behaviors match the needs of the firm. Other means may include management clearly communicating the firm's knowledge management strategy (e.g., knowledge creation vs. knowledge reuse) and knowledge-sourcing strategies and aligning human resource policies such as evaluation and remuneration practices to reflect the desired balance. Finally, various socialization efforts may also help in two ways: 1) to increase participation and knowledge sharing in communities of practice and intra-organizational distributed networks of practice and 2) to increase employee loyalty and commitment to the firm such that individuals make the appropriate decisions when trading knowledge across a firm's boundaries.

7.3.5 The Future Firm

One area for final speculation is what the firm of the future will look like. While we are still in the first years of internet use, one of the main questions that this research raises is what will organizations look like thirty years from now when a generation who has never known life without the internet will have entered the work force. These individuals are learning to use internet-based communication tools in a completely different manner than today's users in firms. One of the main complications for many of today's internet users in firms

is that they have difficulty believing that they can build trust-based relationships with people with whom they communicate over the internet and have not met face-to-face. This affects their ability to then work together with others purely over the internet and thus their ability to exchange the more valuable tacit knowledge with one another. Many of today's users are stuck in old ways of learning to trust others based on physical presence – body language, appearance, tone of voice, etc. However, as individuals increase their use of the internet, they may learn how to trust others based on other cues, for example the timeliness of others' responses, the ways in which messages are formulated, etc. This will then affect their ability to work together with others over the internet and thus the degree to which they choose to participate in both intra-organizational and inter-organizational electronic networks of practice and thus their firm membership.

This speculation then has potential ramifications for the firm as we know it today. Will the dominant organizational form then become one of “fluid and temporary networks” of independent contractors rather than traditional firms? Today this organizational form is already dominant in certain industries such as the film industry. Will this form continue to grow in certain industries, but never gain ground in certain others that will continue to be dominated by face-to-face traditional firms? These questions provide an exciting area for future research, which is the subject of the next section.

7.4 Limitations and Suggestions for Future Research

Despite the strengths of the comprehensiveness of this thesis, we should also note its limitations. On a more general note, first, we have taken primarily a structural approach in the studies and as such, we have generally not focused on any of the cognitive aspects of networks of practice when conducting our analyses. One potential research area then is the interaction between the structural and cognitive dimensions of the various types of networks of practice. Second, the studies relied on cross-sectional data collection. On one hand, this methodology is appropriate for model testing. However, a cross-sectional approach tells us little about how the social context develops over time, what factors influence its development, and how motives and social context interact and change over time. Thus an area of future research could examine network dynamics at different points in time, as well as how individuals' participation in various networks changes over time.

Generalizability of the study findings is also an issue. It is difficult to assess how representative the findings are for other organizations and networks of practice than the ones examined here. Although the focus was on knowledge workers exchanging knowledge, networks of practice within lesser knowledge-intensive firms or consisting of scientists, researchers, or engineers as well as non-business organizations may have different membership and exchange dynamics. Thus, studies comparing various networks of practice and their dynamics across a variety of organizations are suggested.

Additionally, in this research, our definition of knowledge and knowledge sharing incorporated the whole scale from tacit to explicit knowledge. Nor did we look at the strength of the relationships between individuals in the advice networks. However, previous research suggests that at the unit level the relationship between performance and the position in the firm is dependent upon the type of knowledge being transferred as well as the strength of the tie (Hansen, 1996). The work by Jarvenpaa & Staples indicates that a distinction should be made between information and expertise and that the relationship between organizational ownership and self-ownership of information and expertise should be examined. Finally, as Bouty's study revealed, confidentiality is socially constructed and there are open secrets. Thus, future research should incorporate these different dimensions of knowledge, tie strength, knowledge ownership, and confidentiality.

On a more specific level, for the studies on the structural dimensions of a community of practice and an electronic network of practice, we examined only one specific type of network of practice, thus limiting our ability to generalize to other similar networks of practice. For example, other types of electronic community interactive technology exist such as chatrooms, and the use of different media may affect electronic network of practice dynamics. In addition, these studies relied on data that were primarily cross-sectional. Thus, we were not able to investigate changes over time. Subsequent studies should be longitudinal to understand network of practice lifecycles. Longitudinal analysis should also look at the nature of interdependence of individuals' decisions to contribute to the public good in the case of electronic networks of practice. It has also been argued that reciprocal interdependence and not sequential interdependence characterizes interactive communication systems (Fulk et al., 1996). However, it has yet to be tested empirically. In addition, studies should be conducted on the other various types of networks of practice.

A final issue of interest and further research is the aspect of lurkers. In electronic networks of practice, individuals may free-ride through lurking,

reading all messages to gain access to the network's knowledge without ever posting themselves. There is also the question of whether people who continually ask questions, receive help from the electronic network of practice, but never bother to help anyone else in the electronic network of practice are free-riders. It can be argued that these individuals actually do contribute to the public good because they stimulate a thought process by other participants or provide support through side posting. However, this type of participation only works if there is a critical mass of individuals who continue to respond to postings. Finally, while a participant may be interested in contributing, if there is low electronic network of practice activity, then he or she may feel that their actions will not be reciprocated the next time they need help and thus, their time spent helping is lost.

As for the studies investigating individual performance, this research only examined individuals within two companies, thus limiting the generalizability of our findings. Thus, further research should examine knowledge integration and the relationship to individual performance across multiple organizations. Second, data were collected at one point in time. Another limitation is our use of self-reported survey measures for performance. Thus, future research should include other performance data sources as well as the collection of data over time to further establish the relationships between participation in various networks of practice participation and performance. Additionally, we have primarily investigated performance at the individual level. As we found in the review of empirical studies, research looking at the relationship between different types of networks of practice and their dynamics with performance at different levels, such as the network or the organization, is needed. Finally, it may be argued that our results regarding individual performance seem to oversimplify the picture. As indicated above, we have not investigated the antecedents regarding individual decisions to participate and share knowledge in different networks of practice. Not only may personal characteristics influence which individuals participate in which networks of practice, they may even further influence outcomes once the choices are made, thus providing another interesting area for research.

In terms of the knowledge-based view of the firm, we have uncovered several areas for future research. First, Grant (1996a) proposes three dimensions of effective knowledge integration. We investigate two of these: efficient and flexible knowledge integration. However, due to the already complex nature of this study, we did not investigate the third dimension, the scope of integration. Clearly, it would be of interest to look at the effect of the scope of integration and its relationship to individual performance. Second, research on the firm as a

social community and community of communities should examine the motives of individuals and their choices regarding their participation and willingness to share knowledge with others within the firm vs. others outside of the firm. Another interesting research area is the investigation of differences in patterns among individuals from different functional groups.

Although not discussed here, with respect to organization design, the traditional view of organization design proposes that interactions with the environment take place through formal inter-organizational relations or through formal boundary spanning roles in the periphery of the organization. However, our results indicate that individuals are embedded not only in intra-organizational networks of practice but that they are also embedded in networks of practice that extend across an organization's external boundaries. Individuals regardless of position and task rely to a high degree on these external networks of practice for advice and knowledge in solving their everyday work tasks. In the process, individuals exchange knowledge, accessing external knowledge and combining it with internal knowledge. These findings suggest that the boundaries of the firm are not as porous as traditional theory has suggested. Thus, concepts such as the Thompsonian protected technical core surrounded by boundary spanning individuals performing support activities such as salespeople may no longer apply and should be investigated (Thompson, 1967).

On a final note, while studies to date on the structural properties of networks of practice have been limited due to difficulties in collecting data, the ability to conduct studies investigating the structural properties of networks through social network analysis is improving dramatically due to advances in internet-based communication. For example, Tyler, Wilkinson, and Huberman (2003) describe in a working paper a methodology for the automatic identification of networks of practice from email logs at HP labs. Using 185,773 logged emails during a two-and-a-half month period between HP employees, they argue that their method is effective in identifying both formal networks and networks of practice. Thus, one exciting area for future research is to explore the ability to use these new communication media as a tool to investigate various types of networks of practice.

7.5 Conclusions

In summary, the overarching goal of this thesis has been to improve our understanding of networks of practice from a business firm's perspective and in particular to investigate issues of structure and performance. First, we

conducted an extensive literature review of the research conducted on the various networks of practice to provide us with a current “state of affairs”. Second, we conducted a series of seven complementary empirical studies that addressed two research purposes based on the identified gaps of structure and performance within the network of practice literature. Results from the studies addressing the first research purpose provided the development and testing of various network of practice structural properties and revealed that the two polar forms of networks of practice have significantly different patterns of knowledge flows, suggesting that the various types of networks of practice differ in terms of their cognitive dimensions. The studies addressing the second research purpose provide evidence that an individual’s performance is related to participation in various types of networks of practice. Finally, this thesis provides a more comprehensive view of networks of practice than if the studies were conducted separately due to our ability to compare the various networks of practice on various dimensions based on both the literature review as well as our empirical studies. As a result, this thesis suggests taking a *differentiated* view of networks of practice over a unitary one since imposing one view on networks of practice masks possible heterogeneity along two dimensions: 1) the knowledge of the practice and 2) the form of the network of practice.

In addition to contributions to the network of practice literature, we then applied our findings to the extant knowledge-based view of the firm literature and suggested areas for future development. In particular, the findings of the last two studies, one based on an extensive social network study of a modern multinational and the other based on case studies of three large, traditional multinationals, are compatible with the view of the firm as a social community and a community of communities in which individuals are fuzzy members. Finally, we provided a discussion of our findings in terms of implications for practice before leaving the reader with an understanding of where future research could be conducted.

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APPENDIX ONE

A Look at Knowledge

THIS SECTION PRESENTS some of the current perspectives relating to knowledge, e.g., dimensions of knowledge (individual vs. collective, tacit vs. explicit) and knowing. This discussion is not meant to be exhaustive of the perspectives relating to knowledge, rather the idea is to give the reader an initial understanding of these perspectives as related to the purpose of this thesis.

1.1 Dimensions of Knowledge

Since its appearance in the 1970s in connection with the organizational learning literature, research on “knowledge” has continued to grow. In recent literature, researchers have tended to focus their discussions on two dimensions of knowledge: (1) the tacit / explicit dimension and (2) the individual / collective or group dimension (Cook & Brown, 1999). We discuss each of these dimensions separately before looking at the relationships between these.

The tacit-explicit dimension was one of the first distinctions of knowledge to be made in the organizational literature. This distinction has its roots in the work by the philosopher Ryle (1949:25), who distinguishes between “knowing that” of theory and “knowing how” of practice. Polanyi (1962:56) further expanded on this to discuss the two inseparable aspects of knowledge: “knowing what” and “knowing how”. Based on Polanyi’s work, Nelson & Winter (1982) then introduced this tacit-explicit distinction into the organizational literature when they defined tacit knowledge as “knowledge that cannot be articulated” (ibid: 76). In essence, explicit knowledge is that which has been codified and refers to knowledge that is transmittable in formal, systematic language. Tacit knowledge, on the other hand, has a personal quality and is deeply embedded in action and context, making it difficult to formalize and communicate. Other distinctions along these lines include that by Kogut & Zander (1992) who discuss “information” and “know-how”. Information is defined as “knowledge that can be transmitted without loss of integrity once the syntactical rules

required for deciphering it are known” while know-how is based upon von Hippel’s (1988: 76) definition: “know-how is the accumulated practical skill or expertise that allows one to do something smoothly and efficiently”. Polanyi’s (1962:49) example of bike-riding provides an example of this tacit-explicit distinction. Individuals who know how to ride a bike know which way to turn the handlebars when they are riding in order to keep their balance. However, they have difficulty in explaining to another individual which way they turn the handlebars to remain upright. Thus, what Polanyi called the tacit dimension is what the individual knows in terms of maintaining balance while the explicit dimension is what the individual can communicate to another about riding a bike.

Whether tacit and explicit knowledge are two distinct forms of knowledge or the ends of a continuum is one area of debate among researchers. In his framing of “knowing how” and “knowing that”, Ryle (1949) described these as two distinct kinds of knowledge. This view is adapted by Brown & Duguid (1998) since they propose that “know-how” is different from “know-what” in dispositional character. Cook & Brown (1999:384) also argue that, “explicit and tacit knowledge are two distinct forms of knowledge (i.e., neither is a variant of the other); that each does work the other cannot; and that one form cannot be made out of or changed into the other.” However, Taylor (1993) proposes that tacit and explicit knowledge exist on a kind of a continuum. Tacit knowledge provides the background understanding on which an individual’s explicit knowledge rests.

In recent years, the second dimension – individual/collective - has gained increasing attention. The traditional Cartesian view considers knowledge as held by the individual since it sees the individual thinker as the primary wielder and repository of what is known (Cook & Brown, 1999). This view is presented in Polanyi’s (1962) work since he viewed knowledge at the individual level and originating in individual intuition, as even reflected in the title of his book, *Personal Knowledge*. This individual focus is also represented in Simon’s (1991:125) statement that “All learning takes place inside individual human heads”.

However, of late the volume of research and publication focusing on a more sociological approach to knowledge has grown considerably. This approach sees knowledge as socially constructed and embedded in the social relationships between individuals (Kogut & Zander, 1992) and as distributed across groups or collectives of individuals who develop and possess social relationships. Durkheim (1893) serves as the ascribed source for the origins of knowledge as a

social construction, arguing in his work that individuals are not only independent psychological decision-making entities, but they are also purely social beings within a “collective conscience” (1960: 283). Another source of the sociological perspective is work by Fleck (1935, 1979) on thought collectives. In his work first published in 1935, Fleck provided an insightful description of knowledge communities, combining the creativity and socialization aspects of thought. Fleck’s main thesis was that the development of knowledge is a social phenomenon and that knowing, thinking, and knowledge creation are not something that an individual is capable of doing alone. Instead, these activities take place in thought collectives – sociological groups with a common style of thinking (Haas, 1992; Tuomi, 1999)⁶⁰.

In line with this, Weick & Roberts (1994) discussed a ‘collective mind’ in the organizational literature while examples of an interest in the collective level include work such as that by Wenger (1998) and Brown & Duguid (1991, 1998) in which they discuss communities of practice, by Kogut & Zander (1992, 1996) in their view of the firm as a social community, and by Nonaka & Takeuchi (1995) in their spiral of organizational knowledge creation. Spender (1996) also discusses this dimension, building on Durkheim (1893). In addition, von Krogh and co-authors (1994, 1995) have investigated epistemological issues at the collective level, discussing such terms as “organizational knowledge” and “organizational epistemology”. The main argument of this perspective on knowledge is that a collective or group of individuals possesses a “body of knowledge” that the individual member of the collective does not⁶¹. For example, a group of copier repair technicians possesses a body of knowledge about copy repair that is held in common by the various technicians; however, each individual technician does not possess the entire body of knowledge (Cook & Brown, 1999).

⁶⁰ Fleck’s original work was widely neglected since it proposed an all too unconventional way of looking at science. Instead of science being based on objective facts independent of any social processes, Fleck proposed that scientific facts only make sense within a given style of thought that is learned through socialization into the worldview of a specific thought community (Tuomi, 1999). Fleck’s work was further developed by Knorr-Cetina (1981) and Pinch & Bijker (1984) into the social constructivist view of science. This view holds that science, as the product of human activity, is not objective, but rather that this knowledge is “constructed” by researchers whose perceptions of reality are shaped by their training, beliefs, and life experiences (Lievrouw et al., 1987).

⁶¹ There are numerous definitions of knowledge using a sociological perspective: (1) socially spread and influenced by social settings (Schutz, 1970), (2) a social construction, embedded in a system of individual, lasting relationships (Berger & Luckman, 1966; Weick, 1979), (3) based on the interaction of several meanings (Derrida, 1978), (4) shared by “agents who process data” through cultural processes (Boisot, 1995), (5) material, but also mental and social (Latour, 1987). See also Blackler (1993, 1995) for a further discussion.

The two dimensions of tacit/explicit and individual/collective have been incorporated into models by several researchers. Spender (1996) developed a two-by-two matrix, creating four types of knowledge: conscious (explicit knowledge held by the individual), objectified (explicit knowledge held by the collective), automatic (preconscious individual knowledge), and collective (highly context-dependent knowledge that is manifested in the collective's activities). In this manner, he argued that the psychological individual type of tacit knowledge that was examined by Polanyi could be separated from the sociological or collective type. An extension of this 2x2 model to the firm has been made by several scholars. Hedlund & Nonaka (1993) and Kogut & Zander (1992) present models of organizational knowledge in which information and know-how are on one axis and individual, group, organization, and network on the other.

Several models have also been proposed in order to account for the dynamics of complex organizational work. In their model of organizational knowledge creation, Nonaka (1994) and Nonaka & Takeuchi (1995) discuss the interactions between the two dimensions, arguing that a firm's knowledge creation is performed by individuals and cannot occur without these individuals. However, the organization plays a critical role in articulating and amplifying this knowledge. In this model, knowledge creation spirals between tacit and explicit knowledge and moves between the individual, group, organization, and inter-organizational levels. One of their key arguments is that knowledge creation occurs when individuals share and develop knowledge through social interaction with others throughout the formal and informal levels of the organization (Nonaka, 1994).

1.2 Knowing

Cook & Brown (1999) further argue that a static discussion of the four types of knowledge merely provides us with an understanding of the knowledge possessed by people. To say that " 'Robert knows auto mechanics' points to Robert *possessing* knowledge of auto mechanics" (p.382, italics in original). Yet in order to give a full account of what individuals know, we need to focus on both the knowledge they possess as well as the actions they perform using the knowledge they have. Merely describing the knowledge that individuals or groups have does not provide us with an understanding of how this knowledge is used when individuals or groups take action in their work. Thus, researchers are now widening their focus of knowledge to include *knowing*, a verb connoting action, doing, and practice as well as knowledge, a noun connoting things,

elements, facts, processes, etc. (Orlikowski, 2002). Cook & Brown (1999:387, italics in original) defined the concept of “knowing” as “not something that is *used in* action or something *necessary to* action, but rather something that is a part of action (both individual and group)”. Thus, knowing is part of the actual work performed such as when an auto mechanic tunes an engine.

While there is a growing interest in knowing, researchers have differing opinions regarding this concept. Building on the American Pragmatist perspective and in particular the work of the philosopher John Dewey (1934), Cook & Brown see knowing as being distinct from knowledge and thus distinct from the tacit form of knowledge. However, Orlikowski proposes that tacit knowledge is a form of knowing, inseparable from action since it is constituted through such action, basing her argument on the work of Ryle (1949), Polanyi (1966), and Schön (1983). Whether tacit knowledge and knowing are distinct will continue to be an area for debate, but what is more essential to the introduction of knowing into the organizational literature is the argument that knowing (and tacit knowledge depending on one’s definition) and action are mutually constituted. Empirical studies of work practices have provided evidence of this recursive relationship (Suchman, 1987; Lave, 1988; Orr, 1996). Knowing is thus argued to be an ongoing social accomplishment that is constituted and reconstituted in everyday work practice (Orlikowski, 2002).

In order to emphasize the relationship between knowledge and/or knowing and action at work, researchers have developed the practice-based perspective. The main idea of the practice-based perspective is that it emphasizes the collective, situated, and provisional nature of knowledge in contrast to the rational-cognitive view of knowledge (Sole & Edmondson, 2002). The object of focus is practice as a means to capture the nature of knowledge in action in organizations, and researchers have developed concepts such as “knowledge-in-practice” (Carlile, 1997), “knowing in practice” (Orlikowski, 2002), and “epistemology of practice” (Cook & Brown, 1999). The notion of practice has a long intellectual history. John Dewey, mentioned above, argued that knowledge is manifested most rigorously not in what you claim to understand, but what you can do (see Schön, 1983). In addition, in social theory Bourdieu (1977) developed the nature of practice in his seminal work, *Outline of a Theory of Practice*. Practice implies the actions of individuals and groups when conducting real work, e.g., the practice of software engineers, nurses, hotel managers, etc. Practice is an activity, an interaction among individuals (Lave, 1988) doing their “real work” as it is informed by a particular organizational or

group context (Cook & Brown, 1999:387)⁶². Cook & Brown (1999) distinguish practice from behavior and action, explaining that behavior is “doing of any sort” and action is behavior instilled with meaning, while practice refers to action informed by meaning within a particular group context. The differences are best explained by example provided by Cook & Brown (1999). If my knee jerks, then this is behavior, and if I tap my knee with a physician’s hammer to check my reflexes, then this is action. However, if a physician taps my knee with a hammer as part of my yearly check-up, then this is practice.

Researchers argue that if we are to understand the means with which organizations generate knowledge as well as new ways of using knowledge, we need to focus on both knowledge as well as practice and their interplay (Cook & Brown, 1999)⁶³. When individuals and groups interact with the world through performing their practice, the four forms of knowledge are brought into play. Through this interaction between action and knowledge, new knowledge as well as new ways of using knowledge are then generated. As a group of individuals collaborate on a common task, they apply a common body of knowledge. Through applying this common knowledge, they also increase their knowledge since knowledge and learning are difficult to separate in dynamic task environments. An individual learns by participating in an activity and thus builds his or her knowledge. Thus, social interactions and not the isolated behavior of individuals are the basis for knowledge creation, exchange, evaluation, and integration. As such, knowledge creation and learning are situated, social processes that cannot be separated from working with knowledge as the outcome (Brown & Duguid, 1991; Lave & Wenger, 1991; Purser, Pasmore, & Tenkasi, 1992; Boland & Tenkasi, 1995; Wenger, 1998).

⁶² For a review of distributed practice at the organizational level, see Tsoukas (1996).

⁶³ As mentioned earlier, for discussions and reviews of organizational learning, see Huber (1991), Crossan & Guatto (1996), and Easterby-Smith et al. (1998).

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APPENDIX TWO

Empirical Studies

Article 1

Theorizing Structural Properties of Communities of Practice: A Social Network Approach

By A. Schenkel, R. Teigland, & S. P. Borgatti

Previous version presented at *Academy of Management*, 2001.

Article 2

The Provision of Online Public Goods: Examining Social Structure in a Network of Practice

By M.M. Wasko & R. Teigland

Nominated runner-up Best Paper ICIS 2002

Previous version published in *The Proceedings of the 23rd International Conference on Information Systems (ICIS)*, Barcelona, Spain, 2002.

Article 3

Communities of Practice in a High-Growth Internet Consultancy: Netovation vs. On-Time Performance

By R. Teigland

Versions published in three books:

In E. L. Lesser, M.A. Fontaine, & J.A. Slusher (eds.), *Knowledge and Communities*, Boston: Butterworth-Heinemann, 2000.

In J. Birkinshaw & P. Hagström (eds.), *The Flexible Firm*, London: Oxford University Press, 2000.

In F. Delmar & P. Davidsson (eds.), *Tillväxtföretagen (High-Growth Firms)*, Stockholm: SNS Förlag, 2001 (in Swedish).

Article 4

Extending Richness with Reach: Participation and Knowledge Exchange in Electronic Networks of Practice

By R. Teigland & M.M. Wasko

To be published in P. Hildreth & C. Kimble (eds.), *Knowledge Networks: Innovation Through Communities of Practice*, London: Idea Group Inc., 2004 (forthcoming).

Previous version published in W.J. Orlikowski, S. Ang, P. Weill, H.C. Krcmar, & J.I. DeGross (eds.), *The Proceedings of the 21st International Conference on Information Systems*, Brisbane, Australia, ICIS, 2000.

Article 5

Integrating Knowledge Through Information Trading: Examining the Impact of Boundary Spanning Communication on Individual Performance

By R. Teigland & M. M. Wasko

Version published in *Decision Sciences*, Special Issue on Knowledge Management, 2003 (forthcoming).

Article 6

Exploring the Relationships Between Network of Practice Participation, Centrality, and Individual Performance in a Multinational Organization

By R. Teigland

Previous version presented at *INSNA – International Network of Social Network Analysts Sunbelt Conference*, 2002.

Article 7

Knowledge Dissemination in Global R&D Operations: An Empirical Study of Multinationals in the High-Technology Industry

By R. Teigland, C.F. Fey, & J.M. Birkinshaw

Published in *Management International Review*, Special Issue on International Management of Technology, 2000, 1.

Note to Reader:

As we have progressed through the research presented in these studies, we have used a variety of different terms for more or less the same group of ideas. If we were writing a monograph instead of a compendium of articles, we could have easily resolved this problem by ensuring that the terminology is consistent by going back and making the necessary corrections throughout the entire thesis. However, as the majority of these articles are published, this task is not possible. Thus, in order to try and prevent any confusion for the reader, we feel that it is necessary to provide an overview of the different terms that are used throughout the empirical studies. At the beginning of each individual article, we clarify the terms that we have used in the article and how they relate to the terms that we use in the thesis.

Article One

Theorizing Structural Properties of Communities of Practice: A Social Network Approach

Note to Reader on Terminology:

In general, the terminology in this article corresponds to the terminology in this thesis. We use one abbreviation:

- 1) CP for Community of practice

Previous version presented at Academy of Management, 2001

Theorizing Structural Properties of Communities of Practice: A Social Network Approach

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ABSTRACT

Management researchers are paying considerable attention to communities of practice (CPs) as a means to better understand the creation, transfer, and embedding of knowledge in organizations. However, scant attention has been paid to understanding the structural dimensions of these organizational forms. Thus, this study's purpose is to conceptualize the structural properties of communities of practice. We draw on the social network literature and apply some of the extensively used network concepts and measures to develop five structural properties for CPs. We illustrate the usefulness of these properties through applying them to data from a complex construction project. Finally, we develop a series of propositions that link the structural properties of CPs to organizational performance before concluding with a discussion.

Keywords: community of practice, social network, knowledge, performance, construction

INTRODUCTION

Due to considerable changes in the competitive environment during recent decades, an increasing number of scholars are suggesting that knowledge is perhaps the only “true” source of competitive advantage for a firm (Drucker, 1991; Kogut & Zander, 1992; Spender & Grant, 1996). Many of these scholars have chosen to anchor their work in the knowledge-based view of the firm. Within this perspective, the concept of communities of practice (CPs), or emergent, informal groups that form through the mutual engagement in a shared practice (Brown & Duguid, 1991; Lave & Wenger, 1991), is rapidly gaining attention. The concept of CPs is related to several key knowledge activities and offers considerable promise for several reasons. First, CP research provides insight into how the informal organizational structures are the nexus for the sharing and transfer of valuable individual and group tacit knowledge (Kogut & Zander, 1992). Second, this informal organizational structure also provides a protective capability that helps impede the transfer of valuable knowledge to outside the firm (Kogut & Zander, 1992, 1996; Liebeskind, 1996). Third, communities of practice provide firms with a vital source of incremental innovation as community members continuously create knowledge to improve the practice. Finally, communities of practice have strategic implications since researchers have noted that the patterns of informal organizations directly affect organizational outcomes (Kotter, 1982, 1985, Kanter, 1983, 1989).

However, research on communities of practice is still in its earliest stages of development. The majority of the CP literature has concentrated on defining communities of practice, primarily focusing on the cognitive processes of how communities emerge and operate and often relying on anecdotal accounts as the basis for recent theory development (Wenger, 1998). However, researchers have paid little attention to conceptualizing the *structural* properties of communities of practice. In addition, few researchers have looked at how CPs impact organizational performance and competitive advantage (Liedtka, 1999; Storck & Hill, 2000). These gaps in the research seem surprising because on the one hand, there is such a strong relationship between cognition and structure, and on the other hand, the informal structure has been shown to play an important role in organizational outcomes (Kotter, 1982, 1985; Kanter, 1983, 1989; Miles & Snow, 1994).

Thus, the purpose of this paper is twofold: 1) to conceptually develop the structural properties of communities of practice and 2) to propose a series of relationships between CP structural properties and performance. Through identifying and specifying structural properties of communities of practice, we may open the door for additional theorizing on both the structural as well as the cognitive aspects of CPs as well as for further empirical studies. For example, we may use these structural properties to help detect and analyze communities of practice within organizations, to track their development over time, or to measure their relationship to organizational performance.

To achieve the above, we draw on the extensive field of social networks since we believe that the logic of communities of practice carries with it strong parallels with the structural characteristics of embedded networks. The vast stream of social network literature offers analytical tools that describe and analyze organizational structures. We select extensively used concepts, measures, and techniques from social network analysis based on their ability to help describe CPs and then synthesize these with existing concepts from CP literature to develop five structural properties of communities of practice. Finally, we propose a series of relationships between these structural properties and performance.

This paper is organized as follows. We begin by reviewing the literature on communities of practice and thereafter, we develop five structural properties of communities of practice. Following that, we use a case study of a multi-billion dollar construction project to illustrate these properties. We then develop a series of propositions relating the structural properties to performance before concluding with a discussion of the research implications and study limitations.

THEORETICAL BACKGROUND

Communities of Practice

In an ethnographic study of Xerox service technicians during the late 1980s, it was observed that there was a variance between the organization's formal description of work and the way in which the actual work was performed (Orr, 1990). When the technicians were faced with problems for which the formal structure often did not provide solutions, they relied on the organization's informal systems for help, such as story-telling, conversation, mentoring, and experiential learning (Orr, 1990; Brown & Duguid, 1991; Lave & Wenger, 1991; Wenger, 1997). These emergent structures have been coined communities of practice and have been defined in the following manner – a group of people informally and contextually bound in a work situation who are applying a common competence in the pursuit of a common enterprise (Brown & Duguid, 1991; Lave & Wenger, 1991; Wenger, 1998).

The work situation can be seen as the context for the process of negotiating a common enterprise (Wenger, 1998), the pillar of any community of practice. During this negotiation process, members engage in three cognitive processes: narration, collaboration, and social construction (Brown & Duguid, 1991). Through the narration of stories, employees help each other to make sense of ambiguous, problem-centered situations and in this context noncanonical practice is exercised. Problems are diagnosed through the building of a coherent account of a random sequence of events, while at the same time a causal cognitive map is developed (Brown & Duguid, 1991). The second aspect of CPs is the collaboration that occurs among its members. With knowledge-intensive tasks, often no one individual can solve the problem on his or her own due to an individual's bounded rationality. By relying on the community, individuals can perform their work without needing to know everything (Wenger,

1998). The third process, social construction, occurs through the mutual engagement of the members of a community of practice. During a process of comprehension, members negotiate meanings, turning incoherent events into coherent accounts and creating insights for the benefit of the community (Brown & Duguid, 1991; Wenger, 1998). In this process, the members develop a shared repertoire consisting of both the tacit and explicit means of communication and working that enable the community to perform its practice. In particular, the explicit means include the community's own language and vocabulary, codified procedures, documents, regulations, etc. But more interestingly, the tacit means, such as the implicit relations, cues, unarticulated etiquette, etc., are the invisible glue that holds the community together (Brown & Duguid, 1991; Boland & Tenkasi, 1995; Wenger, 1998). In addition, through these three cognitive processes, individuals satisfy their social needs of companionship, belonging, identity, and status. Members become bounded together by the context of the situation in an informal manner creating the social fabric of the organization (Brown & Duguid, 1991). It is precisely this invisible glue that bonds the community together and differentiates a community of practice from any other type of community (Wenger, 1998).

In addition to the above cognitive aspects of CPs, researchers have also begun to look at various structural aspects of CPs, and in particular, participation levels within communities. And as far as we have been able to discern, participation levels are the only structural aspects of communities of practice that have been discussed in any significant detail. Thus, we include here a somewhat lengthy discussion of this dimension since it provides a platform for some of the structural properties that we develop later in the paper.

Wenger (1998) has suggested the following categories of community participation: 1) full participation (insider), 2) legitimate peripherality, 3) marginality, and 4) full non-participation (outsider). In full participation, the person is an inclusive member of the community. He or she has gained legitimacy through engaging with other actors of the community in common actions and has acquired the formal and informal ability to behave as a community member (Lave & Wenger, 1991). The member is proficient in the tacit and explicit means of communication and working that enable the community to perform its practice. However, legitimate peripherality, the second category, connotes a level of only partial participation in the community. Gaining access to the periphery is not unproblematic since boundaries and entrance requirements may exist. For example, full participants may develop close relationships that exclude outsiders, or a complex, detailed understanding of the community's practice may be required to become a full participant. Thus, legitimate peripheral participation indicates that the individual has gained some legitimacy among full participants. An apprentice is one example of a legitimate peripheral participant, gaining community knowledge and acceptance, and on his or her way to becoming a full participant.

As in the case of legitimate peripherality, marginality is a mixture of participation and non-participation. While the boundary between these two levels is

unclear, the key difference between them is the participant's trajectory in the community (Wenger, 1998). In the case of legitimate peripherality, the person is either on an inbound trajectory to becoming a full participant or on a circular trajectory around the periphery. However, in the case of marginality, the person's trajectory is outbound, and he or she is thus either moving from being a full participant to becoming an outsider or is restricted to the periphery by the community with little hope of becoming a full participant. Marginal participants may be best understood by looking at practices of discrimination. In such cases, while participants wish to become community insiders, they are continuously pushed back into identities of non-participation (Wenger, 1998).

Finally, the opposite of full participation is full non-participation, or total exclusion from the community. This form of participation may either be decided by the community or by the non-participant since there is no desire to be part of the community.

Of primary importance is that an individual's participatory status can be considered to be a public good and not wholly owned by either party. The individual and the community *jointly and continuously* determine the individual's status with regard to participation. In addition, these levels of participation are not absolutes. Rather, they are contextual and temporal, which means they are fluid and contingent upon the current community configuration.

To summarize, our primary objective in this section was to discuss the two main elements of CPs: cognitive and structural. The cognitive elements consist of narration, social construction, and collaboration, while the structural elements connote the different participation levels. We now turn to the field of social networks to help conceptually develop structural properties of CPs.

DEVELOPMENT OF CP STRUCTURAL PROPERTIES

A social network has been defined as a "specific set of linkages among a defined set of persons" (Mitchell, 1969:2). The fundamental principle in social networks is that pairwise relationships among individuals link to form networks whose structural characteristics (discussed in greater detail below) are both the result of dynamic processes and affect group and individual outcomes. At the individual level, the notion is that a person's position in the network provides both constraints and opportunities for the individual. At the network level, there is the holistic notion of emergent properties that suggests that at least some properties and outcomes of a social network are a function of its complete structure and are not reducible to either an individual actor or a single link (Degenne & Forsé, 1993). For a review of social network concepts and principles, see Wasserman & Faust (1994).

With regard to this connection between communities of practice and social networks, Wenger has noted their relationship in several places (1998: 74, 126, 287, 298). In fact, he states that CPs can be viewed as nodes of "strong" ties within interpersonal networks. However, he takes pains to point out that there is a clear distinction between the two: "A community of practice is not defined merely by who

knows whom or who talks with whom in a network of interpersonal relations....What is of interest to me is not so much the nature of interpersonal relationships through which information flows as the nature of what is shared and learned and becomes a source of cohesion – that is the structure and content of practice" (ibid: 74, 21). Thus, what distinguishes a community of practice from other networks is that a community of practice is a contextually based network consisting of individuals who are involved in a common enterprise. Through this common enterprise and continuous mutual engagement, members develop a shared repertoire of meanings and practices. Thus, *every community of practice consists of a network, but not every network forms a community of practice.*

If we agree that a community of practice is a network but not every network is a community of practice, then the question arises whether there are specific structural properties that are likely to distinguish a community of practice from other networks. In this section, we develop five distinguishing structural properties of CPs: 1) connectedness, 2) graph-theoretic distance, 3) density, 4) core/periphery structure, and 5) coreness.

Connectedness

Perhaps the most fundamental aspect of communities of practice is mutual engagement (Wenger, 1998). Through engagement, individuals participate in each of the three cognitive CP processes: narration, collaboration, and social construction. The result of this interaction is a complex network of social relations and interdependency. Thus, the extent to which members of a group are connected via pair-wise interaction ties is an index of the extent to which the group can potentially function as a community of practice. Individuals who are not interacting with others in a group cannot learn the community's practice and thus will not be identified as being members of the community. Therefore, a minimum structural characteristic of a CP is that every member has appropriate ties (e.g., advice-giving, trust, etc.) with some if not all other members of the community. In other words, all community members are directly or indirectly connected with each other and there are no isolates. In social network analysis, the maximal set of individuals who are directly or indirectly connected to each other in a network is called a *connected component* (Harary, 1969). Therefore, a CP is necessarily located wholly within a single connected component. This then leads us to our first structural property:

STRUCTURAL PROPERTY 1: Connectedness - In a community of practice, every member is connected, directly or indirectly, to every other member. That is, a community of practice is contained within a connected component.

Graph-theoretic Distance

Another fundamental characteristic of communities of practice is the notion of shared repertoire (Wenger, 1998). Social network research has studied the diffusion (sharing) of ideas and attitudes extensively (Friedkin, 1982; Burt, 1992; Rogers 1995). A

central tenet of this research is the notion that in both diffusion and influence processes, the graph-theoretic distance between nodes in a network dictates the extent to which they are expected to share ideas. The graph-theoretic distance between two nodes is defined as the number of links in the shortest path connecting them. Thus, the greater the graph-theoretic distances between pairs of group members, the longer it takes for information to flow from one to the other, and the greater the likelihood that what is transmitted arrives too late, too distorted, or fails to arrive at all. Individuals separated by wide distances tend to develop variations (e.g., in language, values, norms, etc.) that are not shared, contrary to the notion of a single community of practice. Thus, communities of practice can be expected to have shorter distances on average than organizational networks in general. Thus, we suggest the second structural property:

STRUCTURAL PROPERTY 2: Graph-theoretic distance - Relative to organizational networks in general, communities of practice have shorter graph-theoretic distances between all pairs of members.

Density

Through mutual engagement and the associated cognitive processes, the practice of the community is disseminated and developed. Connectedness is a necessary prerequisite for this development but not sufficient in and of itself since a certain level of density is required. The density of a network measures the degree of cohesion in the group (Blau, 1977) and is defined as the total number of ties divided by the total number of possible ties in the network. A dense network consists of people who are for the most part directly connected to each other, rather than connected through intermediaries. Direct connections are far more powerful in terms of influence and transmitting tacit knowledge. Hence, through a dense network, a community's practice is more evenly disseminated. In social network terms, density is a function of the average number of contacts that each individual possesses, and it is the average number of ties per person divided by $N-1$, where N is the number of individuals in the network. A community of practice should exhibit a higher density than the organizational network in which it is embedded, which is discussed further in structural property 4. Therefore, we propose the following:

STRUCTURAL PROPERTY 3: Density - Relative to organizational networks in general, communities of practice have a greater density of ties.

Core/periphery Structure

Community of practice theory distinguishes between communities and constellations (Wenger, 1998). A constellation is a set of different communities of practice (possibly involving overlapping membership) that have different shared repertoires and different joint goals. Groups that have largely different membership, interact primarily within-group rather than with members of other groups, and develop separate sets of shared

repertoire can be seen as forming a single constellation, but not a single community of practice. Structurally then, it is obvious that communities of practice do not contain significant subgroupings since such subgroupings will constitute separate, although interlinked, communities of practice. This in turn implies that communities have a core/periphery structure as is described in social network theory. A network has a core/periphery structure to the extent that it contains no significant subgroups, factions, or cliques except the core itself (Borgatti & Everett, 1999; Everett & Borgatti, 1999). Stated in another way, a network has a core/periphery structure if it “can be partitioned into two sets: a core whose members are densely tied to each other, and a periphery whose members have more ties to core members than to each other” (Everett & Borgatti, 1999: 397.) Network researchers have developed statistical procedures for measuring the extent to which an observed network conforms to a core/periphery structure (Borgatti & Everett, 1999).

Core/periphery structures facilitate the diffusion of information and innovation because they do not contain significant clusters of nodes that are poorly connected to the rest of the network. Consequently, they can be expected to lead to a relatively homogeneous group culture (a shared repertoire) in which most individuals are exposed to new practices and ideas soon after they emerge. In contrast, networks that are divided into cliques or factions work against the establishment of a single community of practice. Different subgroups tend to develop their own norms, beliefs, and practices, which then effectively create separate CPs that are loosely connected to each other – i.e., constellations. Thus, we have our fourth structural property:

STRUCTURAL PROPERTY 4: Core/periphery - Communities of practice have core/periphery structures rather than clique structures.

Coreness

As described above, Wenger (1998) distinguished full participation in a community of practice from legitimate peripheral participation and marginal participation, and the distinction between the latter two depends on the legitimacy of the individual. This distinction is fundamentally cognitive rather than structural. Thus, in a network analysis of a set of relations at a single moment, it would be difficult to distinguish between legitimate peripheral participation and marginal participation. However, the difference between these and full participation can be detected by the coreness measures that are produced as a byproduct of fitting the core/periphery model (Borgatti & Everett, 1999). Technically, coreness is defined as the principal eigenvector of the network matrix (Bonacich, 1972). In non-mathematical terms, coreness indicates the extent to which a node is located in the center or periphery of a group. Nodes with high coreness are well connected to both core and peripheral members. Nodes with low coreness are connected mostly to core members. Thus, this structural property mimics the position of new apprentices in a community, who initially are connected through a few experienced members who show them the ropes,

and who gradually form ties with more and more people. Hence, coreness is the basis for our last structural property:

STRUCTURAL PROPERTY 5: Coreness - The greater an individual's participation in a community of practice, the greater his or her coreness score.

To the extent that the above translation from social network theory to community of practice theory is faithful, we now have a set of properties for detecting and evaluating communities of practice in a variety of empirical or consulting situations. In the next sections, we use a case study of a major construction project to illustrate and evaluate these structural properties of communities of practice.

METHODS

This study uses data from Sundlink Contractors, an international contractor consortium that designed and constructed the Öresund Bridge, a five-mile multi-level bridge connecting Denmark and Sweden, during 1996-2000. It is important to remark that the focus of our study represents a highly complex infrastructure project of immense size, stringent quality requirements, well-defined completion time, and harsh environmental conditions. In addition, a continuous stream of emergent problems situations, which are the nexus of CPs, characterized the environment of this research site. Therefore, this was a very interesting site in which to explore the structural characteristics of communities of practice.

Sundlink's organizational structure was functional in nature with personnel divided into four categories: Operations, Support, Project Management, and Other. Operations and Support were chosen for this study while Project Management and Other were excluded due to their small size. Operations included five departments that were responsible for building the immense concrete and steel structures while the Support personnel were from two departments and worked with quality and technical issues. A description of these seven departments is included in Table 1.

The work sites of this project were physically dispersed with only the Quality and Technical Departments located in the same building. Distances ranging from one to more than 1,000 kilometers separated the different sites with four of five of the operational departments located within a ten-kilometer radius of each other. The various sites corresponded with the different operational entities.

Sundlink Contractors utilized a formal quality system based upon ISO 9000, which articulated the work processes and procedures. It is within this quality system that we have defined the joint enterprise for communities of practice in this study (Schenkel, 2002). In particular, we look at the management of "deviations" or situations in which articulated procedures or processes are not followed or articulated objectives are not achieved. The management of deviations requires 1) the use of already existing work methods, 2) a change in existing work methods, or 3) the development of new technical solutions. Thus, examining deviations provides the context for exploring joint enterprise (management of the deviation within the project),

a shared repertoire (the common means/behavior in which the incidents are approached and managed), and mutual engagement (the collaboration of multiple individuals/groups of different and/or the same competences).

Table 1 Description of Departments

Department	Activity	Size of Structure	Location
Offshore Onshore (Operations)	To construct prefabricated concrete structures called caissons and piershafts	800 to 4700 tons 10 to 51 meters tall	Malmö, Sweden
High Bridge (Operations)	To build concrete bridge pylons	Over 200 meters tall 4355 m ³ of concrete 800 tons of reinforcement concrete	Malmö, Sweden
Bridge Line (Operations)	To construct viaduct using steel and concrete	560 meters long	Malmö, Sweden
Prefab Approach Bridge (Operations)	To construct steel and concrete girders	2000 to 6300 tons 120 meters long	Cadiz, Spain
Technical (Support)	To work with design, survey, and other technical issues		Malmö, Sweden
QAD (Support)	To draft and implement a quality system similar to ISO 9000		Malmö Sweden

A questionnaire was administered during a nine-month period ending in May 1999. Two types of data were collected: 1) communication patterns in managing deviations, e.g., whom the respondent contacted both within and outside the organization for advice in situations which deviated from prescribed ISO 9000 standards, and 2) socio-demographic information such as age, education, and experience data - all potential factors that can influence the formation and maintenance of communities of practice. The population was delimited by choosing those who were not construction workers, i.e., those who had a managerial or support function. In total, 137 people of both an operational as well as support character were included in the population and 120 people responded (87.6%). Of interest is that only two respondents provided names that were not within the list of 137 participants. The mean age of the respondents was 41.29 (s.d. = 11.45), and the mean education was equivalent to that of a high school diploma. The respondents had worked in the construction industry a mean of 17.00 years (s.d. = 12.51) and on this particular project for a mean of 2.15 years (s.d. = 1.11). For a more detailed examination of the observed communication patterns, see Schenkel & Rognes (1999) as well as Schenkel (2000).

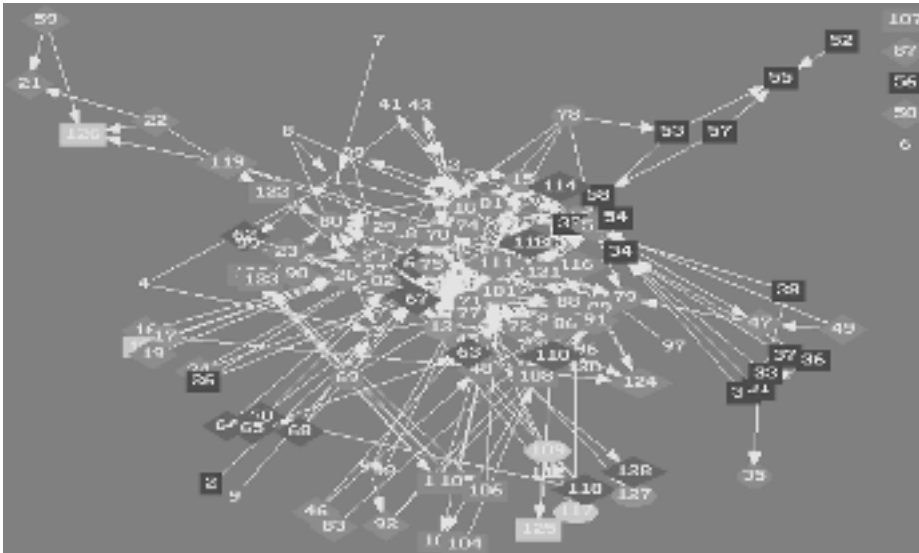
To illustrate the structural properties of CPs, we performed three separate analyses to determine to what degree the unit of analysis fulfilled the structural properties of communities of practice. The three units of analysis were 1) the overall project based on relationships between individual project members regardless of department membership, 2) each department based on relationships between the department individual members, and 3) the overall project based on the aggregated individual relationships between departments. The data were analyzed using the UCINET network analysis software package (Borgatti, Everett, & Freeman, 1999) and imported into Krackplot (Krackhardt, Blythe, & McGrath, 1994), a program used for the graphical analysis of networks, as well as SPSS.

ANALYSIS AND DISCUSSION

The Overall Project

The first step of our analysis was to look at the overall project structure to determine to what degree the project as a whole exhibits the structural properties of a community of practice. We looked at the communication relationships between the individual project members who were spread across the seven different departments. Figure 1 diagrams the overall project network.

Figure 1 Network of Help-Seeking among All Project Members



Note: Node Shape Indicates Section Membership

Connectedness

Of the 120 project members there were only five isolates or individuals who possessed zero ties to other members. All other members were connected by at least one tie, forming a single connected component. This extent of connectivity or connectedness is consistent with the community of practice structural property 1.

Density

The density of the network was calculated to be 3.9%. Unfortunately, no standard database of published organizational networks exists that we can use to compare to our result. However, based on the non-representative sample of the authors' experience, we would judge the observed density as quite low for an organizational network of this size and scope. We have seen that even organizations containing unrelated subunits (which therefore would not be expected to communicate to a high degree) tend to achieve a density higher than 3.9%. Hence, if communities of practice were expected to have an even higher density than typical organizational networks, this would suggest that this project does not fulfill the second structural property to a high degree.

Graph-theoretic Distance

The average graph-theoretic distance among all pairs of persons in the network (excluding the five isolates) was 3.551 (s.d. = 1.471). Once again, no standard database exists for comparison, but experience suggests that this value is certainly no lower than that obtained in a variety of organizational networks, indicating that the structure of this network does not fulfill this CP structural dimension to a high degree.

Core/periphery Structure

The crucial structural indicator of a CP is the presence of a core/periphery structure, i.e., the absence of factions. For this network, we obtained a fit to the core/periphery model of 0.327, which is significantly greater than zero, but a far cry from what we conceive as a well-functioning community of practice structure. Thus, this project does not fulfill the fourth structural property to a high degree either.

Coreness

We then examined the characteristics of those individuals in the core vs. those in the periphery by correlating coreness with several demographic variables. As shown in table 2, coreness was not related to age, years of experience in the construction industry, or years of experience in similar duties elsewhere, but it was significantly related to the number of years in the current position. In addition, coreness was negatively related to time spent at the construction site versus at the office where most people were. Finally, we found that coreness was related to the level of education. A discussion of how these findings relate to the CP literature is found below.

Table 2 Correlations between Demographics and Coreness^a

Variable	Coreness
Age	-.14
Education	.41***
Years in Construction	-.07
Years of Similar Duties	-.07
Years in Current Position at Sundlink	.37***
Time Spent on Construction Site	-.44***

^aN ranges from 112-113

* $p < .05$

** $p < .01$

*** $p < .001$

Summary of the Overall Project

Overall, we find very weak support for considering the project as a whole to display the structural properties of a community of practice. While the project fulfills the first structural property, it fulfills the next three structural properties to a very low degree. In particular, there is little support in terms of density that the project network is a strong community of practice. This low density could be explained by the disciplining nature of ISO 9000 and its key role in the shaping of practice to the extent that the formal and informal practices overlapped one another to a high degree in this project, thus reducing the number of potential communications among individuals (Schenkel, 2002). Furthermore, the geographical separation of sites and uneven resource allocation meant that not all the people in the respective departments could interact on a face-to-face basis. This finding supports our argument that face-to-face interactions are important for the development of communities of practice and that communities of practice primarily develop within co-located groups of individuals.

The results most consistent with a strong community of practice structure are those associated with the individual coreness property. Individuals with high coreness had been in their current position the longest, had higher levels of education, and were less often at the construction site, all aspects that make sense within the CP literature. We would expect the relationship with time in current position because the longer a person participates in a community of practice, the more opportunity there is for building relationships and moving from the periphery (where all newcomers begin) into the core. In terms of education, this may be partly due to management's preference for hiring more educated people for central positions, requiring a high degree of theoretical technical knowledge, but it also may be that more educated people were considered to be more knowledgeable than others and, therefore, more often approached for help. Alternatively, the coreness of more educated people may be again that ISO 9000 acts as a disciplining system, i.e., ISO 9000 dictates that certain individuals should be contacted and in this case these individuals were those who happened to have a high degree of education (Schenkel, 2002). Finally, the negative relationship with time at the construction site also makes sense in light of the

CP literature since physical proximity and thus face-to-face communication are thought to be important facilitators of mutual engagement.

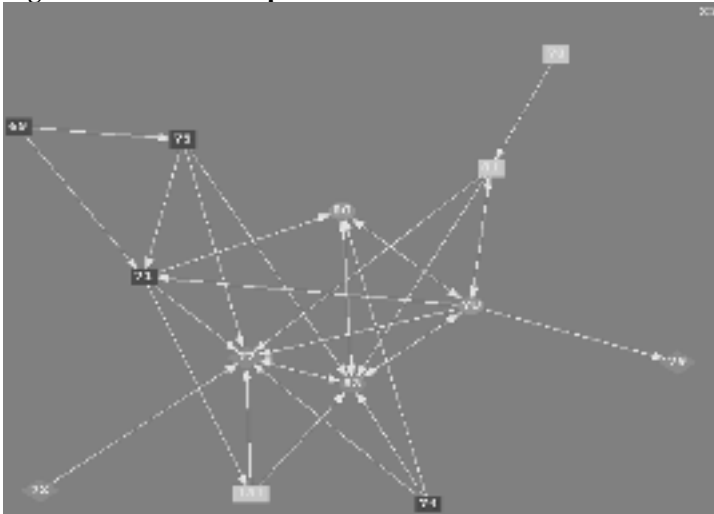
The Departments

Although we find that the project as a whole displays only weak structural properties of a community of practice, this does not preclude that individual departments might display strong CP characteristics. Thus, here we look at to what degree an individual department fulfills the structural properties based on the communication relationships between the individual members in the department. We look only at the first four properties, leaving aside the fifth structural property temporarily since it does not speak directly to the question of to what degree a network shows characteristics of a community of practice. Due to space constraints, we only look at results from three departments, chosen because they clearly depict a variety of network attributes.

Technical Department

Visual inspection of the Technical Department in figure 2 shows that its members were very well connected, with just one isolate. Thus, if we exclude this individual (35), this department fulfills the first structural CP property. The second property was fulfilled to a satisfactory degree since this department (among all but the excluded individual) had an average graph-theoretic distance of 1.91 -- less than two links. The third property, or department density, is a healthy 27.5%, which is comfortably high. For the fourth property, the fit of the core/periphery model was 0.569, which is very high, indicating that this department does have a core/periphery structure, thus satisfying the fourth property to a high degree. In sum, we find that the Technical Department as a whole fulfills the first four structural conditions of a community of practice to a very high degree, thus displaying characteristics of a strong community of practice.

Figure 2 Technical Department

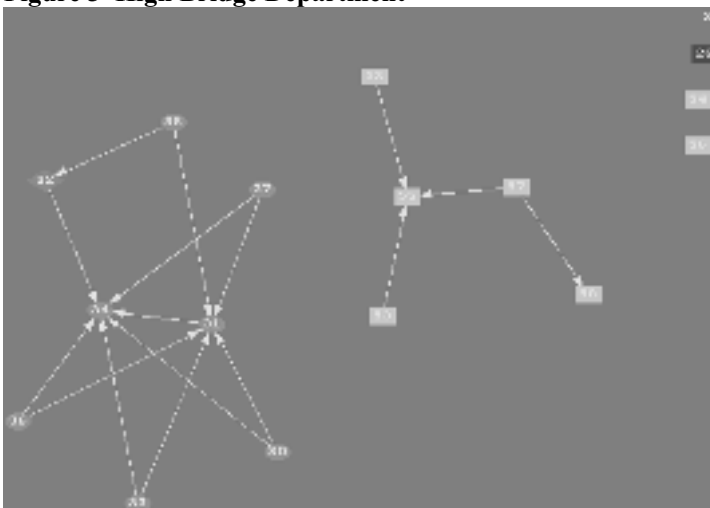


Note: Node Shape Indicates Section Membership

High Bridge Department

In contrast to the Technical Department, the High Bridge Department is split into two mutually exclusive subgroups that are largely based on operative sections: circles and squares, as shown in figure 3. Furthermore, there are four isolated individuals. Due to the split and presence of isolates, it is not necessary to run the density and graph-theoretic property analyses since it is clear from the initial analysis that this department will score extremely low on these. Thus, this department fails to fulfill the first four structural properties to any kind of satisfactory degree. However, we do see

Figure 3 High Bridge Department



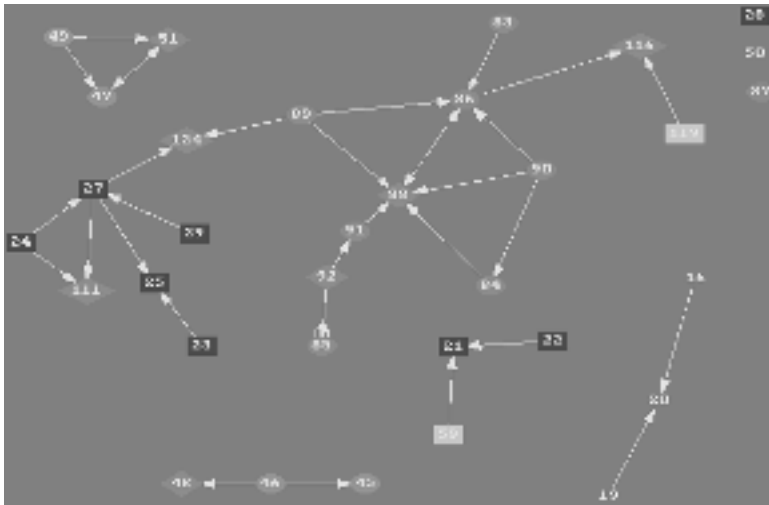
Note: Node Shape Indicates Section Membership

indications of two smaller CPs within the department. These subgroups consist almost entirely of members from individual sub-department sections (circle and square nodes). This suggests that interactions within this department are rather strongly patterned by the formal organizational structure and that the communities of practice follow the formal organization in this department. An analysis of these two subgroups is beyond the scope of this study; however, of additional interest, is that one of the most central players (31) is in a position of authority (a manager) while the other central player (34) is a supervisor. Thus, the question of what role formal authority plays in the formation of CPs comes into question.

Bridge Line Department

Like the previous department, the Bridge Line Department also fails to satisfy the structural properties for a strong community of practice as a whole. As shown in figure 4, it is extremely disconnected, divided into many smaller components. Even the one larger component is nearly disconnected, held together by nodes 89, 124, and 27. Once again, it is interesting to note that some of the key structural nodes that hold the network together, 124 and 88, are the Quality Controllers.

Figure 4 Bridge Line Department



Note: Node Shape Indicates Section Membership

Summary of the Departments

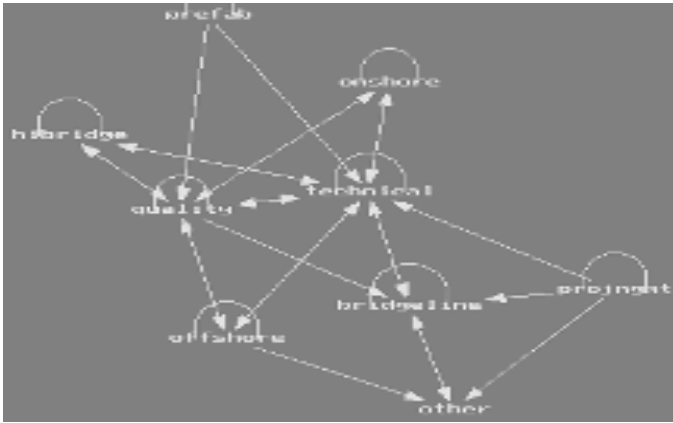
In summary, only one department fulfills the first four structural characteristics of communities of practice to a satisfactory degree. However, we did also see indications of two smaller CPS within the High Bridge Department. Thus, we do see some

support for the relationship between the development of CPs and the formal organization.

The Overall Inter-department Project

An alternative way of analyzing the project is to determine to what degree the project at the inter-department level, and not the inter-individual level, satisfies the CP structural properties. The most common reason why organizations have long graph-theoretic distances and imperfect fit to the core/periphery model is that they exhibit departmental homophily – the tendency for individuals within a department to interact more with members of their own department than with members of other departments. Normally, strong departmental homophily is inconsistent with the core/periphery pattern since in effect the departments form a series of cliques. However, if the departments themselves interact with other departments in a pattern resembling a core/periphery structure, this will mitigate the effect of cliquing and yield a middle core/periphery score at the individual level. Hence, we now ask whether the organization can be seen as a community of practice in which the members are departments rather than individuals.

To examine this, we constructed an aggregate network at the department level. We counted the number of ties between each member of each pair of departments and divided by the maximum number of ties possible. When this ratio exceeded 10% of possible ties, it was considered as a tie between departments. We refer to this ratio as the density of ties between departments. Figure 5 shows the resulting network in which an arrow drawn from one department to another indicates that members of the first department seek advice from the second department, but not the other way around. Double-headed arrows indicate reciprocal advice-seeking, with members of each department seeking advice from members of the other department. The "halo" atop most departments is a reflexive tie; it indicates that members of that department go to other members in the same department for assistance.

Figure 5 Network of Inter-department Relations

The results show that the departments are well connected and that there are no isolates. Thus, the structural property 1 of connectedness is satisfied. The average graph-theoretic distance in the inter-department network is 1.47 -- less than two links, which is lower than the expected value for random networks of this size and density. Therefore, our second property is satisfied to a relatively high degree. The third property, or density, was found to be 53.06%, which seems to be more than adequate. The fourth property, the presence of a core/periphery structure, shows that the departmental network fits extremely well (fit coefficient = 0.69). Thus, the QAD and Technical Departments form the core, and the Prefab, High Bridge, Onshore, Offshore, and Bridge Line Departments form the periphery.

Summary of Overall Inter-department

In summary, we can argue that the project at the macro-level fulfills the first four structural criteria of a community of practice to a considerably satisfactory degree. The QAD and Technical Departments form the core and are essentially responsible for the connectedness of the project network as a whole. Without these departments, the organization would be largely disconnected. This can be seen as underscoring the importance of such support functions as well as the key role of ISO 9000 in shaping practice (Schenkel, 2002). However, it should be questioned as to whether the operational departments should have direct contact with each other instead of through the QAD and Technical Departments. Thus, this level of analysis provides an alternative method of understanding how well an organization fulfills the structural properties of a CP.

Summary of Results

Concluding our analysis and discussion, we find that the inter-department network displays structural CP characteristics to a higher degree than the project as a whole. Looking at individual departments, we find that only the Technical Department exhibits strong structural characteristics. Thus, the suggestion that the shared repertoire was stronger at the department level than at the project level did not find any support. In addition, these findings suggest that the formal organization on the departmental level does not necessarily coincide with emergent communities of practice, thus confirming previous research on CPs. Finally, the presence of micro-communities at the sub-department level does suggest that communities do exist below the entire project and inter-department level.

PROPOSITION DEVELOPMENT

In this section, we now turn to the relationship between CPs and organizational performance and develop a series of propositions that relate CP structural properties to performance.

Density and Community Performance

According to structural properties 1 and 3, a certain level of density is required to hold the CP together. If the CP dips below this, then it is likely that it would disintegrate and no longer fulfill the structural properties of a CP. But what is to be made of a community with a density just greater than the minimum that still satisfies the cognitive aspects of CPs (common enterprise and mutual engagement) and other structural properties? On the one hand, it seems likely that if knowledge transfer is an emergent outcome of social interactions -- a fundamental axiom in the CP literature -- then as the density of the network increases so will the transfer of knowledge among its members. On the other hand, if the density is very high, and particularly so in large networks, then individuals are spending a considerable amount of time maintaining a large number of relationships. It has been suggested that community members can spend too much time managing their relationships to the detriment of their work (Hansen, 1996). Thus, for smaller communities, we would expect an increase in density to be associated with an increase in knowledge transfer. In contrast, for larger communities, we would expect the relationship between density and knowledge transfer to be curvilinear. Research in non-organizational settings suggests that North Americans maintain an average of about 20 significant relationships at any given time (Walker, Wasserman & Wellman, 1994). Thus, in the absence of any other information, let us assume that this number applies to work relationships as well, and that more than, say, 40 relationships is clearly difficult to manage. Obviously, the size of the community is an empirical question that has to be investigated. However, we suggest 40 individuals as the boundary between smaller and larger communities. We thus formulate the following propositions:

PROPOSITION 1A: For smaller communities of practice (≤ 40 members), knowledge transfer increases linearly with density.

PROPOSITION 1B: For larger communities of practice (> 40 members), knowledge transfer increases curvilinearly with density.

Network Centralization, Task Complexity, and Community Performance

Centralization, as we use the term here, refers to the extent to which a network revolves around a clear core. Operationally, we can measure centralization as a function of the variance of coreness. If each member has the same coreness value, the variance is zero, indicating that the network is not centralized at all. If two or three members have very high coreness values while all the others have very low coreness values, the variance will be high, indicating strong centralization.

There is a long research tradition, dating back to the 1940s and 1950s (e.g., Bavelas, 1948; Leavitt, 1951, etc.), which consistently shows that more centralized networks do a better job of solving simple problems than less centralized networks do. Decentralized networks, however, do a better job of solving complex problems. Similarly, Tushman (1977) reported that high-performing teams working on complex research projects had more decentralized communication structures than teams working on more routine projects. Applying these findings to communities of practice, we propose the following:

PROPOSITION 2A: For communities of practice solving more complex problems, performance will increase as the variance among members' coreness values decreases.

PROPOSITION 2B: For communities of practice solving more routine problems, performance will increase as the variance among members' coreness values increases.

Coreness and Individual Performance

Essential to the notion of CPs is that knowledge and practice are constructed through interactions among community participants. Members help each other by taking the time to work through each other's problems, developing insights into new methods and new applications for existing knowledge for the community (Wenger, 1998). Exercising intellect by helping others is also likely to help people maintain and even improve their own technical skills. Research has shown that individuals with a higher degree of interaction with other community participants have a higher level of individual performance (Teigland, 2000). However, peripheral individuals have the least access to others, both in terms of the number of connections and path lengths. Therefore, they have less opportunity to gain knowledge from others in the community, resulting in less community-specific knowledge and a more idiosyncratic practice. At the same time, their lack of connection with others makes them less

influential and less able to shape the community's practice. This leads us to the following proposition:

PROPOSITION 3: Community participants with higher coreness scores will have more community-specific knowledge and thus a higher level of individual performance.

IMPLICATIONS, LIMITATIONS, AND CONCLUSIONS

Research Implications

Several implications for research were developed during the study. First, it is important to note that inherent in the concept of communities of practice is the concept that organizations are homogeneous. This means that a firm's environment and evolutionary stages (on a firm level) are not considered. Thus, the introduction of organizations as heterogeneous entities that face different environments and evolutionary stages calls into question the concept of a general theory of communities of practice. We would expect then that the structure of communities of practice should be affected by the organization's environment and the nature of the task (Lawrence & Lorsch, 1967). In adapting this view, we suggest a contingency approach (Galbraith, 1973) toward the structural aspects of communities of practice and that there may be no one best way of how a community of practice should be structured. Second, the CP concept does not take fully into account that individual communities evolve and develop over time. We propose that communities have lifecycles and that the community may have different characteristics depending upon what point it has reached in its development. Thirdly, what became evident in the analysis is that the makeup of the individuals in a community of practice is critical to the structural aspects of the community and that social network analysis and the concepts we have developed allow us to analyze CPs. Thus, it would be of interest to further investigate what constitutes "the right mix" of members of a community in terms of demographics. Finally, this research has suggested that positions that are not of importance in the formal organization are actually of high importance in the informal organization since novices (QCs) were found to be critical in establishing links between various parts of the organization. This may then suggest that perhaps the best way to organize is around the emergent informal network. All of these implications deserve further research, but what is of primary interest is the question of whether or not management can in fact influence the dynamics of a community of practice since they are emergent and of an informal nature.

Limitations

We should note the limitations of the study and caution that this study was of an exploratory nature, with the findings merely acting as guidelines for further research. We have focused on only one organization, thus limiting the generalizability of our findings. In addition, for the purpose of this study, we have merely analyzed existing

organizational units to see to what degree they fulfill the structural properties of a community of practice. However, as research has shown, the boundaries of communities of practice are ethereal and may not necessarily conform to the formal boundaries of an organization (Wenger, 1998). Thus, further research needs to look at how these structural properties may be applied to organizations without being confined by the formal organizational boundaries.

In addition, since the focus of this study was on the structural dimensions, we have not taken into consideration any of the cognitive dimensions of CPs when conducting our analyses. However, further research should look at the interaction between the structural and cognitive dimensions of communities of practice and their relationship to organizational performance.

Conclusion

In conclusion, we feel that we have made considerable progress towards our two objectives, and in the process we have opened the door for further theorizing and empirical studies. First, our results show that network analysis does provide an illuminating way to better understand the structural properties of communities of practice. We have identified specific structural criteria implicit in the logic of communities of practice, reframed these criteria in terms of social network theory, and then developed five measurable structural properties (connectedness, graph-theoretic distance, density, core/periphery structure, and coreness). Using data from a major complex infrastructure project, we illustrate the usefulness of the structural properties and find that the project as a whole on an aggregate department level fulfills the structural CP dimensions to a higher degree than the whole project at an individual level. In addition, we find that the Technical Department forms the mainstay of the entire project community's core. Investigating the organization more deeply by analyzing each individual department, we find that only the Technical Department satisfies the structural properties for a community of practice to a high degree.

Second, we developed a set of three propositions linking the structural aspects of a community of practice to performance. Scholars often assume that the more a community resembles the ideal CP, the better its performance. However, as discussed above, the connection between performance and communities of practice is a largely neglected area. Thus, if the CP concept is to be of value, then the connection between the community and organizational performance must be further investigated. This research then provides some antecedents with which researchers may examine the relationship between communities of practice and organizational performance.

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Article Two

The Provision of Online Public Goods: Examining Social Structure in an Electronic Network of Practice

Note to Reader on Terminology:

In general, the terminology in this article corresponds to the terminology in this thesis. We use one abbreviation:

- 1) ENOP for Electronic Network of Practice

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The Provision of Online Public Goods: Examining Social Structure in an Electronic Network of Practice

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ABSTRACT

Electronic networks of practice (ENOP) exist primarily through computer-mediated exchange and are social spaces where individuals working on similar problems self-organize to help each other and share perspectives about their occupational practice or common interests. This exchange of knowledge through message postings produces an online public good, where all participants in the network can access the knowledge, regardless of their contribution. Thus, this research builds upon theories of collective action and public goods to better understand the provision and maintenance of knowledge in an electronic network of practice. We use social network analysis to examine the following research questions: 1) what is the pattern of contribution that produces and sustains the ENOP public good, 2) are ENOPs characterized by a critical mass constituting a core? and 3) how does the heterogeneity of resources and interests of participants impact ENOP collective action? We find that the network of practice is sustained through generalized exchange, is supported by a critical mass of active members, and is shaped as a star. The critical mass is significantly related to occupational tenure, expertise, availability of local resources and a desire to enhance one's reputation.

Keywords: collective action, public goods, knowledge, electronic community, community of practice, social network analysis, law

INTRODUCTION

Recent advances in information and communication technologies (ICT) have led to the development of extra-organizational electronic networks. These electronic networks enable the creation of weak structural links between thousands of geographically dispersed individuals, who are typically strangers and come from diverse organizational, national, and demographic backgrounds (Sproull & Faraj, 1995). In these networks, individuals are able to engage in knowledge sharing, problem-solving, and learning through posting and responding to questions on professional advice, storytelling of personal experiences, and debate on issues relevant to the community (Wasko & Faraj, 2000). Individuals benefit from these networks since they gain access to new information, expertise, and ideas that are often not available locally. Termed electronic networks of practice (ENOP), these electronic networks exist primarily online and are similar to communities of practice in that they are a social space where individuals working on similar problems self-organize to help each other and share perspectives about their occupational practice or common interests (Brown & Duguid, 2000).

Despite the growing interest in online cooperation and virtual organizing, surprisingly little empirical research has investigated the communication and organizing processes in online networks (Monge et al., 1998; Lin, 2001). Thus, the goal of this research is to better understand these emerging organizational forms by drawing upon the well-established theories of public goods and collective action. Building upon work by Fulk and colleagues (Fulk, Flanagan, Kalman, Monge, & Ryan, 1996), we extend collective action theories to interactive communication systems, examining participation in ENOPs as a form of collective action. The collective action is exhibited through the interactive posting and responding of messages to the network. This interaction produces and maintains the public good of a continuous stream of relevant practice knowledge that all participants may access.

This extension of collective action and public goods theories to ENOPs is highly exploratory. Thus, rather than test hypotheses, we develop and examine three research questions that we see as fundamental to understanding ENOPs: 1) what is the pattern of contribution that produces and sustains the ENOP public good, 2) are ENOPs characterized by a critical mass constituting a core? and 3) how does the heterogeneity of resources and interests of participants impact ENOP collective action? To address these questions, we collected postings from a successful ENOP during two months and then administered a survey to all active participants. The shared practice of this network was US federal law, where participants (lawyers) actively engaged in exchanging legal advice. The paper concludes with a discussion of findings and areas for future research.

THEORY DEVELOPMENT

Members of a collective must often make decisions that balance the benefits of maximizing self-interest with the collective's interests. This phenomenon is best explained through an example, such as wheat farming. Wheat prices are primarily set by market supply and demand. Each farmer attempts to grow and sell as much wheat as possible to obtain the greatest profit. However, in surplus years there is the risk that prices fall dramatically if farmers flood the market with wheat. Thus, for the collective, the rational action is to restrict the total market supply of wheat to maintain high prices. However, each farmer has the individual incentive to try to sell as much wheat as possible. Yet when each individual acts rationally, the market is flooded and wheat prices fall, leaving everyone with less profit. Thus, the sum of individually rational actions leads to collective irrationality, leaving everyone worse off.

This example is a special problem referred to as a social dilemma. Social dilemmas arise when a set of individuals act rationally in their own self-interest, yet the sum of their actions leads to collective irrationality (Kollock, 1998). Social dilemmas involving more than two individuals are N-person dilemmas and fall into two categories, the provision of public goods and the tragedy of the commons. First, the provision of public goods dilemma, or the social fence, involves the *production* of a public good. Public goods are resources from which all individuals in a collective may benefit regardless of whether they have contributed to providing the good, such as a public park or public television (Kollock, 1998). In the provision of public goods dilemma, the optimal individual decision is to enjoy the public good without contributing anything to its creation or maintenance.

The specific characteristics of a public good have implications for its provision and use. First, a public good is a resource that can be provided only if members of a collective contribute towards its provision. It is *non-excludable*, i.e., the good cannot be withheld from any member of the collective, even if he or she does not participate in the production or maintenance of the good (Komorita & Parks, 1995). A second characteristic is known as *non-rival*, meaning that the good is not used up or depleted in its consumption, thus one person's use of the good does not diminish its availability to others in the collective (Shmanske, 1991). Public goods are generally considered to evidence both non-rivalry and non-excludability. Since public goods are not used up in their consumption due to non-rivalry, there is no incentive to add costs by controlling access to the good through exclusion (Musgrave, 1959). However, a connection between the two characteristics of non-rivalry and non-excludability does not necessarily exist: a non-rival good can be excludable while a non-excludable good can be either rival or non-rival (Shmanske, 1991). Thus, true public goods are completely non-excludable and non-rival; however, it is argued that many public goods exhibit these characteristics to varying degrees (Kollock, 1998).

The second type of social dilemmas is the social trap or the tragedy of the commons and involves the *consumption or replenishment* of a joint good. The commons dilemma differs from the provision of public goods dilemma because the joint good is not a public good. Rather the joint good is *subtractable*, the opposite of

non-rival. In other words, the use of the joint good by one individual diminishes the availability of the good to another individual, resulting in the “tragedy of the commons” (Kollock & Smith 1996).

This research focuses on the production of knowledge as a public good in ENOPs. In the formal language of collective action theory, the network participants are the interest group and the public good is the continuous stream of knowledge produced and jointly held by the network’s participants. We argue that the knowledge produced by the ENOP in this study is a true public good. First, it is non-excludable due to the network’s open nature. When one participant responds to a posting, then all members may benefit from this knowledge, even though they did not contribute to its production through either posting or responding. Second, the knowledge is non-rival because even if the person receiving the help uses the knowledge, it still remains available to other members, who may also apply the knowledge in their own situations. Thus the social dilemma faced in ENOPs is the provision of public goods dilemma. Specifically, we are interested in understanding how open, voluntary ENOPs are sustained, given that individuals are better off not contributing and free-riding on the efforts of others.

Prior research in social dilemmas has identified critical factors underlying the production and maintenance of public goods (Oliver, Marwell, & Teixeira, 1985; Oliver & Marwell, 1988; Fulk et al., 1996). Building upon this research, we examine these factors through three research questions, providing evidence from our study. Specifically, we examine the patterns of exchange, the existence of critical mass, and the heterogeneity among actors to better understand the provision of online public goods in networks of practice.

STUDY DESIGN AND DATA COLLECTION

Conducted in a field setting, this study examines a single extra-organizational ENOP of a US professional legal association. All association members have ENOP access as part of their membership benefits, yet participation is voluntary. Individuals were chosen to take part in this study based on their ENOP participation, which consisted of posting a message to the network during the two months of April and May 2001. This ENOP is supported by “bulletin board” technology, similar to that of Usenet newsgroups where questions and responses are connected in a “thread”, resembling a conversation.

The name of the person posting was included in each message. During the two months, there were 2,460 messages posted to the network by 526 unique individuals. Each participant was sent a survey and we received 152 valid responses for a response rate of 29%. To assess response bias, we compared the participation rates of survey responders with those of non-responders and found that the participation rates of the two groups were not significantly different ($F = .823, ns$). We use both the objectively collected message postings as well as survey results to examine our research questions. The following sections examine the three research questions as well as the specific data and methods used to explore each question.

RESEARCH QUESTIONS AND RESULTS

RQ1: What is the Pattern of Contribution That Produces and Sustains the ENOP Public Good?

The first key issue for examination is the pattern of contributions that create the good. In ENOPs, contribution is reflected in the posting of questions and replies that take the form of a conversation. This interaction creates social ties between participants. We define a social tie in ENOPs as the tie created between two individuals when one person responds to another's posting. While it has been argued that social ties are important for collective action, it is less well established as to exactly how and why social ties are important (Marwell & Oliver, 1988). Initial research proposes that the overall frequency or density of social ties within a group is related to the achievement of collective action. When networks are dense, consisting of direct ties between all members, collective action is relatively easier to achieve. This argument goes back to Marx, who reasoned that the more individuals are in regular contact with one another, the more likely they will develop a "habit of cooperation" and thus act collectively (Marwell et al., 1988). Thus, one view is that ENOPs may be characterized by a dense network structure, where all members interact with all other members.

An alternative view suggests that the pattern is more like a reciprocal gift exchange. This view suggests there is a dyadic exchange between a help provider and a help seeker, with the expectation that the gift of help will be reciprocated some time in the future (Kollock, 1999). Thus, the nature of exchange in an ENOP may be structured as reciprocal dyadic exchanges between individuals, where the motivation to help others stems from the expectation of obligation and reciprocity from the receiver. A third view stemming from collective action argues that public goods can be provided through generalized exchange (Fulk et al., 1996). A generalized exchange occurs when one's giving is not reciprocated by the recipient, but by a third party (Ekeh, 1974). In contrast to dyadic exchange characterized by direct reciprocity and accountability, generalized exchange is based on indirect reciprocation and interest-based contribution. Therefore, ENOPs may also be sustained through generalized exchange.

RQ1 Results. All ENOP messages were examined to determine the identity of the person posting, and were then coded as seeds (the first message in a thread), singletons (seeds without responses), questions, responses, or other. We built a social network matrix consisting of all 526 participants to determine who was responding to whom, creating a directional, social tie. The first question examines whether individuals are participating equally. If people participate equally, we would expect all participants to have posted the average of 4.7 messages. However, the median participation is two message postings, and 64.8% of network members posted less than four messages, indicating that people are not equally sustaining the public good. The frequency rates of participation are provided in table 1.

Table 1 Frequency of Participation

Messages Posted	Individuals	Percent	Cumulative Percent
1	173	32.89	32.89
2	109	20.72	53.61
3	59	11.22	64.83
4	34	6.46	71.29
5	28	5.32	76.62
6-10	72	13.68	90.30
>10	51	9.69	100.00

We are also interested in examining whether the exchanges are directly reciprocal or generalized. The data indicate that there were 1306 exchanges between 455 individuals, and 130 were reciprocated by the same individuals. Thus, only 10% of the contributions sustaining the network are directly reciprocal. General findings and results are summarized in table 2. These findings indicate that people do not participate equally in the public good provision, rather the ENOP is sustained through generalized exchange between members.

Table 2 Summary of Exchanges

Exchange Characteristics	Result
Number of Unique Participants	526
Number of Messages Posted	2,460
Average Participation Rate	4.7 messages / person
Number of Seeds	1,121 by 436 individuals
Number of Singletons	104 by 71 individuals
Number of Threads	1,017, average length 2.4 messages
Dyadic Exchanges	1,306 between 455 individuals
Unique Exchanges	1,176
Direct Reciprocal Exchanges	130, 10% of total

RQ2: Are ENOPs Characterized by a Critical Mass Constituting a Core?

Until recently, the majority of formal collective action analyses assumed that contribution was uniformly distributed across members. However, RQ1 results indicate that this is not so in ENOPs. A competing argument suggests that a subset of the group may be responsible for making the majority of the contributions to the production and maintenance of the public good. Borrowing from nuclear physics, this subset is labeled critical mass, referring to the idea that a certain threshold of participation or action has to form before a social movement may come to exist (Oliver & Marwell, 1988). As in RQ1, this property is examined by looking at the pattern of social ties. The presence of critical mass is determined by the degree to which ties are centralized or concentrated to a few individuals rather than spread across the entire group.

In order to investigate the critical mass principle in our ENOP setting, we build upon some of the ideas underlying communities of practice (COPs). Wenger (1998) has suggested that there are different levels of COP participation: 1) full participation (insider), 2) peripherality (legitimate peripheral participant or LPP), and 3) full non-participation (outsider). In full participation, the person is an inclusive community member. He or she has gained legitimacy through engaging with other community actors in common actions and has acquired the formal and informal ability to behave as a community member (Lave & Wenger, 1991). Peripherality connotes legitimate partial participation in the community. Full non-participation is total exclusion from the community and occurs because the individual either does not desire to participate or the individual is not allowed to participate by the community.

Further, it is argued that a true COP has a central group of insiders to whom all other LPPs are connected (Wenger, 1998). If a community of individuals is divided into cliques or factions with separate central groups of active individuals then this is effectively a number of separate communities or constellations that are loosely connected to each other (Wenger 1998). Thus, we are interested in examining whether the ENOP has a critical mass of participants sustaining the good for all as well as whether the ENOP consists of multiple constellations of loosely related cliques.

RQ2 Results. We investigate the question of critical mass by examining the participant matrix. As apparent from table 1, some members are significantly more active than others, indicating the likelihood of a critical mass. Building upon Wenger's categories and based upon the analysis of messages, we created four categories of participants: outsiders (people who posted seeds, but never received a response), seekers (people who posted only questions), periphery (people who posted 10 or less responses) and insiders (people who posted more than 10 responses). Using UCINET software (Borgatti, Everett, & Freeman, 1999), we analyzed the ego network of each individual to determine centrality in terms of "in degree" (the number of times other people respond to an individual) and "out degree" (the number of times an individual responds to others). Table 3 summarizes these categories.

Table 3 Categorization of Participation

Category	#	Average In Degree	Range In Degree	Total In Degree	Average Out Degree	Range Out Degree	Total Out Degree
Outsiders	71	0	n/a		0	n/a	0
Seekers	166	2.08	1-15	346	0	n/a	0
Periphery	266	2.53	1-15	673	2.48	1-10	660
Insiders	23	12.48	4-33	287	28.09	11-114	646

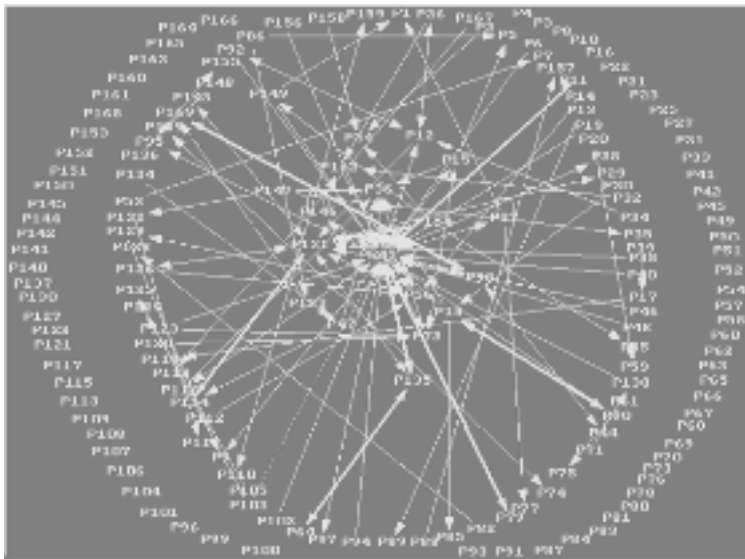
This analysis indicates that there is a critical mass of 23 insiders who are the most active in posting responses to other members. The second analysis examines the extent to which the critical mass is a clique (responding only to each other) and draws

upon recent work extending social network analysis to COPs (Schenkel, Teigland, & Borgatti 2002). First, we analyzed the data matrix using UCINET to determine whether the network has a core/periphery structure. A low core/periphery score of 0.27 indicates that there is no central core of individuals closely tied to each other. Second, we performed a component analysis, which revealed that the ENOP is characterized by only one component and not a set of subsets, indicating that the ENOP does not have multiple cliques.

Additional analysis indicates that the 4% of members who comprise the insider critical mass posted 646 responses (50% of exchanges). Of these responses, 84% were to unique individuals, also indicating little overlap within the critical mass. In addition, this analysis indicates that peripheral members are actively engaged in generalized reciprocity: LPPs are the recipients of 52% of the exchanges and are responsible for sustaining 50% of the exchanges by replying to others. By analyzing the unique number of participants in these exchanges, we note that of the 673 messages received, 614 (91%) were from unique individuals. Of the 660 response messages posted to others, 635 were to unique individuals (96%).

Thus, the network is structured as a star with a critical mass surrounded by peripheral connections emanating outwards. There are no cliques, rather the critical mass actively responds to many unique and overlapping individuals, and the periphery engages in both receiving and providing advice to others. Using Krackplot, Figure 1 shows the network structure of survey respondents (Krackhardt, Blythe, & McGrath, 1994).

Figure 1 Network Structure



RQ3: How Does the Heterogeneity of Resources and Interests of Participants Impact ENOP Collective Action?

A population's heterogeneity of resources and interests are argued to affect collective action (Olson, 1965; Hardin, 1982; Oliver et al., 1985). The more heterogeneous a group is, the more likely there is a critical mass or subset of members who have a high enough level of resources and/or interests to produce the public good. However, heterogeneity can also hinder collective action even when the mean levels of heterogeneity appear sufficient. As such, the distribution of heterogeneity is important in terms of collective action, i.e., the more positive skew and deviation from the mean, the more likely a critical mass may result (Oliver et al., 1985).

Looking at interests, in most collectives, individuals have differing levels. Individuals with higher interest levels are those who tend to gain more from additional contributions to the public good. Hardin (1982) argued that individuals with a high interest level are those who lack private alternatives. Individual interests also vary in their underlying motivations for seeing the good realized, which also affects the potential contribution level (Marwell et al., 1988). These motivations may include social and/or professional motivations (Wasko et al., 2000).

Resources include money, time, expertise, energy, and influence (Oliver et al., 1985). For a public good to be produced and maintained, it is argued that those forming the critical mass are more likely to have access to the required resources. Previous research has found that people who have higher levels of professional expertise and organizational tenure are more likely to provide useful advice on computer networks (Constant, Sproull, & Kiesler, 1996). Thus, the final research question examines the role of individual interests and resources underlying the provision of online public goods.

RQ3 Results. We examine the importance of resources and interests by analyzing the correlations between network centrality data and survey measures of resources and interests. The survey assessed two types of resources: 1) ENOP expertise measured by the number of months of professional association membership (objective measure from association member database) and 2) professional expertise measured by self-rated expertise. We assessed four types of interests: 1-2) professional motivations of reputation, and a desire to learn and challenge oneself, 3) social motivation of sustainability of participation, and 4) lack of private alternatives. Alternatives were assessed by examining the type of law firm (sole practitioner = 1, associate = 2, partner = 3), indicating that a lawyer in a sole partnership would have fewer private alternatives for professional discussion than a lawyer in a law firm with more colleagues. Reliabilities and validity of constructs demonstrated convergent and discriminant validity. The multi-item constructs were calculated by taking the average of the items. Actual items, reliabilities and factor analysis are reported in Appendix A. Table 4 presents the correlations between constructs.

This analysis suggests that the resources and interests examined in this study had little correlation with people *receiving help* (in degree). The only significant relationships with in degree are sustainability and challenge, thus those who receive help are interested in continuing their ENOP participation and the challenge associated with doing so. Resources and interests had higher associations with *responding to others* (out degree). The results indicate that longer professional association tenure and higher levels of expertise are associated with responding to others. In addition, individuals who are sole practitioners are significantly related to responding to others as are those concerned with enhancing their reputations. Thus, while interests and resources were not as significant for people who receive help, they are reasonably good indicators of why people provide knowledge to others.

Table 4 Correlations of Constructs

	1	2	3	4	5	6	7
1 Months in Assoc							
2 Expertise	.44**						
3 Type of Firm	.16*	.01					
4 Reputation	.04	-.01	.05				
5 Sustainability	-.40**	-.26**	-.04	.25**			
6 Challenge	-.39**	-.23**	-.10	.16*	.68**		
7 In Degree	-.01	.03	-.09	.12	.23**	.15*	
8 Out Degree	.17**	.15*	-.15*	.18*	.12	.02	.73**

* p < .05

** p < .01

DISCUSSION AND AREAS FOR FURTHER RESEARCH

Theories of collective action and public goods contribute significantly to our understanding of ENOPs. In this particular ENOP, the public good of knowledge was produced through a generalized exchange between members. However, this exchange was not evenly conducted by all members, rather it was sustained by a critical mass of individuals who primarily responded to others and not only to themselves. This critical mass was then surrounded by a group of peripheral individuals who both asked and received advice. Thus, the network is structured as a star with a central critical mass and connections radiating outwards. In addition, the heterogeneity of resources and interests provided good indications of why people contributed to the public good provision. Therefore, we have support to proceed further with these theories to help us understand ENOP dynamics.

However, we examined only one specific type of ENOP, an extra-organizational network using bulletin board technology. Other types of ENOP interactive technology exist such as listservs, chatrooms, and voice, and the use of these different media may affect ENOP dynamics. In addition, this study was conducted over two-months and relied on cross-sectional survey data. Thus, we were not able to investigate changes over time or how the public good was achieved in the

first place. Subsequent studies should be longitudinal to understand ENOP lifecycles. Longitudinal analysis should also look at the nature of interdependence of individuals' decisions to contribute to the public good. It has been argued that reciprocal interdependence and not sequential interdependence characterizes interactive communication systems (Fulk et al., 1996). However, it has yet to be tested empirically.

A final issue of interest to managers and researchers is the problem of free-riders and how they affect ENOP dynamics. Free-riders are those "who do not contribute sufficiently to the jointly held body of information while continuing to enjoy its benefits" (Fulk et al., 1996: 78). Two explanations have been provided: 1) greed or the desire to obtain the best possible outcome for oneself and 2) the "fear of being a sucker" or the fear that no one else will contribute even though one wants to (Kollock, 1988:189). In ENOPs, individuals may free-ride through lurking, reading all messages to gain access to the network's knowledge without ever posting themselves. There is also the question of whether people who continually ask questions, receive help from the ENOP, but never bother to help anyone else in the ENOP are free-riders. It can be argued that these individuals actually do contribute to the public good because they stimulate a thought process by other participants. However, this participation only works if there is a critical mass of individuals who continue to respond to postings. Finally, while a participant may be interested in contributing, if there is low ENOP activity, then he or she may feel that their actions will not be reciprocated the next time they need help and thus, their time spent helping is lost.

In conclusion, this study's goal was to apply the theoretical lens of collective action and public goods to examine online cooperation through the provision and maintenance of knowledge in ENOPs. Our findings suggest some practical implications for the development and maintenance of ENOPs. First, ENOPs do not need equal member participation, but rather can be sustained through the collective actions of a small percentage of members who form a critical mass. This critical mass is able to provide the public good through generalized exchange of advice and solutions. These individuals are concerned with enhancing their reputations in the network, thus technology that supports identifiers of individuals will more likely succeed than systems where participation is anonymous. In addition, those most likely to develop the critical mass are tenured experts in their area, but do not have easy access to interested others. Thus, unlike COPs that require face-to face interaction, ENOPs transcend traditional barriers to knowledge exchange through the creation of knowledge as a communal public good, available to all members of the collective.

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Article Three

Communities of Practice in a High-Growth Internet Consultancy: Netovation⁶⁴ vs. On-Time Performance

Note to Reader on Terminology:

We use the term ‘community of practice’ to represent networks of practice both within the firm and outside the firm. Additionally, we use the term on-time performance to indicate efficient performance.

⁶⁴ Netovation has been used to describe the use of the internet as a source of creativity or innovation.

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Communities of Practice in a High-Growth Internet Consultancy: Netovation⁶⁵ vs. On-Time Performance

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ABSTRACT

This article describes the findings from a study of the patterns of individual-level knowledge flows at Icon Medialab, a high-growth internet consultancy with multinational operations, and the impact of those patterns on individual performance. Building on the knowledge-based view of the firm literature, and specifically the work concerned with communities of practice, a series of propositions linking various sources of knowledge (internal vs. external, tacit vs. codified) to individual performance are developed. Using data collected from 203 employees at Icon Medialab, it is found that creativity is associated with social contact and internet-based sources such as electronic communities, while on-time delivery of results is associated with the use of codified internal sources and *negatively* related to the use of internet-based sources. Implications for community of practice theory, and for practice, are discussed.

Keywords: community of practice, knowledge, internet, performance

⁶⁵ Netovation has been used to describe the use of the internet as a source of creativity or innovation.

INTRODUCTION

Seldom does a day go by in which one does not read about the knowledge-based economy. New business models as well as whole new industries are popping up, resulting in an increasing number of high-growth firms. Yet, despite all the publicity and information about these firms, we are still a long way from understanding the workings of these new high-growth firms as well as the knowledge-based economy. Many of the management theories that we have at our disposal today were developed in the pre-internet era and may no longer be applicable. For example, we have a very limited understanding of how individuals in these new age firms exchange knowledge or how the internet is affecting knowledge flows across firm boundaries. In addition to the interest in these high-growth, internet-based firms is the rapidly growing interest in the relatively new field of communities of practice by both academics and practitioners. In numerous firms, management is attempting to support or formalize these informal organizational forms in the hope of improving the firm's competitive advantage based on knowledge (Boland & Tenkasi 1995, Brown & Duguid 1998, Davenport & Prusak 1998). Thus, the purpose of this article is to tie the two areas above together by focusing on communities of practice within the setting of a high-growth, internet-based firm. The primary intent is to understand how individuals access knowledge in their everyday work in an internet-intensive environment and what role the internet and communities play. The second intent is to then take this research one step further by linking an individual's knowledge access behavior to an individual's work-related performance.

With the above in mind, I performed an exploratory study of Icon Medialab (Icon), a rapidly growing firm within the new industry of internet consulting. Founded in 1996, the company had grown to 240 employees with offices in eight countries within two and a half years.⁶⁶ In addition, Icon was considered to be on the "bleeding edge" of knowledge-intensive companies typical of the new economy. Icon specialized in technologically complex digital communications solutions for large multinationals as well as for start-ups with radically new business models. Icon's products include business-to-business, business-to-consumer, and consumer-to-business internet-based solutions. A major objective for Icon management was to ensure not only the development and use of the latest internet technology, but also the reuse of this technology in subsequent projects. However, this is a difficult challenge since the pace of technological development is so rapid with products often becoming outdated within six months or less from development. A final reason for choosing Icon was that its employees in all functions were not only extremely adept at using new internet-based communication media such as bulletin boards, chatrooms, email, etc. but they also used these to a high degree in their everyday work.⁶⁷

66 At the end of 1999, Icon Medialab had 1056 employees spread across the globe in 19 offices in 13 countries.

67 One potential explanation is that the average age at Icon was 29.9 years.

My first step was to conduct a substantial number of interviews of various functions and levels at Icon. I then administered a detailed questionnaire to every employee in the firm aimed at developing an understanding of the sources of knowledge that each individual used in the course of his or her everyday work. With this data, I was then able to build a rich picture of an individual's knowledge networks inside the firm, and more interestingly of an individual's networks that reached across the boundaries of the firm. I then linked these knowledge flow patterns to individual performance on various dimensions in order to provide clear evidence regarding the value of these knowledge flows.

This article is organized as follows. In the following section, the Communities of Practice literature is reviewed briefly. This literature provides the foundation for the conceptual model, and the specification of six hypotheses linking knowledge flows to individual performance. Section three describes the research methodology and provides a brief description of Icon Medialab. Section four reports on the results of the empirical study while the last section provides a discussion of the results and the implications of the research for theory and practice.

BACKGROUND

In today's highly competitive environment, traditional industries are merging at the same time as completely new industries are emerging. With these changes comes the birth of numerous new firms that is considered important to the vitality of these industries. In addition, many of these new firms experience a period of rapid growth as they struggle to gain leading market positions (Aldrich & Fiol 1994, Davidsson et al. 1996, Delmar & Davidsson 1998a, 1998b). However, the ability to succeed is becoming increasingly difficult due to shrinking product lifecycles, the need for integration across an increasing diversity of technologies in products and services, and increasing levels of competition from new competitors crossing not only geographical but industrial borders as well (Boland & Tenkasi 1995, Purser, Pasmore, & Tenkasi 1992). All of this puts increasing pressure on these high-growth firms to do a better job of gaining access to new knowledge in their business environments while at the same time leveraging their existing knowledge across the firm (Bartlett & Ghoshal 1989, Doz & Hamel 1997, Drucker 1990, Hedlund & Nonaka 1993). While there has been considerable interest in studying the creation and leverage of knowledge at the firm level (see for example, Spender 1989, Nonaka 1991, 1994), until recently there has been little interest in the individual and the manner in which his or her knowledge contributes to the knowledge of a firm.

One area that looks more closely at the individual is the knowledge-based view of the firm. This view argues that a firm should be understood as a social community of individuals who have a shared identity (Kogut & Zander 1992, 1995). As individuals work together over time, they develop shared mental models, a common language, and common behaviors. This shared identity lowers the costs of communication between the firm's members and results in explicit and tacit rules of coordination as routines are built over time. In addition, a common language enables

members to codify their tacit knowledge. Relative to individuals outside the firm, employees can then easily access and reuse this codified knowledge as they share the same communication code and mental models as those who codified it (Nonaka & Takeuchi 1995). In this manner, it is relatively easy for employees to search the company for advice or existing solutions (Constant, Sproull, & Kiesler, 1996). One conceptual lens through which the firm as a community of individuals can be studied is the emerging community of practice body of research, which is the subject of the next section.

Communities of Practice

In an observed that there was a variance between the organization's formal description of work and the way in which the actual work was performed. When the technicians were faced with problems for which the formal structure often did not provide solutions, they relied on the organization's informal systems for help, such as storytelling, conversation, mentoring, and experiential learning. (Brown & Duguid 1991, Orr 1990, Snyder 1997, Wenger 1997). Individuals collaborated with each other through an emergent and fluid structure of relationships and engaged in patterns of exchange and communication to reduce the uncertainty of their tasks (Pava 1983, Purser et al. 1992). Thus, the procedures required to fulfill the tasks were developed informally as the workers performed their tasks, demanding the creation and use of knowledge along the way (Purser et al. 1992, Stebbins & Shani 1995). These informally established groups of collaborating individuals were then named communities of practice.

Communities of practice have no ethnographic study of Xerox service technicians in the late 1980s, it was real boundaries and are in a constant state of evolution as members come and go and commitment levels fluctuate. This fluidity creates difficulties when management wants to pin down communities of practice, determine their boundaries, and develop some form of recipe to manage them. Indeed, it is argued that this is not possible due to the pure informal nature of communities of practice (Wenger 1998). Thus, we must satisfy ourselves at this point with a definition that captures this fluidity and intangibility.

A group of people informally and contextually bound who are applying a common competence in the pursuit of a common enterprise (Brown & Duguid 1991, Lave & Wenger 1991, Snyder 1997, Wenger 1998)

Operationalizing Communities of Practice

While the amount of papers and articles focusing on communities of practice continues to grow, few researchers have attempted to understand the relation between communities of practice and performance. This is understandable because they are – by definition extremely hard to pin down. Any individual can potentially be involved in numerous communities of practice, varying from one's immediate workgroup to a set of internet contacts on the other side of the world. Moreover, the process of

defining the membership of communities of practice apparently takes away their very essence, because they thrive on their informal nature. Bearing this in mind it is not surprising that the community of practice literature is populated with ethnographies and case studies rather than surveys or experiments.

The approach in this paper is to bring the community of practice thinking down to the level of the individual. Rather than attempt to define the community of practices within and across the firm's boundaries, it is assumed that an individual's performance at work is associated with the extent to which he or she is a member of various communities of practice, including those facilitated by electronic means. Thus, by measuring the patterns of communication of the individual with various groups of people, and through various different forums, one can predict to some degree his or her performance. In the next section, this idea is developed into a series of testable propositions.

CONCEPTUAL FRAMEWORK AND PROPOSITIONS

As discussed earlier, competitive advantage is built on the firm's ability to acquire new knowledge from outside the boundaries of the firm while at the same time leveraging the existing knowledge within the firm. However, this leaves us with a vague idea regarding on which level knowledge acquisition and leverage occur because they can potentially occur at all levels – the individual, the group, the business unit, and the firm. As suggested by Hedlund (1994), it is the ability to transfer knowledge *between* levels of analysis (e.g., from the individual-level to the firm level and vice versa) that is valuable, and indeed one of the major characteristics that makes the firm unique.

In this paper, two levels of analysis are of interest: the individual and the community of practice. The logic here is that individuals are able to draw from their communities of practice to solve problems they encounter in the course of their work, and that they also contribute back to these communities in a reciprocal manner. Thus, the extent to which an individual is actively involved in communities of practice will *ceteris paribus* be associated with superior performance at work.

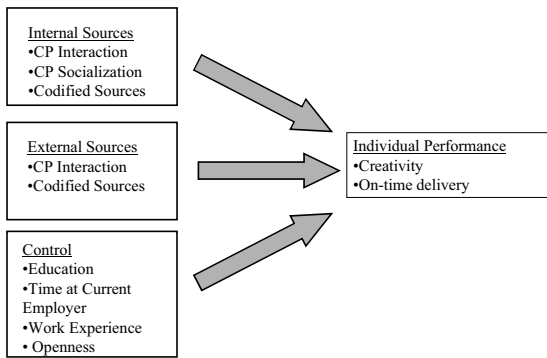
But as previously noted, there are significant methodological problems in studying communities of practice. The primary concern is that the concept is typically defined in such a way that all informal interactions, inside or outside the firm, could represent participation in communities of practice. If this broad definition is accepted, then the concept becomes very difficult to research in a rigorous manner because nothing is excluded. The theory, in other words, cannot be falsified.

The approach taken here, as hinted above, is to move down to the level of the individual and to then examine the way in which that individual acquires new knowledge to address work-related problems. Some knowledge, as we will see, is gained through access to "codified" sources such as the internet or company databases, but most is gained through interaction with other people in the firm and outside. The premise, in other words, is that the frequency and quality of the interaction an individual has with specific groups of individuals is a manifestation of the

communities of practice with which he or she is involved, and that such interactions will have a positive impact on his or her individual-level performance.

The conceptual framework in figure 1 illustrates this approach. Individual level performance, I argue, is a function of the various ways knowledge is acquired by the individual, and the sources of that knowledge can be divided into (1) internal vs. external sources, and (2) tacit vs. codified sources. In addition there are many other factors contributing to individual level performance, some of which are empirically examined as controls.

Figure 1 Conceptual Framework



Proposition Development

The first proposition follows directly from the discussion about the nature of communities of practice inside the firm. As stated above, individuals within organizations are thought to be members of numerous communities of practice. Informally collaborating within these communities, individuals create and exchange tacit knowledge in a more effective means than through formal structures and systems (Schön 1983, Snyder 1996, 1997). Being an active member of communities within the organization thus implies a high degree of collaboration and interaction with other members through primarily face-to-face but also non-face-to-face interactions. A high degree of interactions with other community members should therefore lead to a greater individual development of task-related knowledge and thus higher performance. Thus we have our first proposition.

PROPOSITION 1: The greater the level of individual personal interaction with members of communities within the firm, the higher the level of individual performance (creativity, on-time).

For an individual to truly become a member of a community of practice and access the community's knowledge, it is argued that he or she must not only have a high degree of interaction, but also become an "insider" through the development of shared trust with other members of the community (Lave & Wenger 1991, Snyder 1997). Through a high level of shared trust, the member learns of other members' mistakes and breakthroughs through storytelling and narration of work-related happenings. While trust is difficult to measure, and particularly so when the community in question is not clearly specified, one manifestation of it is in the existence of social contacts outside of work. Thus:

PROPOSITION 2: The greater the level of social interaction with community members outside of work, the higher the level of individual performance (creativity, on-time performance).

The two propositions above are concerned with an individual's participation in communities of practice within the boundaries of the organization. However, it is central to the concept of communities of practice that they also spread across organizational boundaries, through professional or technical relationships (Venkatraman & Henderson 1998). These communities may involve members from the suppliers, customers, or even friends working on similar tasks in other companies. A high degree of interaction with members of communities that cross organizational boundaries can be expected to broaden the individual's knowledge through the exchange of knowledge from outside the firm. Thus, much in the same manner as proposition 1, proposition 3 becomes the following:

PROPOSITION 3: The greater the level of individual personal interaction with members of communities that spread across organizational boundaries, the higher the level of performance (creativity, on-time).

Propositions four and five are concerned with the acquisition of knowledge through codified sources. The spread of the internet and the development of intranets are factors that have led to this explosion of rapidly accessible codified knowledge. While face-to-face collaboration with a community of practice is understood to be the primary channel for the development and exchange of primarily tacit knowledge, this channel can also be supplemented with non-face-to-face lateral written communications taking the form of electronic communities. Many organizations are in the process of implementing electronic communities to promote knowledge sharing between organizational individuals (Alavi & Leidner 1999, Davenport & Prusak 1998, Fulk & DeSanctis 1995). In addition, the use of codified sources of data such as company documents facilitates an individual when solving work-related tasks. For example, access to an internal document can help an individual to avoid reinventing the wheel, thus facilitating the completion of a work-related task. This codification and documentation of knowledge within the firm is one of the main thrusts of

management in organizations in order to ensure the transfer and application of knowledge throughout the firm. Thus, we have our fourth proposition.

PROPOSITION 4: The greater the use of internal codified sources of information, the higher the level of individual performance (creativity, on-time).

In addition to company-specific codified knowledge, individuals also have access to numerous sources of codified knowledge outside the firm. In today's fast-changing world, the knowledge required to solve a new, challenging task may not exist inside the firm, and thus the individual may have to search outside the firm for help. An individual can participate in numerous electronic communities that extend across organizational boundaries (Hagel & Armstrong 1997). Thus, an individual can communicate with thousands of others anywhere across the globe, regardless of demographic characteristics, organizational setting, or local culture (Hinds & Kiesler 1995, Sproull & Faraj 1995, Faraj & McClure Wasko 1999). We then have our fifth proposition.

PROPOSITION 5: The greater the use of external codified sources of information, the higher the level of performance (creativity, on-time).

Finally, we have the rather general proposition that the extent to which the above approaches to knowledge acquisition affect performance will be contingent on the nature of the task being performed. Space limitations prevent a detailed discussion, but one would expect *ceteris paribus* that the less routine, the more intellectually challenging, and the more fast-changing the work, the more important it would be to have ready access to personal and codified sources of knowledge. In terms of the specifics of this study, those individuals who work in software programming and web design have been separated from those doing other tasks (such as administration, sales, and management), on the basis that the former group are likely to rely more on knowledge acquisition from a variety of sources to undertake their work effectively. Thus:

PROPOSITION 6: The relationships put forward in propositions 1-5 will be stronger for "technical" employees (software programmers, web designers) than for other employees.

Many other factors are also expected to be associated with individual performance. In this study, the education level of the individual, the amount of time he or she has spent with Icon Medialab, and their general work experience are also measured. In addition their perceptions of how "open" the work environment is at Icon are measured because it is a factor that is likely to effect their propensity to exchange information with others.

Finally, it is worth observing here that individual-level performance is not a uni-dimensional construct. At the very least, we would expect to see a split between “exploration” and “exploitation” (March 1991) where exploration would be manifested as creativity or the development of novel solutions, while exploitation would be manifested in the ability to get work done on time and on budget. However, given the exploratory nature of this research I have not specified any *a priori* expectations regarding the type of performance associations we expect to see.

METHODS

Sample and Analysis

The research was undertaken in a single firm, Icon Medialab. While the objective in the future is to broaden the investigation to other firms, it makes sense to begin in a single case and then to re-evaluate on the basis of the findings from that study. As already mentioned, the choice of Icon was motivated primarily on the basis that it is a high growth, quintessential “IT-intensive” firm, in which a large proportion of the employees are working on a day-to-day basis with the latest internet technology. Many of these employees, it turns out, are interacting frequently with “communities” of “techies” whom they have never met. As such, this setting represents a fascinating test of the communities of practice concept.

It should be noted that Icon is based in Stockholm. This was not only convenient, but Stockholm is also quite an opportune location for studying such a firm because Sweden is at the forefront of digital communications technology. The country has one of the highest penetration rates in the world of mobile telephones and internet subscriptions per capita, and Stockholm is a recognized high-technology “cluster”. Icon is one of many recent start-up Internet firms in the area (founded 1996), and one of the world’s best 350 small companies according to Forbes (Forbes 1998). A description of the company follows.

Two phases of data collection and analysis were conducted. The first phase was conducted at the Swedish office, in which thirty in-depth field interviews were held from May 1998 to June 1998. People at different areas of the company, e.g., corporate management, business development, sales, and different production competencies, were interviewed for one-and-a-half to two hours each. Interviews with management were conducted first in order to understand the formal structures that had been put in place to facilitate knowledge acquisition mechanisms. Extensive written material was also collected from the companies.

The second phase of the data collection during the fall of 1998 involved a questionnaire sent to all 242 employees of Icon Medialab at their local offices. Questionnaires were then sealed in individual envelopes and returned to us either by mail or directly. Of the 242 questionnaires, 203 usable questionnaires were collected, an 84% response rate. Throughout the data collection process, individuals were assured that their responses would be kept confidential and that all results would be

presented on an aggregated level. In addition to these individual questionnaires, each of the managing directors of the eight subsidiaries and seven managers at the Stockholm office were asked to complete a questionnaire relating to the performance of the individuals at their office. The average age of the respondents was 29.9 years with an average of 385 days employed at Icon and 4.8 years experience in their competence. The sample was 30% women.

In terms of the split between functions, there were 72 respondents working in technically oriented functions (e.g. programmers, web-page designers) and 131 working in the non-technically oriented functions (e.g. sales, administration). As discussed in the previous section, this split is important in terms of understanding the types of communities of practice individuals are likely to develop.

Measures

Dependent Variables

Several different approaches exist for measuring performance, including both subjective and objective measurements. For the purposes of this study we used two different subjective dependent variables that measure individual performance, creativity and on-time performance. As discussed above, these measures represent the two dimensions of performance of exploration and exploitation where exploitation is manifested as creativity or the development of novel solutions and exploitation manifested as the ability to get work done on time and on budget (March 1991). While it is somewhat difficult to distinguish between these two measures, we do feel that it is important to measure both since it is often difficult to develop solutions that are highly creative but that are also on budget and on-time.

1) *Creativity* – Individuals were asked to answer 3 questions that created a creativity scale (Sjöberg & Lind 1994). These were based on a seven-point scale from 1, “strongly disagree”, to 7, “strongly agree” (three items, $\alpha = .64$).

2) *On-time performance* – The final performance measure asked respondents to answer to what degree they felt they delivered their work on-time on a seven-point scale from 1, “strongly disagree”, to 7, “strongly agree” (two items, $\alpha = .66$).

In addition, we asked the managers in each of the offices to rate the performance of each individual reporting to him or her on two different items: ability to meet superior’s objectives and to develop creative solutions. While the two items were strongly correlated with each other ($r = .75$), the correlation with the various self-reported performance measures was very weak (between 0.05 and 0.28). After discussing this matter with several of these individuals, it became clear that the managers often had remarkably limited contact with many of their direct reports, and that they could not easily assess their performance. We therefore concluded that the

self-reported performance measures were more valid, an observation that is consistent with a number of previous studies (e.g., Heneman 1974; Wexley et al. 1980)⁶⁸.

Independent Variables

These variables included the different dimensions of the knowledge acquisition processes and we have chosen to split them on the external vs. internal dimension. The external mechanisms consisted of two measures. The first measure which relates to proposition 5, *Codified - external*, asked respondents to answer on a seven-point scale the frequency of use of external knowledge sources. These sources included traditional sources such as externally produced books or journals in addition to recently developed sources such as Internet web pages or Internet discussion forums (five items, $\alpha = .73$). The second measure, *External community interaction*, was measured on a four-point scale relating to the degree of interaction on work-related matters with customers and friends. Respondents were asked how often they initiated the interaction as well as how often the external party initiated the interaction (four items, $\alpha = .80$) and relates to proposition 3.

The second group of variables, internal mechanisms, consisted of 7 different measures. The first measure relating to proposition 4, *Codified - internal*, asked respondents to answer on a seven-point scale the frequency of use of internal knowledge sources. These included using the company's intranet as well as materials such as documents that were produced internally by Icon (three items, $\alpha = .64$). The next measure, *Interaction with internal community*, that relates to proposition 1 was based on a four-point frequency scale on two dimensions. The first one was based on whether it was the respondent who initiated the interaction and the second one based on whether the other party initiated the interaction. This measure was built upon the interaction with others within the same function, others within one's workgroup, and others outside of one's workgroup (three items, $\alpha = .64$). For example, the workgroup of a programmer included art directors and web designers as these three functions comprised the production team for each project. Those outside of the programmer's workgroup included those in support functions, e.g., sales, or those in management functions, e.g., human resources. The final measure, *Social contact*, was measured through the level of social contact outside of work with any individual throughout the organization. This was measured on a simple 1-2 scale, 1 for no and 2 for yes (3 items, $\alpha = .86$) and relates to proposition 2.

Control Variables

These variables included level of education (1-5 scale), time employed at Icon (no. of days), related work experience (years)⁶⁹, and openness. Openness was created to measure the level of openness at Icon perceived by the individual on a seven-point

68 It is worth noting in passing that the significant correlates with manager-rated performance were (a) age of employee, and (b) lack of socialization with other people outside of work. In other words, managers believe that older employees without social contacts with colleagues are the better performers!

69 In order to avoid multicollinearity problems, we decided not to include age as it correlated highly with related work experience.

scale from 1, “strongly disagree”, to 7, “strongly agree” (11 items, $\alpha = .65$). Summary statistics for the control variables and the other variables are presented in the table in the appendix.

The propositions were tested through a series of stepwise regression models. The stepwise approach was chosen primarily because of the small sample size and the relatively large number of independent variables. Also, the exploratory nature of the study makes it appropriate to work with a rather larger number of independent variables than would normally be the case. The plan in future iterations of this research will be to move towards a more carefully specified model.

Company Description

Icon Medialab was founded in March 1996 in response to the rapid growth of the internet ⁷⁰. The company’s mission was to facilitate the creation of competitive advantage for its customers through the incorporation of the internet in customer operations. Products and services included internet homepages, intranets, extranets, and e-commerce solutions. Icon Medialab’s clients ranged from the Swedish Postal Service and Compaq to British Petroleum and Volkswagen. The company posted sales of SEK 65 million for the fiscal year ending April 1998 (SEK 13 million in 1997) and at the time of this study had 242 employees with 46% of these in Sweden. The remaining employees were spread throughout offices of 10-25 employees in Spain, USA, Finland, Denmark, Germany, Belgium, and the UK, with new offices planned for France and Norway. Table 1 provides some key figures for Icon Medialab.

Table 1 Figures for Icon Medialab

	1999	1998	1997	1996 (10 mos.)
Sales (SEK mln)	412	132	43	4.59
Number of Employees	1056	300	141	62
Number of Offices	19	9	6	3
Number of Countries	13	9	6	3

A strategy of rapid global growth was developed by the founders at the company’s inception. One of the means by which Icon hoped to achieve profitable growth was through the reuse of knowledge developed throughout its different projects. In fact, management set a target that more than 50% of all projects should include already proven successful products or services. Thus, Icon Medialab invested heavily in building its structural capital, with the key objectives to transfer and reuse knowledge complemented with follow-up and reporting.

In addition, Icon Medialab was unique in its representation of a mixture of competencies under the same organizational umbrella. These disciplines included Technology, Design, Usability Engineering, Statistics and Analysis, Media and

⁷⁰ The digital communication market is among the fastest growing markets ever. In a report by the International Data Corporation, the market for internet services is predicted to grow from USD 2.5 billion in 1996 to USD 13.8 billion in 2000.

Entertainment, and Business Strategy, representing the 6 sides of the “Icon Cube”. Thus, Icon Medialab brought together art directors, behavioral scientists, copywriters, journalists, scriptwriters, animators, TV-producers, software programmers, management consultants and web designers, with accounting, personnel, and administration completing the organization.

RESULTS

Descriptive Statistics

Before moving to the results of the regression analysis, it is important to describe the patterns of knowledge acquisition among the Icon employees, and in particular whether there are any significant differences between technical employees and others (cf. proposition 6). Table 2 presents a comparison of the means of the use of different sources of knowledge for the two groups at Icon. While there is no significant difference in the level of internal community interaction and social contact outside of work, Codified – internal sources, Codified - external sources, and Interaction with the external community do differ significantly. The technically oriented people tended to use external codified sources of information more than the non-technically oriented people while the opposite is true for the internal codified sources. Based on our scale, technically oriented people used external codified sources once a week on average, while the non-technically oriented people used these sources between once to twice a month. With regard to internal codified sources, non-technically oriented people accessed these about once a week and the technically oriented people closer to once a month. In addition, the level of interaction with the external community was higher for non-technically oriented people than for those who are technically oriented. Non-technically oriented people interacted with the external community an average of about two times a week while the non-technical people interacted about two times a month.

Table 2 Comparison of Means

Variable	Nontech.	Tech.	t
<i>External</i>			
1. Codified - External ^a	3.43	4.00	3.30**
2. Interaction with External Community ^b	2.96	2.46	-4.00***
<i>Internal</i>			
3. Codified – Internal ^a	3.95	3.20	-3.90***
4. Interaction with Internal Community ^b	3.07	3.15	-0.88
5. Social Contact Outside Work ^c	1.36	1.34	-0.35

^a 1 – yearly or less, 2 – four times a year, 3 – once a month, 4 – once a week, 5 – twice a week, 6 – once a day, 7 – several times a day

^b 1 – rarely or never, 2 – once a month, 3 – twice a week, 4 – a few times a day

^c 1 – no, 2 – yes

** p < .01

*** p < .001

Propositions

Individual performance was measured using two different constructs, Creativity and On-time performance. In addition, we have reported two different models for each dependent variable— one for the whole sample, and one for just the technical employees. The purpose of this split is to see if the results differ significantly when one just considers technical employees.

Self-reported Creativity – Whole Sample

In table 3, limited support for propositions 5 and 2 is received for the whole sample size. Consistent with proposition 5, the coefficient of the use of External codified sources is positive ($p < .10$). In addition, the coefficient of Social contact outside of work is positive ($p < .10$) and is consistent with proposition 2. Thus, the higher the level of social contact and the higher the use of external codified sources, the higher the level of individual creative performance. In addition, the control variables were also highly significant: Education ($p < .05$), Office openness ($p < .01$), and Related work experience ($p < .001$).

Self-reported Creativity – Technically Oriented

Table 3 also provides the results for only the technically oriented people. Stronger support is provided for proposition 5 since the coefficient for Codified external is more significant ($p < .05$) than in the above regression. Social contact is the same as above ($p < .10$), thus providing limited support for proposition 2. In addition, there was only one significant control variable, Openness ($p < .05$). Of interest is that the adjusted R^2 is the highest for this regression than any of the others, 0.45.

Self-reported On-time Performance – Whole Sample

Support for proposition 4 is given in table 4 as the coefficient is positively related ($p < .05$). Thus, on-time performance is positively related to the use of codified internal sources. In addition, two control variables turned out negatively related to performance: Education ($p < .05$) and Time at Icon ($p < .10$). This regression had the weakest R^2 of the regressions, 0.11.

Self-reported On-time Performance – Technically Oriented.

Table 4 shows that there is support for proposition 4 as the coefficient, Codified internal, is positively related to On-time performance ($p < .01$). In addition, proposition 5 was rejected as the coefficient, Codified external, was negatively related to performance ($p < .05$). Only one control appeared significant, Openness ($p < .10$), in this equation.

Table 3 Results of Regression Analysis of the Relationship between Knowledge Acquisition Mechanisms and Self-reported Creativity

Variable	Model 1 Whole Sample		Model 2 Tech. Only		
	Prop.	Var.Incl.	Var.Excl.	Var.Incl.	Var.Excl.
<i>Control</i>					
1. Education		.18*			-.00
2. Work Experience		.31***			.10
3. Time at Icon			.03		-.22
4. Office Openness		.30**		.42*	
<i>External Knowledge</i>					
5. Codified - External	5	.15 [†]		.35*	
6. External Community	3		.08		-.22
<i>Interaction</i>					
<i>Internal Knowledge</i>					
7. Codified - Internal	4		.08		.11
8. Internal Community	1		.07		.06
<i>Interaction</i>					
9. Social Contact Outside Work	2	.17 [†]		.30 [†]	
R2		.28		.51	
ΔR2		.25		.45	
F for ΔR2		7.97***		8.31**	

[†] p < .10 * p < .05 ** p < .01 *** p < .001

Table 4 Results of Regression Analysis of the Relationship between Knowledge Acquisition Mechanisms and Self-reported On-time Performance

Variable	Model 1 Whole Sample		Model 2 Tech. Only		
	Prop.	Var.Incl.	Var.Excl.	Var.Incl.	Var.Excl.
<i>Control</i>					
1. Education		-.23*			-.11
2. Work Experience			.04		-.04
3. Time at Icon		-.16 [†]			-.09
4. Office Openness			.08	.28 [†]	
<i>External Knowledge</i>					
5. Codified - External	5		-.04	-.31*	
6. External Community	3		-.10		-.06
<i>Interaction</i>					
<i>Internal Knowledge</i>					
7. Codified - Internal	4	.23*		.55**	
8. Internal Community	1		.11		.26
<i>Interaction</i>					
9. Social Contact Outside Work	2		-.11		.08
R2		.13		.48	
ΔR2		.11		.42	
F for ΔR2		5.25**		7.43**	

[†] p < .10 * p < .05 ** p < .01 *** p < .001

DISCUSSION AND IMPLICATIONS

Table 5 provides an overview of the support for the different propositions from the different regression models. Altogether we see support for propositions 2, 4, and 5. Moreover, what is interesting here is that we see such different results for the two dependent variables. Again, as discussed above the study looked at two dimensions of performance, creativity and on-time performance that represent exploration and exploitation, where exploitation is manifested as creativity or the development of novel solutions and exploitation manifested as the ability to get work done on time and on budget (March 1991). Following is a discussion of the regression findings related to the qualitative findings.

Table 5 Support for Propositions

Proposition	Creativity		On-time	
	Whole	Tech.	Whole	Tech.
1. Interaction with Internal Community				
2. Social Contact outside Work	.17 [†]	.30 [†]		
3. Interaction with External Community				
4. Codified - Internal			.23*	.55**
5. Codified - External	.15 [†]	.35*		-.31*

[†] p < .10

* p < .05

** p < .01

*** p < .001

Creativity

Taking creativity first, we see social contact outside of work and the use of external codified sources of information (internet communities and the like) as the significant predictors. Building on our qualitative findings, the impression one gets is that technical employees attach great importance to their external internet-based relationships as sources of ideas and as ways of solving tricky problems. Several programmers even stated that they preferred to go first to their internet community or use their private email list for help instead of asking someone at their own company even if he or she was sitting at the next desk. Through interviews, several reasons were found. The first was that by posting a question in an open forum on the internet, people were not obligated to help. Instead those who wanted to help could do so in a voluntary fashion. By reaching out to the electronic community for help, one did not disturb a colleague at work who had his or her own schedule and deadlines to meet. Another reason found was that people could access a much broader source of expertise than at their own company. In many instances, individuals claimed that there was no "critical mass" internally, especially when discussing the intranet, within Icon. However, this critical mass could be found on external websites and communities. Members of external communities worked at different types of companies all over the world, yet they worked on the same type of problem. Thus, it was felt that this

enabled one to gain access to the latest thinking within one's field, especially since the change of pace within this industry was so rapid.

To turn the discussion to the second predictor, Social contact, individuals became members of a tightly knit community of practice through extensive social contact outside of work. During this social contact, these individuals discussed the difficult problems encountered during the day, the responses received from the electronic community, and how they then attempted to solve the problem. The latest solutions or tips from both the outside communities and one's own work were passed between the members of the community. In this manner, these community members socially constructed their world through the narration of stories, turning incoherent data into coherent information. This enabled them to gain insights into the work they were performing, allowing them to be more creative in their daily work. What is interesting here then is that it is the combination of the use of an external community with one's internal community. As ideas cross community boundaries, resulting in the cross-fertilization of communities, knowledge is combined to foster creativity. Based on these findings and previous research, we then developed the term Netovation to describe this creative performance that was fostered through the use of the internet (Teigland 1999).

On-time Performance

In terms of achieving on-time performance, a very different picture emerges. Here, the use of internal codified sources of information is a positive predictor of on-time performance, while the use of external codified sources is a *negative* predictor. This is entirely in keeping with intuitive expectations. Building relationships with external communities and creating unique or "elegant" solutions on the basis of those relationships works well when creativity is the objective, but it is a strong negative when on-time delivery matters. Gathering information from the outside takes time because first either the sources must be located or one must wait for someone to voluntarily help. And once the information or help is received, it must be assimilated into the context of both the problem and the company's way of doing things. This may take considerable time depending on the complexity of the information and the problem.

In addition, reciprocity within these electronic communities is necessary in order to become a true member. In other words, to be able to ask the other internet community members for help, one must prove that one also gives back to the community through providing help to others when asked. This returning of help then results in the individual performing work for others outside the company. This then takes away time from the individual's internal responsibilities, potentially leading then to poor on-time performance.

Thus, on-time performance can best be achieved by re-using existing solutions that can be accessed through the firm's intranet or company documents. To give an example, Icon's intranet included a programming module database that included both a description for the sales force and a technical description for the programmers.

Programming modules were building blocks of programming code that could be reused in a number of customer projects, such as a discussion forum, telephone book, or conference room booking system. In addition to a technical description, the module list also specified how many hours were required to develop the module. This information was added to help determine the pricing and planning of future projects.

Participation in Communities of Practice

While it was found that both internal and external sources of codified information were significant for different types of performance, it was quite puzzling that no support was found for the relation between performance and the frequency of interaction with members of communities of practice either internally or externally located. As we saw above (table 3), both non-techies and techies used codified internal and codified external sources of information to a higher degree than interaction with communities either internally or externally. This seems to go against the community of practice literature that says that individuals draw upon their communities to help them in their everyday work. However, a deeper analysis of community interaction is necessary. In addition to asking the set of questions regarding the *frequency* of use of information sources, a set of questions was asked which looked at the *helpfulness* of information sources when solving a particularly difficult problem. This was designed in order to get a picture of the usefulness of different information sources as opposed to the frequency of use. The results are presented in table 6 below.

As we can see, non-techies ranked informal discussions with someone in their office (not their immediate superior) as the most helpful source while techies ranked these informal discussions as the second most helpful. Thus, we see that internal communities are of importance when solving a particularly difficult or challenging problem. This is in line with the communities of practice literature that says that individuals do turn to their community for help with tasks that fall outside of the routine way of doing things. What is of interest here is that techies ranked internet web pages as the most helpful information sources over interaction with communities. Some individuals even ranked internet discussion forums and electronic communities as the most helpful. As discussed above, one of the reasons was that the technology was changing so rapidly thus in order to access the latest thinking within the field, it was quicker to go to external sources through the internet to get an idea of what the answer might be and to then discuss this with internal community members to adapt it to the specific task at hand.

Table 6 Sources of Information Used for Solving a Difficult Problem

<i>Think back to the last really difficult problem that you solved. Rank the following sources of information</i>	Whole Sample (n= 200)	Nontech. (n=131)	Tech. (n=69)	t
Scanning or reading externally printed materials	3.15	3.04	3.33	1.05
Internet web pages (company pages, FAQs, help desks etc)	3.39	2.99	4.13	4.14***
Internet discussion forum, electronic community	1.89	1.64	2.35	3.26**
Private email list	2.04	2.00	2.10	0.43
Icon's Intranet	1.72	1.76	1.64	-0.67
Informal discussions with project manager, competence coach, leader	3.01	3.20	2.64	-1.83 [†]
Informal discussions with someone other than above in your office	4.04	4.11	3.90	-0.74
Informal discussions with someone in another Icon office	2.31	2.52	1.91	-2.46*
Informal discussions with customers	2.15	2.35	1.75	-2.52*
Informal discussions with someone at another Internet company	1.79	1.76	1.84	0.42
Scheduled meetings	2.50	2.73	2.04	-2.70**

[†] p < .10 * p < .05 ** p < .01 *** p < .001

The cells indicate the average rating for the item in question. Respondents were asked to indicate up to five sources of information, where a score of 6 = most helpful, 5 = second most helpful, 4 = third most helpful, 3 = fourth most helpful, 2 = fifth most helpful. A score of 1 meant that the source of information was not mentioned. Thus, a higher average rating means the source was more helpful in solving problems.

However, another quite interesting reason for the significant use of internet webpages and electronic communities was uncovered during the qualitative phase – that of prestige. Several interviewees commented that some individuals feared making mistakes or making themselves look stupid by asking others at Icon for help. So, they turned to the internet where “no one knows if you’re a monkey”. Another aspect was that it was seen as prestigious if one belonged to some of the closed internet communities. Some of these qualitative findings seem to be in accordance with Zipf’s Law of Least Effort (1949), which argues that individuals when choosing a path towards a goal are more interested in minimizing effort than maximizing gain. This effort includes both physical as well as psychological effort. Thus, although asking another programmer within the company for help may result in a larger gain, it may cost the knowledge seeker more in terms of psychological effort, showing that he or

she does not know the answer⁷¹. The following quotation exemplifies this, “Sometimes it seems that there are some programmers who are afraid to ask for help. So, instead they just sit there and work for hours trying to solve something instead of asking.” In relation to the community of practice literature, this psychological effort may be higher for those individuals who are not legitimate members of a community. These individuals do not have a feeling of shared trust with the core members of a community and experience a higher level of psychological effort by asking questions to the internal communities.

Turning to Icon, at the time of data collection, the company was in a very high rate of growth both in terms of the number of employees as well as in the number of offices. The Stockholm office was only two and a half years old with four of the offices less than one year old and an average individual tenure at the company of 385 days. Thus, many of the individuals had not yet had time to become legitimate community members. In addition, in many offices other than the Stockholm office there was only a handful of individuals within each function, and potentially even fewer for the technical functions. Thus, the ability to interact with internal community members was limited in many respects by either lack of members or the insufficient tenure to become a community member. The importance of becoming a member within the community in order to access help was exemplified in the following citation. “Other programmers call me up pretty often because they have heard about me. But it feels really strange when you don’t know them. It then becomes a matter of prestige - why should I help you?”

Implications for Theory and Practice

This study raises a number of very interesting theoretical and practical issues. First, what do we make of the concept of the community of practice in the light of our findings? Some support was clearly found, in terms of the importance of work-related and social interaction with other community members. But there were also some surprises, notably the importance of so-called “internet communities” as sources of knowledge for technical employees. This is a curious discovery because these “communities” exhibit many of the characteristics of communities of practice – reciprocity, identity, and so on—but the individuals involved have typically never met, and they work through what is by definition a *codified* exchange of information, which goes against other aspects of the theory. One programmer commented,

I've been really active in the internet community for a long time. I'm in contact with a group of about 20 people who are experts at what they do. But I have never met them physically. But it doesn't matter because on the internet we have always been friends. It's just like when you used to go

71 This also has some parallels to the work done by Edmondson (1999) on team psychological safety. Team psychological safety is defined as the shared belief by the team that the team is safe for interpersonal risk-taking, thus encouraging people to express their ideas without fearing that they will be rejected. This belief stems from mutual respect and trust among the team’s members.

snowboarding 10 years ago. If you were somewhere and saw another snowboarder, you said hi and then you'd hang out together in the evening. Just because we snowboarded and there were so few who did it. We were on the same level...we knew where we had one another.

The development of these electronic communities has added a spoke of a new dimension to the community of practice literature. Whether or not these electronic communities can be considered communities of practice is an issue currently being debated among scholars. According to Lave & Wenger (1991), socialization (i.e., face-to-face contact) among members is an important factor in the building of a community of practice. Nonaka & Takeuchi (1995) further explain that socialization requires the sharing of tacit knowledge that in turn requires a shared space among the community of practice members. Since communication through the internet is textual among individuals who often are spread across the globe, it is argued that participating individuals do not have a shared space, thus there is no socialization, and more importantly, no sharing of tacit knowledge. Followers of this view would then argue that these internet-based communities are not communities of practice in the “true” meaning of the term. As a result, we need to revisit certain aspects of the community of practice to better understand which theories are still valid and which need to be adapted to the new empirical contexts.

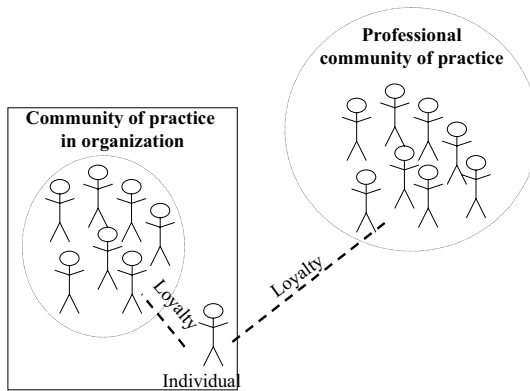
Secondly, our results provide some preliminary support for the idea that the firm is a vehicle that brings together members from different communities of practice that are more professionally oriented. Thus, a programmer may belong to a C++ community that spreads across many firms' boundaries while the other functions at Icon, e.g., management consultant, art director, etc., do the same. Icon then brings together these different communities by hiring members and incorporating them into project teams. Professional knowledge flows across firm boundaries as individuals seek out help from their external professional communities. The firm then develops the knowledge as to how to coordinate these different professional individuals.

The third implication from our findings is that the building of the capability to manage these knowledge flows presents considerable challenges for a company's management. First as we found in our research, on-time performance was negatively correlated to the use of external codified sources, yet positively correlated to the use of internal codified sources. Too much external knowledge leads to missed deadlines and overrun budgets, while the reuse of internal knowledge leads to on-time performance. Based on our qualitative findings, the aspect of prestige including the “not-invented-here” syndrome – the desire to develop one's own solutions rather than reuse existing solutions – and Zipf's Law of Least Effort (1949) play a significant role in the choice of knowledge sources.

While it was found that this matter of prestige was strong within Icon, it may have its roots outside of Icon's borders in the global community, primarily among the programmers. One programmer explained that he started working on one project because he really wanted to show Silicon Valley that other areas of the world could produce “bleeding edge” products as well. While on the one hand, programmers were

inspired to make Icon the world's best company, on the other hand, programmers were pressured by their global community to produce the latest "cool" solution. In addition, programmers were under a form of social pressure from their external community to help fellow members solve their difficult problems, often attempting to "show off" in front of the others. This was found to lead to conflicting goals or loyalty for the programmers: best company vs. best profession (see figure 2). Creating a "cool" solution or trying to impress a global community through solving another external member's difficult problem leads to longer hours worked, using unnecessary resources as well as causing delays in product delivery to the customer. However, it is this communication with communities that span organizational boundaries that leads to the cross-fertilization of communities that then fosters creativity. And it is this creativity that is essential for the continuous creation of a firm's competitive advantage.

Figure 2 An Individual's Conflicting Loyalties



Thus, the challenge for management is then to be able to align the use of both the internal and external knowledge sources with the company's competitive strategy. If the company is pursuing more of a knowledge creation over a knowledge reuse strategy (Hansen et al. 1999), then a greater use of external sources over internal sources ensures creativity and the access to the latest solutions. However, if the strategic focus is on knowledge reuse, then too much external use leads to an inefficient use of resources. This is no new challenge, merely the exploration vs. exploitation balance in a new setting. What perhaps has intensified this challenge is that as internet technology develops so rapidly, management may have difficulty in keeping abreast of developments, making it a challenge to know whether employees are working on necessary value-adding activities. One manager summed up this situation with reference to the programmers. "Programmers take us (management) hostage. We never know whether they're working on extra bells and whistles to impress their buddies or whether it's really a value-adding activity for the customer."

A second challenge for management is that when employees are active in their external communities, they are often involved in disclosing proprietary company knowledge to other external community members. As stated above, an unwritten code of conduct with fellow community members exists that includes reciprocity. In order for members to gain knowledge, they must provide knowledge to others. Those who do not give are cut off from the knowledge flows. In many cases, individuals pass right over firm policies prohibiting such action as indicated in this quotation by one programmer, "We pass over the nondisclosure agreements of different companies all the time and trade company secrets." Thus, management must be aware that knowledge is leaking through the boundaries of the firm to the external world through participation in these electronic communities. Whether or not this leakage dilutes the firm's competitive advantage is an area for further research although previous research has indicated that the greater the trading of information across company boundaries, the higher the firm's relative performance (Schrader 1991). Again, what we are seeing at Icon is no new phenomenon (see Mansfield 1985, Schrader 1991, von Hippel 1987, and von Hippel & Schrader 1996); however, the ease with which this knowledge leakage can occur has been greatly facilitated with the spread of the internet. Finally, a third challenge is that when management hires a person, management is also "hiring" the employee's network as well. Thus, management must consider the potential employee's external network and how active this person is in his or her network. If the person is very active in his or her external network, then the individual's time may be spent on external activities. As shown above, this can lead to both positive and negative results for the company.

Thus, this research has provided us with several areas that require management's attention in a rapidly growing company in order to facilitate the creation of competitive advantage based on knowledge. First, a clear knowledge management strategy (e.g., knowledge creation vs. knowledge reuse) should be communicated. Secondly, a high number of socialization activities is an important factor in ensuring the creation of communities that are aligned with the company's corporate and knowledge management strategy. As individuals join the firm at a rapid pace, this socialization facilitates the creation of and membership in communities of practice. In addition, socialization promoting alignment between the culture of the communities and that of the firm enables individuals to conduct themselves in the company's interests when trading information across company boundaries. Finally, management should focus on building a critical mass within the knowledge management systems in the company's intranet, whether it be codified documents or discussion forums. Communication of the importance of the company's knowledge management systems and the use of the intranet will then further improve usage.

In terms of the limitations of this study, we acknowledge that there is a need to look at more than one firm and preferably with a larger sample of respondents before coming up with any definitive conclusions. The questionnaire suffers from common-method bias, so ideally we would also complement some of our measures with

secondary data on e.g. meetings attended, emails sent, hours on the web. But such a data-collection process would be extremely time-consuming and difficult to arrange.

Finally, it is important to acknowledge that our choice of communities of practice as our theoretical lens has its drawbacks. As noted several times, it is almost impossible to define communities of practice in an operational way, so one ends up falling back on measuring individual level patterns of interaction. And having moved in that direction, there are a number of other theoretical angles that could and perhaps should be incorporated, such as the vast literature on groups, environmental scanning, and organizational cognition. These are issues that will be considered in future research.

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APPENDIX

Table 7 Descriptive Statistics and Correlations for All Variables^a

Variable	Unit	Mean	s.d.	1	2	3	4	5	6	7	8	9	10
<i>Self-evaluated performance</i>													
1. Creativity	1-7 scale	5.06	1.04										
2. On-time performance	1-7 scale	4.96	1.22	.08									
<i>Control</i>													
3. Education	1-5 scale	2.98	1.03	.10	-.15*								
4. Related work experience	years	4.76	4.42	.29***	.20*	-.04							
5. Employed at Icon	days	385.52	349.92	.18*	-.08	.03	.11						
6. Office openness	1-7 scale	5.13	0.63	.27***	.18**	-.06	.05	.16*					
<i>External</i>													
7. Codified	1-7 scale	3.63	1.21	.17*	.00	-.00	.13	.02	.05				
8. External community interaction	1-4 scale	2.79	0.84	.21**	.04	.07	.17	.14	.14	.13			
<i>Internal</i>													
9. Codified	1-7 scale	3.68	1.34	.06	.23**	.04	.18	-.14	.13	.15*	.17*		
10. Internal community interaction	1-4 scale	3.12	0.62	.15*	.15*	.11	.02	.09	.29***	.10	.20**	.08	
11. Social contact	1,no; 2, yes	1.36	0.41	.27**	-.06	.05	-.08	.10	.24**	.12	.14	.09	.27**

^a Range of *N* is 154-203.

* $p < .05$

** $p < .01$

*** $p < .001$

Article Four

Extending Richness with Reach: Participation and Knowledge Exchange in Electronic Networks of Practice

Note to Reader on Terminology:

In general, the terminology in this article corresponds to the terminology in this thesis. The only concept worth noting is “General Performance”, which is neither the same as Creative Performance or Efficient Performance in the other articles. General performance does, however, relate to a high level of expertise and is primarily related to creativity. In addition, we use two abbreviations:

- 1) CoP for Community of practice
- 2) ENoP for Electronic network of practice

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Extending Richness with Reach: Participation and Knowledge Exchange in Electronic Networks of Practice

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ABSTRACT

In an effort to replicate communities of practice online, organizations are investing in information technologies that create intra-organizational electronic networks, or “electronic networks of practice”. These networks are designed to enable the creation of electronic “bridging ties” between geographically dispersed organizational members to provide a communication space in which individuals working on similar problems may quickly ask each other for help on task-related problems. This article compares the dynamics of knowledge exchange between electronic networks of practice and traditional communities of practice. In addition, this article examines why people participate and help others in an electronic network of practice as well as whether electronic network of practice participation has an impact on knowledge outcomes and individual performance. In order to investigate these issues, data were collected from a successful electronic network at one of Europe’s largest consulting companies. The article concludes with a discussion of the results and implications for both managers and researchers interested in the dynamics of electronic knowledge exchange.

Keywords: knowledge management, electronic community, community of practice, internet, performance

INTRODUCTION

Communities of practice (CoPs) are regarded as essential building blocks of the knowledge economy and are being promoted within organizations as sources of competitive advantage and facilitators of organizational learning. In organizations, CoPs traditionally emerge through the mutual engagement in work performed by individuals who are either physically co-located or who frequently meet each other face to face (Orr, 1996; Wenger, 1998). However, due to hypercompetitive conditions in the marketplace and the increasing complexity and diversity of global organizations, knowledge workers engaged in the same practice are increasingly becoming more distributed across an organization's geographical locations. Thus, in an effort to replicate traditional CoPs electronically, management in numerous organizations has invested in computer-mediated communication technologies to facilitate knowledge sharing regardless of time and space constraints. We refer to these emergent virtual communities as electronic networks of practice (ENoPs). We follow Brown and Duguid (2000) in their use of the term "networks of practice", yet we add the term "electronic" to highlight that communication within this network of practice occurs primarily through computer-based communication technologies, such as bulletin boards, listservs, etc. In this article, we use the terms electronic networks of practice, networks, and ENoPs interchangeably to avoid repetition.

While traditional, face-to-face CoPs within organizations have received increasing attention, we know much less about the dynamics underlying ENoPs and the electronic knowledge exchange supported by these computer networks. Initial research suggests that participation in these networks provides access to useful sources of technical advice for organizational members (Constant, Sproull, & Kiesler, 1996). However, there is ample evidence that simply investing in information technologies does not directly enhance knowledge sharing. In fact, researchers estimate that between 50-70% of knowledge management projects fail to meet expectations and stated objectives and attribute these failure rates to an over-reliance on information technology (Ambrosio, 2000). Thus, a key question for researchers and managers alike is how to turn an empty electronic space into a vital, active forum devoted to knowledge exchange.

The goal of this article is to provide guidelines to both researchers and managers interested in studying and supporting electronic networks of practice within and across organizations. In order to do so, we begin by presenting the key characteristics that define an ENoP and compare ENoPs to CoPs. We then examine two questions related to individual participation in an ENoP: (1) why do people participate and help others, and (2) does participation result in positive knowledge outcomes? Finally, we present and discuss findings from a

recent study that investigated the above two questions in a successful ENoP at a global consulting organization.

ELECTRONIC NETWORKS OF PRACTICE

The concept of a community of practice has highlighted the importance of emergent mutual engagement in practice, where mutual engagement typically refers to physically co-located, face-to-face interactions. However, emergent mutual engagement can also occur through text-based communication and discussion fora, such as bulletin boards, listservs and Usenet Newsgroups. Thus, electronic networks of practice are similar to communities of practice in that they are a social space where individuals working on similar problems self-organize to help each other and share perspectives about their practice. However, unlike a CoP, in an ENoP mutual engagement occurs through computer-mediated communication. This profoundly affects how knowledge is exchanged in several ways.

First, as mentioned, similar to a CoP, knowledge is exchanged in an ENoP through mutual engagement in practice. Thus, one defining characteristic is that participants in an ENoP interact with one another to help each other solve problems. By posting a message to the network, individuals requiring help with a problem may quickly reach out to other participants that then provide valuable knowledge and insight in response. The network also provides a forum for participants to share stories of personal experiences and discuss and debate issues relevant to their practice (Wasko & Faraj, 2000). The posting and responding to messages is recorded like a conversation between participants, representing active mutual engagement in problem solving. This characteristic of mutual engagement distinguishes ENoPs from more static forms of electronic knowledge exchange, such as document repositories and other types of databases.

Second, knowledge in an ENoP is exchanged through asynchronous, text-based computer-mediated communication. In face-to-face interaction, participants perceive a variety of social and visual cues, and have access to immediate feedback. However, in electronic communication these cues are filtered out, making it a lean medium of exchange and impacting how knowledge is actually exchanged between participants (Daft & Lengel, 1986). In addition, the technology creates a weak structural link between like-minded individuals who are physically dispersed, thus eliminating the need for people to know one another personally in order to access knowledge. In an ENoP, the technology supports any number of participants, eliminating constraints due to size. Therefore, knowledge seekers are not limited to asking only experts whom they personally know or are able to identify, increasing the likelihood of connecting with someone willing and able to help. Finally, mutual engagement in an ENoP is typically archived and available to all participants in

the network. This creates an on-line repository of questions and answers that can be referred to at a later time by any interested individual, regardless of his or her participation in the original engagement or tenure in the electronic network of practice. This contrasts with knowledge exchange in a CoP where access to advice is limited to whom you know, and knowledge is exchanged between seeker and provider without necessarily being made available to other members of the community.

Another defining characteristic of an ENoP is that participation is open to anyone with a desire to interact. The electronic links created by internet and intranet technologies that enable individuals to communicate are practically ubiquitous, thus membership is available to anyone with a connection. In addition, because membership is open, membership is fluid, making it difficult to create and enforce boundaries. This sharply contrasts with the tightly knit relationships between specific members that typify CoP structures. Also, this characteristic separates an ENoP from a virtual group or team, where members are designated and assigned.

Fourth, participation in an ENoP is voluntary. Individuals choose whether or not they want to participate as well as how often they participate - ranging from simply lurking to becoming an active participant. In addition, individuals have choices about how they participate, deciding whether or not to post questions, replies, or both. Finally, individuals voluntarily determine what they want to contribute, choosing what knowledge they are willing to disclose as well as the length of the messages they contribute, influencing the quality and helpfulness of the knowledge exchanged. This criterion of voluntary participation distinguishes an ENoP from other forms of virtual work, such as virtual teams, where participants are expected to coordinate efforts to deliver a specific outcome.

Finally, participants in an ENoP are typically strangers. Because access to the technology is practically ubiquitous, there are basically no limits to size, and these networks are open to anyone, knowledge exchange occurs between people regardless of personal acquaintance, familiarity and location. Also, because participation is voluntary, a knowledge seeker has no control over who responds to their questions or who uses their responses. This sharply contrasts with a CoP where people typically know one another and interact over time, creating expectations of obligation and reciprocity that are enforceable through social sanctions.

We now turn to the two questions we raised above regarding participation in an ENoP: (1) why do people participate and help others in an ENoP, and (2) does participation in an ENoP result in positive knowledge outcomes.

Investigating Participation in an Electronic Network of Practice

Mutual engagement in an ENoP is open, voluntary and results in the creation of a knowledge repository of archived messages that is available to all individuals regardless of their original participation. Thus, one helpful theoretical lens with which to investigate ENoPs is the theory of collective action and public goods. A public good, for example a public park, is a resource that is created only if a group of individuals contribute towards its production. However, a public good cannot be withheld from any member of the collective, even if he or she does not participate in the production or maintenance of the good (Samuelson, 1954; Olson, 1965). With public goods, the optimal individual decision is to enjoy the public good without contributing anything to its creation or maintenance and to simply free-ride on the efforts of others. However, if everyone were to act rationally and decide not to contribute, then the good would never be created and everyone would be worse off.

ENoPs are a type of collective in which the knowledge exchanged and created is the collective's public good. As discussed above, mutual engagement in an ENoP is open and voluntary. Participation typically results in the creation of a knowledge repository of archived messages that is available to all individuals regardless of their original participation. This begs the question then – why would anyone invest their valuable time and effort helping strangers in an ENoP if it is in their best interest not to do so?

Does Participation in an Electronic Network of Practice Affect Knowledge Outcomes?

Another important issue to investigate is whether ENoPs exhibit the same degree of continuous incremental innovation as CoPs. As mentioned above, CoPs are generally characterized by rich, face-to-face exchange through person-to-person interactions. Mutual engagement between individuals in a CoP creates boundaries around the shared practice within which the community's knowledge is embedded, and tacit knowledge is shared relatively easily between individuals within the community, often without ever being made explicit. These tightly knit social structures facilitate the creation of a shared identity through the development of a common language, social capital (such as norms, trust, and obligation), boundaries, and social controls, resulting in strong social ties between individuals. These characteristics have been argued as essential for the continuous incremental improvements in the community's practice and the reason why CoPs are centers for learning and innovation within organizations (Wenger 1998, Brown & Duguid 1991, 1998).

In contrast, interactions in an ENoP are limited to text-based, asynchronous, computer-mediated communication. As a result, the ability of members to develop a shared identity and common language through narration, collaboration, and social construction is hampered. However, ENoPs have a greater reach than CoPs, supporting the creation of weak electronic "bridging

ties” between an unlimited number of like-minded others. Due to the extensive reach of these networks, individuals benefit from ENoPs since they gain access to new information, expertise, and ideas that are often not available locally. As such, the weak tie relationships created in an ENoP potentially increase an individual’s access to greater resources and advice than are available in the local community. Thus, one question to ask is whether this extended reach results in positive knowledge outcomes. In other words, are weak electronic links, like their strong tie counterparts, also useful for supporting knowledge sharing and innovation?

EMPIRICAL STUDY

This study was undertaken in the Nordic operations (Denmark, Finland, Norway, and Sweden) of Cap Gemini and was performed prior to the merger of Cap Gemini and Ernst & Young Consulting. As a result, the company description considers only the Cap Gemini organization. Cap Gemini is Europe’s largest IT services and management consulting company, and within the Nordic region, Cap Gemini has numerous networks designed to enhance the company’s knowledge management activities. We chose participants in one electronic network, which was referred to as the NCN MS Community. This electronic network had 345 members spread across the Nordic countries, and the members of this network all worked with applying Microsoft products in their responsibilities with Cap Gemini. In order to communicate with each other, a listserv was created that was nicknamed the L2A2L mailing list. The nickname was based on the slogan “Learn to Ask to Learn” that was developed to encourage knowledge sharing within this network. Network members primarily used the L2A2L mailing list when they had a question regarding how to perform their tasks at work. Thus, when one person needed help, he or she posted a question to the whole network through the listserv. At the time of the data collection, there were between five and ten requests for help per day on the L2A2L mailing list.

Data were collected through the use of a web-based questionnaire that was sent as an email attachment to each of the NCN MS Community members during January 2000. Of the initial 345 individuals with valid email addresses, we received a total of 83 usable survey responses for a response rate of 24%. These 83 indicated that they had developed on average personal ties with 2.8 other members through participation in the listserv. The average age of the respondents was 35.6 years with an average of 4.0 years employed at Cap Gemini and 7.7 years of experience in their competence. The sample was 8% women. Consultation with Cap Gemini’s management indicated that the demographic characteristics of the group of respondents were representative of those of the entire NCN MS Community. Specific variables were assessed

through survey responses, and participants also provided insights by responding to open ended questions about their participation.

Survey Results

In order to assess why people participate, and whether or not participation results in positive knowledge outcomes, we posed four open-ended questions to the participants in network: (1) why do you participate in the NCN MS Electronic Community, (2) why do you help others with their problems, (3) has your participation improved your work performance, and (4) how can the NCN MS Community be improved? The following provides a summary and a discussion of the results.

1) Why Do You Participate in the NCN MS Electronic Community?

In response to this question, respondents indicated that the ENoP was an excellent means of improving their own level of technical competence. Individuals responded that they learned through their participation by receiving help and information related to their work tasks through participation. Additionally, they felt that participation enabled them to keep up-to-date with technical developments as well as to know who was actively working in different areas. One respondent summarized the above in the statement, *“There is so much to know in this field and new applications/methods, etc. are introduced all the time. I never know when I need this new knowledge in my daily work or for a new project. The only thing I know is that I must always learn new things!”*

2) Why Do You Help Others with Their Problems?

There seem to be a variety of reasons why people take time out from solving their own problems to help others in the ENoP. From the answers provided, it appears that a norm of reciprocity developed between the members of the network. In other words, in order to receive help from the network, individuals felt obligated to help others in return. One individual explained, *“It’s the way it is! I help them; they help me in return.”* In this manner, individuals felt that they ensured that their individual competence level remained competitive, as one respondent wrote, *“Why shouldn’t I participate - knowledge devaluates over time. Who likes to sit alone back with yesterday’s knowledge?”* In addition, respondents felt that helping others was a part of their job at Cap Gemini. Through their participation, they were able to improve the level of technical competence of the network as a whole and ultimately Cap Gemini’s ability to be competitive in the market. One respondent summarized this in the following quotation, *“At the end of the day, we are a knowledge company. My company moves faster the more knowledge can flow freely inside. This knowledge flow will result in happier customers and more business.”*

3) Has Your Participation in the NCN MS Electronic Community Improved Your Work Performance?

The third question focused on investigating whether participation in the listserv had helped improve work performance. Of the 83 respondents, 65% replied that participation in the network had helped them. Two categories of answers were provided. First, participation greatly improved the speed with which participants were able to solve their problems. One individual replied, “*Yes, I get answers to more complicated questions much faster than trying to find the answer by myself.*” Second, individuals were able to learn and receive new insights from the network as one commented, “*Yes. I learn things from every topic. Even when I am not working within the actual topic.*”

4) How Can the NCN MS Electronic Community Be Improved?

Finally, we asked about how the listserv could be improved. Suggestions included creating a database of all the postings such that individuals could easily find previously discussed topics as well as a means to educate people on how to use the list. There also seemed to be a discrepancy in terms of the most effective communication channel for this network. Several individuals indicated that they would prefer a discussion forum to a mailing list since they felt that the overall level of email received daily was too high. We discussed this with the network head. However, he felt that one of the reasons that this network did have such a high participation rate was due to the choice of a mailing list over a discussion forum. He explained that a mailing list led to a higher level of activity since participants automatically received postings in their inbox while the use of a forum required that the participant actively enter the discussion forum.

Summary of Survey Items

In addition to the open-ended questions, we also included specific survey items to provide additional quantitative support examining the relationships between participation in the network and knowledge outcomes. Summary statistics and correlations are presented in table 1. The exact wording of specific items is listed in Appendix 1.

Results indicate that higher levels of participation and tenure in the ENoP are associated with both acquiring knowledge from participation in the network and contributing knowledge to others. In addition, both knowledge acquisition from, and knowledge contribution to the network are positively related to individual performance. However, tenure in the ENoP is not associated with higher rates of participation or with individual performance. Finally, the results suggest that individuals who rely on their co-located colleagues for help or advice with their work tasks report no associations with participation, knowledge acquisition, or knowledge contribution. In fact, the

survey results indicate that *reliance on co-located colleagues is associated with lower levels of self-reported individual performance.*

Table 1 Quantitative Results from Survey

	Scale		Std. Dev.	Cronbach's Alpha					
	Range	Mean			1	2	3	4	5
1. ENOP Participation Level	1-7	2.3	0.82	n/a					
2. ENOP Tenure	1-50	10.81	11.64	n/a	.06				
3. Knowledge Acquisition	1-7	3.62	1.75	0.95	.52**	.29*			
4. Knowledge Contribution	1-7	2.34	1.57	0.85	.59**	.23*	.52**		
5. Co-located Coworkers	0-3.71	2.99	1.05	n/a	.04	.06	.02	.08	
6. Individual Performance	1-7	4.30	1.29	0.82	.41**	.13	.24*	.57**	-.24*

* Significant at the $p < .05$ level, two-tailed

** Significant at the $p < .01$ level, two-tailed

DISCUSSION AND IMPLICATIONS

This research indicates that people who participate and help others in this ENoP are not acting irrationally. Rather, they choose to participate in order to gain exposure to critical new ideas and to access help and advice not available locally. In addition, another key dynamic underlying knowledge exchange in this network is a strong norm of reciprocity. Individual participation is sustained by a strong sense of paying back to the network by helping others in return. Another key motivation underlying why people participate is related to identification with the organization, or a strong sense of organizational citizenship. Interestingly, the results suggest that the level of participation in the network is more important for supporting positive knowledge outcomes than the length of time an individual has participated. This implies that newcomers to the network can reap the same benefits of participation as long standing participants.

Results also indicate that characteristics of the communication technology supporting the network are important. The two major technologies supporting ENoPs are listservs and bulletin boards. One advantage to the listserv technology is that it is delivered to participants via e-mail, which people frequently check or are notified automatically when a new message is received. Thus messages posted to the network are “pushed” to the participants and made visible along with e-mail. However, participants in this ENoP indicate that one disadvantage of this technology is that the messages are not stored in a single repository that can be accessed as a FAQ for newcomers, or searched for historical information. Bulletin boards are automatically arranged in discussion threads, making it easier to archive and search prior interactions. However, participants must voluntarily take the time to actually visit and participate in the network.

Returning to the question as to whether a network of practice is able to support continuous incremental innovation and positive knowledge outcomes, both the quantitative and qualitative results suggest that individual members did improve their individual performance through their network participation. This finding indicates that computer-mediated communication may be sufficient to support the complex interactions necessary for the combination and exchange of knowledge between individuals, thus facilitating their ability to learn. In addition, it appears that individuals value accessing new insights and ideas through weak electronic links that transcend their strong tie networks. There is also evidence to suggest that individuals who participate in an ENoP outperform their colleagues who primarily rely on their co-located colleagues for knowledge and advice.

This finding suggests that knowledge in a tightly knit CoP may be largely redundant, providing little additional information over what an individual may already know, thus impeding the ability to develop new and creative ideas (Granovetter, 1973, 1983). In addition, while CoPs and reliance on face-to-face interactions with coworkers supports knowledge exchange, learning and innovation, it has also been suggested that tightly knit CoPs may lead to the “not invented here” syndrome or the resistance to new ideas not locally developed. Thus, managers concerned with improving knowledge exchange should note that the highly efficient structures that support knowledge integration in a CoP may evolve into core rigidities and competency traps – inappropriate knowledge sets that preserve the status quo and limit new insights (Levitt & March, 1988; Leonard-Barton, 1992). Our findings suggest that one way to alleviate this concern is to use ENoPs to create electronic bridging links between strong tie communities to enhance the flow of new ideas and innovations.

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APPENDIX 1

1. Electronic Network of Practice Participation Level

How often do you participate in the NCN MS electronic community?

Never, I mostly lurk (reading without posting), 0-5 times per week, 5-10 times per week, 10-20 times per week, More than 20 times per week

2. Electronic Network of Practice Tenure

How long have you been a member of the NCN MS electronic community?

___ months

3. Knowledge Acquisition

From your interaction in the NCN MS electronic community have you:

Acquired knowledge that caused you to develop new insights	1, to a very small extent, 7, to a very great extent
Acquired knowledge that enabled you to perform new tasks	1, strongly disagree, 7, strongly agree

4. Knowledge Contribution

From your interaction in the NCN MS electronic community have you:

Contributed new knowledge to the NCN MS electronic community	1, to a very small extent, 7, to a very great extent
Contributed knowledge to other NCN MS electronic community members that resulted in their development of new insights	1, strongly disagree, 7, strongly agree

5. Reliance on Co-located Coworkers

How often do you use the below information sources in your everyday work?

Coworkers in my location	1, to a very small extent, 7, to a very great extent
--------------------------	------------------------------------------------------

6. Individual Performance

Please rate the extent of your agreement with each statement using the scale below:

Able to develop creative solutions relative to your colleagues at Cap Gemini	1, strongly disagree, 7, strongly agree
I have a high level of expertise in the technology with which I work	1, strongly disagree, 7, strongly agree
My colleagues at Cap Gemini consider me to be a guru	1, strongly disagree, 7, strongly agree

Article Five

Integrating Knowledge Through Information-Trading: Examining the Relationship Between Boundary Spanning Communication and Individual Performance

Note to Reader on Terminology:

There are several terms worth explaining in this article. First, boundary spanning communication is used to connote participation in various networks of practice. Below is a further key to how the terminology in this thesis corresponds to the terminology in this article.

Thesis Terminology	Article Terminology
Knowledge trading, knowledge sharing	Information trading
Participation in networks of practice	Boundary spanning communication
Individuals	Knowledge workers
Emergent	Informal
Network of practice	Informal social network
Electronic network of practice	Electronic discussion network
Efficient performance	General performance

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Integrating Knowledge Through Information Trading: Examining the Relationship Between Boundary Spanning Communication and Individual Performance

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ABSTRACT

With the global penetration of internet technologies, individuals may now cross organizational boundaries to communicate efficiently with others in various networks of practice regardless of time and space. Thus, when looking for help in solving work tasks, knowledge workers may just as easily contact individuals in rival firms across the globe as a coworker sitting at the next desk. As a result, management faces questions such as 1) how should firms manage employees' knowledge-sourcing activities when they span both intra-organizational and extra-organizational boundaries, and 2) what is the relationship between different knowledge-sourcing activities and individual performance? Grounded in the knowledge-based view of the firm, we investigate these questions using data from Europe's largest IT services and management consulting company. Our results provide evidence that organizations should support boundary spanning and participation in both internal and external networks of practice. Results suggest 1) a *positive* relationship between boundary spanning communication and creativity and general performance and 2) a *negative* relationship between a reliance on co-located coworkers as knowledge sources and creativity.

Keywords: knowledge, network of practice, community of practice, know-how trading, boundary spanning, performance, electronic community, structural equation modeling

INTRODUCTION

With the rapid penetration of internet communication technologies across the globe, the possibility for individuals to seek out others for advice and know-how has dramatically increased. Individuals may now cross organizational boundaries to communicate efficiently with others regardless of time and space (Hinds & Kiesler, 1995) and participate in networks of practice, or emergent networks of relationships built on work-related interactions (Brown & Duguid, 2000). As a result, many organizations are in the process of implementing intranet-based communication tools, such as electronic discussion networks, to promote knowledge sharing across internal organizational boundaries (Fulk & DeSanctis, 1995; Davenport & Prusak, 1998; Alavi & Leidner, 1999). Investments in these technologies are driven by the assumption that knowledge is the most valuable resource of the firm and that new knowledge is created through the recombination and exchange of existing knowledge (Kogut & Zander, 1992; Nonaka, 1994; Nahapiet & Ghoshal, 1998). This knowledge-based view of the firm proposes that sustainable competitive advantage stems from an organization's ability to integrate tacit knowledge embedded in the minds of individuals (Nonaka, 1994; Grant, 1996a). Thus, increasing the amount of information sources and communication channels employees have available should increase the likelihood of new knowledge creation, resulting in an improved level of performance for both the individual and the firm.

However, in addition to facilitating intra-organizational knowledge flows, the internet also enables individuals to quickly and effortlessly access a wide variety of knowledgeable individuals outside company boundaries through email or other informal means such as Usenet groups, private chat rooms, electronic discussion networks, listservs, etc. Thus, individuals are able to communicate and share advice with thousands of others across the globe regardless of their demographic characteristics, organizational setting, or local culture (Sproull & Faraj, 1995; Faraj & Wasko, 1998). Communication across intra-organizational and extra-organizational boundaries has been researched extensively - a major stream began in the 1960s with the investigation into the communication patterns of scientists and engineers in R&D laboratories (Allen, 1977). However, what has changed within the past ten years is the ease and speed with which employees at all organizational levels can participate in these knowledge flows.

Sharing knowledge across internal and external organizational boundaries poses novel challenges to organizations attempting to manage their knowledge resources (Pickering & King, 1995). Through interaction with external sources, individuals gain access to information and expertise not available locally and can interact informally, free from the constraints of hierarchy and local rules. However, interaction with these external sources usually involves a high degree of information trading and reciprocity. In order for individuals to receive help from external sources, they must be willing to

give advice and know-how as well, some of which company management may consider proprietary (Von Hippel, 1987). In addition, much of the prior research on boundary spanning communication looked at the relationship between these knowledge flows and team performance. Research that examines the relationship between knowledge flows and *individual* performance is scant, as is research on the resulting implications for organizations concerned with managing knowledge assets.

Thus, the goal of this research is to examine whether the performance of an individual knowledge worker varies as a result of boundary spanning communication activity and informal information trading across intra and extra-organizational boundaries within networks of practice. Specifically, we examine whether individual performance is related to informal information trading and accessing knowledge from: 1) co-located coworkers, 2) coworkers within the same organization but located across intra-organizational boundaries (non-co-located), 3) intra-organizational electronic discussion networks, 4) informal contacts in other organizations (i.e., contacts that are *not* the result of a formal relationship with the firm such as a customer, alliance partner, supplier, or other formal relationship), or 5) inter-organizational electronic discussion networks.

Such inquiry makes three important contributions. First, this research empirically examines the trade-offs between accessing and applying local knowledge and accessing knowledge through boundary spanning communications in various networks of practice. Second, this research clarifies how the use of various sources of advice is related to individual performance in complex knowledge environments. Finally, this research makes possible more precise theoretical models of how internet-based communication technologies can be designed and deployed to support knowledge exchange and the creation of new knowledge to enhance individual and thus organizational performance.

THEORETICAL BACKGROUND

Recent advances in strategic management thought suggest that organizational resources and capabilities rather than served markets are the principal source of sustainable competitive advantage, and that knowledge is the most important strategic resource of the firm (Grant 1996a). This increased emphasis on organizational capability and knowledge has led to the development of the knowledge-based view of the firm (Grant, 1996a,b; Spender, 1996). Assuming that knowledge is a critical input to production processes, then organizational capability stems from the ability to integrate the specialized knowledge of individuals (Nonaka, 1994; Grant, 1996a,b; Spender, 1996). Therefore, one of the key issues underlying the knowledge-based view of the firm is to understand how knowledge is integrated in firms to create organizational capability (Hansen, 1996). However, since knowledge creation is based on individual activity, the examination of knowledge integration requires

understanding the organizational processes through which firms access and utilize the knowledge possessed by its members (Grant, 1996b).

According to Grant (1996a), competitive advantage results from how effective firms are in integrating the specialized knowledge of their members, and he proposes that this effectiveness depends upon the efficiency, the scope, and the flexibility of knowledge integration. Efficiency refers to how productive firms are in integrating individuals' specialized knowledge. The scope of knowledge integration refers to the different types of specialized knowledge being integrated – the more complex the scope, the greater the difficulty for competitors to replicate. The flexibility of integration reflects extending existing capabilities through boundary spanning activities in order to access and reconfigure additional knowledge through both internal and external integration (Grant, 1996a). This research focuses on two aspects of Grant's theory of knowledge integration: efficiency and flexibility (Grant, 1996a).

As mentioned above, efficiency refers to how productive firms are in integrating individuals' specialized knowledge. One condition of integrative efficiency is a common language of discourse to ensure efficient communication between individual specialists. Efficient integration is also dependent upon the frequency and variability of task performance, where higher levels of frequency engender automated responses from each organization member. Finally, organizing structures influence integrative efficiency. Organizing activities that reduce the intensity and extent of communication are needed to support efficient integration, such as modularity and division of labor.

In addition to integrative efficiency, Grant also emphasizes the importance of integrative flexibility. Hypercompetitive conditions in the marketplace drive the eventual erosion of all positions of competitive advantage. Thus, sustaining a competitive advantage requires flexibility and the creation of new capabilities. Firms need to establish knowledge integration techniques that extend existing capabilities by bringing in new knowledge and reconfiguring existing knowledge. However, the need to access new knowledge creates complex organizational issues with regard to firm structure, firm boundaries, and choices between internal and external organizational boundary spanning.

Grant's theory of knowledge integration represents a paradox: increasing the efficiency of knowledge integration may hinder flexibility and the ability to create new innovations. For example, prior research suggests that creating organizational structures that increase the efficiency of knowledge integration through common language and frequent interactions may result in knowledge hoarding, less creativity and the "not invented here syndrome" (Granovetter, 1973; Szulanski, 1996). In addition, Grant's theory focuses primarily on the issue of coordination (structuring to enhance the effectiveness of knowledge integration), without referring to issues of "cooperation". The theory leaves out a key component by assuming that people are willing to share

knowledge openly and freely if provided with the structures/opportunities to interact.

However, prior research on boundary spanning communication activities within networks of practice suggests that individuals do not give away help and advice to others in their informal social networks for free. Rather, individuals trade knowledge with expectations of reciprocity. This informal trading activity has been coined informal know-how trading and as originally conceived, the concept did not distinguish between the types of knowledge exchanged. In other words, know-how trading simply referred to the trading of any type of information. Recent advances in knowledge management thought suggest that know-how refers primarily to the more tacit procedural types of knowledge, as distinguishable from know-what or the more explicit declarative types of knowledge (Kogut & Zander, 1992). Thus, in order to stay consistent with current thought, we refer to these informal reciprocal communication exchanges as informal *information* trading rather than know-how trading. In other words, the goal of this research is not to examine the type of knowledge exchanged, rather to investigate the importance of reciprocity as a cooperation mechanism. We propose that trading and expectations of reciprocity are the key cooperation mechanisms underlying cross-boundary knowledge exchange.

Informal information trading between individuals has been shown to be valuable and sustainable over time because the sharing of knowledge is an important aspect of being a member of a professional community, even if the employing organizations are direct competitors (Bouty, 2000). Therefore, key issues for organizations interested in successfully managing their knowledge resources involve understanding where knowledge workers turn for advice, whether internally or across organizational boundaries, and exactly how they access that advice. Previous research has indicated that reciprocal external information trading involves “leakage”, or the flow of company proprietary knowledge across firm boundaries (Mansfield, 1985; Von Hippel, 1987; Carter, 1989; Schrader, 1991). In previous research conducted by one of the authors (Teigland, 2000), one programmer explained his communications in the following manner:

“....but most importantly I have my network from the internet. I’ve been in this for four years so really there is a core clique of people who know each other and who trade secrets with each other. We pass over the nondisclosure agreements of different companies all the time and trade company secrets.”

This participation in information trading and the resulting potential for informal proprietary knowledge flows across organization boundaries are of particular strategic interest to management since such activity may impact a firm’s competitive advantage. Yet, it is very difficult for firms to manage and evaluate the benefits since it occurs “off the books” with employees generally acting completely on their own with no managerial influence and no

documentation of the trade (Von Hippel & Schrader, 1996). In addition, investigation into the relationship between this individual-level knowledge exchange and performance has been extremely limited.

In summary, key strategic issues for firms and their managers are to better understand how to balance efficient knowledge integration with demands for flexibility, and how to manage the intra-organizational and extra-organizational boundary spanning and informal information trading conducted by individual knowledge workers. As a step in this direction, we develop a set of hypotheses relating internal and external sources of knowledge, their influence on information trading, and implications for individual performance.

HYPOTHESES AND MODEL DEVELOPMENT

In this section, we look at the drivers of internal and external information trading and develop the relationships between information trading activity and individual performance. In addition, we examine two types of performance: 1) general performance or the ability to meet one's job demands and 2) creativity or the ability to develop creative solutions. We expect that the knowledge sources used and the trading activities performed by individuals will impact general performance and creativity in different ways, i.e., general performance is reflective of application of current knowledge while creativity is concerned with new knowledge creation and innovation.

Integrative Efficiency

Integrative efficiency requires common language, frequent interaction and modular structure (Grant, 1996a). This suggests that one of the most efficient sources of knowledge should be co-located coworkers who share the same physical space since they are more likely to frequently interact with each other. Ethnographic research on work practices finds that this frequent interaction often occurs in communities of practice (Lave & Wenger, 1991; Orr, 1996; Wenger, 1998). Researchers have found that these networks emerge over time between individuals working on similar task-related issues located in face-to-face settings. With knowledge-intensive tasks, often no one individual can solve the problem on his or her own due to the inability to know everything. Thus, when an individual becomes stuck in conducting a work-related task, he or she often turns to knowledge sources that are the most easily accessed (such as asking co-located coworkers), rather than searching for and using the best knowledge source (such as codified sources or non-co-located coworkers) (Gerstberger & Allen, 1968; O'Reilly, 1982). Through patterns of mutual exchange and collaboration, individuals share knowledge to help each other reduce the equivocality of problematic issues and build the community's memory (Orr, 1996; Wenger, 1998). Thus, individuals who rely on others in their local setting to a high degree are likely to engage in a high degree of mutual knowledge exchange.

Through this mutual exchange and collaboration over time, individuals become bound together by the context of the situation in an informal manner in communities of practice, creating the social fabric of the organization (Brown & Duguid, 1991). These emergent organizational structures provide the nexus for the sharing and transfer of valuable individual and group tacit knowledge (Kogut & Zander, 1992), resulting in higher performance of the community as a whole (Brown & Duguid, 1991, 1998; Wenger, 1998). Individuals develop a common language, explicit and tacit rules of behavior and coordination, and a shared identity, (Wenger, 1998). Accessing knowledge from others who share the same coding scheme and language is highly efficient (Tushman & Katz, 1980), thus economizing on the amount and intensity of communication needed to achieve knowledge integration. In addition, in many work environments, employees are confronted with information overload. Through asking someone in the community for help, time does not have to be spent sorting through piles of information for relevant documents (Wenger, 1998). This suggests that one of the most efficient sources of knowledge should be co-located coworkers, who are more likely to frequently interact with each other and develop into a community of practice due to their sharing the same physical space. Thus, due to the efficiency of integration, people who access knowledge from co-located coworkers to a high degree should report higher levels of individual efficient performance.

However, prior research argues that individuals within a social clique tend to have strong ties, which have been defined as emotionally intense, frequent, and involving multiple types of relationships, e.g., friends, advisors, and coworkers (Granovetter, 1973). The result is that the knowledge held by the members of a social clique tends to be redundant with that held by other members, providing little additional information over what an individual may already know (Granovetter, 1973, 1983). Thus, the knowledge available through co-located coworkers is likely to be limited and superfluous, impeding the ability to develop new and creative ideas. In addition, the highly efficient structures that support knowledge integration and the exploitation of core capabilities may evolve into core rigidities and competency traps – inappropriate knowledge sets that preserve the status quo and limit new insights, resulting in gaps between the knowledge of the firm and changing market conditions (Levitt & March, 1988; Leonard-Barton, 1992). Therefore, while accessing knowledge from co-located coworkers is likely to be highly efficient and lead to better efficient performance, co-located coworkers are less likely to offer the integrative flexibility needed to enhance creativity and develop new capabilities. The above then leads to our first set of hypotheses:

HYPOTHESIS 1A: The greater the reliance on co-located coworkers to access information, the lower the level of individual creativity.

HYPOTHESIS 1B: The greater the reliance on co-located coworkers to access information, the higher the level of individual general performance.

Internal Integrative Flexibility and Information Trading

Internal integrative flexibility involves the extent to which existing knowledge within the firm can be reconfigured. While people tend to access knowledge from those within the same physical proximity, advances in communication technologies have made it easier for people who are working on similar task-related problems across the organization to communicate. Thus, individuals may relatively easily access knowledge from coworkers in their networks of practice whom they personally know but who are working in other offices or on site with clients. However, due to the less frequent patterns of interaction and lower intensities of social pressure, non-co-located coworkers may be less willing or committed to exchange knowledge without some type of return (Blau, 1964). People within the same organization often prefer to hoard their knowledge because they perceive that sharing knowledge results in reduced status and lower levels of personal worth (Orlikowski, 1996). This is especially evident in organizations where knowledge is the basis of a personal competitive advantage over others (Thibaut & Kelley, 1959). Therefore, individuals are more likely to expect reciprocity when engaging in knowledge exchange across internal organizational boundaries, especially in situations where relations are not characterized by frequent interactions and a high level of trust (Nahapiet & Ghoshal, 1998). Thus, accessing advice and knowledge from non-co-located coworkers is likely to result in internal information trading with the expectation of reciprocity in return. This leads to our next hypothesis:

HYPOTHESIS 2: The greater the reliance on coworkers in other locations to access information, the higher the level of internal information trading.

Informal social network structures connecting intra-firm acquaintances have typically emerged through mutual engagement in work tasks, requiring a personal, oftentimes physical, connection. However, recent advances in computer-mediated communication technologies have facilitated the development of intra-organizational, electronic social networks between geographically dispersed organizational members, who are typically strangers. Within these networks, an unlimited number of non-co-located, unacquainted coworkers are able to quickly communicate through their shared organizational and technical code to help each other solve problems and provide useful advice (Constant, Sproull, & Kiesler, 1996).

However, theories of social capital suggest that the ability to develop the commitment and trust that are necessary for knowledge exchange is difficult to achieve in computer networks (Nohria & Eccles, 1992; Nahapiet & Ghoshal, 1998). Thus, norms of participation in electronic networks typically dictate

that those who seek and receive help from the network must also pay back by helping others (Constant et al., 1996; Kollock, 1999; Lakhani & von Hippel, 2000). Therefore, similar to the previous hypothesis, the sharing of organizational knowledge through electronic networks is likely to increase the amount of internal information trading within the firm. This leads to our third hypothesis:

HYPOTHESIS 3: The greater the reliance on intra-organizational electronic networks to access information, the higher the level of internal information trading.

Through internal information trading, individuals exchange information, knowledge and advice. These individuals share the same organizational language and code of behavior and are faced with similar issues related to their knowledge tasks, supporting integrative efficiency (Brown & Duguid, 1991; Wenger, 1998). Internal information trading enables the flow of ideas and innovations within the firm. For example, when seeking help internally, an individual may find that a solution already exists elsewhere within the organization. In this manner, individuals may avoid “reinventing the wheel” by reconfiguring solutions previously developed within the firm to fit new situations. These exchanges retain the context in which the knowledge is embedded, and individuals located across intra-organizational boundaries possess knowledge that may be more locally adapted, supporting efficient integration and in turn, higher levels of general performance.

In addition, the combination and recombination of firm-specific knowledge that is physically dispersed across the organization may facilitate integrative flexibility. Individuals in other organizational units are more likely than co-located coworkers to have important knowledge that is non-redundant, generating access to sources of new ideas and innovations located across intra-firm boundaries (Granovetter, 1973). Engaging in internal information trading, people not only send and receive task-specific knowledge, they also help each other by taking the time to work through each other’s problems. Exercising intellect by helping others is likely to sharpen and even improve an individual’s own technical skills. When an individual works through someone else’s problems, he or she often discovers new methods and new applications for existing knowledge (Wenger, 1998). Additionally, individuals that help others are entitled to reciprocity, gaining access to advice, new ideas and innovations when needed. Thus, we expect internal information trading to have a positive impact on both individual creativity and general performance. This leads to the following hypotheses:

HYPOTHESIS 4A: The higher the level of internal information trading, the higher the level of individual creativity.

HYPOTHESIS 4B: The higher the level of internal information trading, the higher the level of individual general performance.

External Integrative Flexibility and Information Trading

In addition to internal integrative flexibility, firms need to integrate new knowledge found in the external environment to remain competitive (Cohen & Levinthal, 1990). This knowledge may be accessed through either market or relational contracts (Grant, 1996a). While relational contracts tend to refer to formal inter-organizational arrangements, these contracts also comprise informal communication exchanges between individuals. Just as intra-organizational communication has been facilitated with the rapid spread of the internet, so too has the ability to informally communicate with contacts outside of the organization and to thus participate in inter-organizational networks of practice (Brown & Duguid 2000). Thus, when knowledge workers seek help with their work-related tasks, they may just as easily contact individuals working in rival firms as individuals working in the same organization (Sproull & Faraj, 1995; Faraj & Wasko, 1998). As a result, individuals may integrate knowledge from within their organization with new ideas and innovations accessed through communications with individuals outside their organization. This informal relational activity should improve a firm's external integrative flexibility and sustainable competitive advantage (Grant, 1996a).

Informal information and knowledge sharing between firms has been detected in several settings, e.g., semiconductor, specialty steel and mini-mill industry, and R&D operations (von Hippel, 1987; Carter, 1989; Schrader, 1991). Reciprocity was found to be one of the guiding principles in these informal exchanges, where individuals expected that their chances to receive information in return would increase after they sent out information (Schrader, 1991). Certain professional disciplines encourage knowledge sharing and information trading within the occupational community to keep abreast of new ideas and innovations and to stay competitive with other professionals (Pickering & King, 1995). As such, knowledge workers may also rely on their informal external contacts, such as friends, family, ex-coworkers, people with whom they attended school, etc., to access critical knowledge that resides externally to the firm. However, due to strong norms of reciprocity within the occupational community, relying on contacts in other organizations for advice obligates the knowledge seeker to share knowledge in return (Van Maanen & Barley, 1984). Thus, accessing knowledge from contacts in the occupational community requires reciprocation through external information trading. This leads to our next hypothesis:

HYPOTHESIS 5: The greater the reliance on external contacts to access information, the higher the level of external information trading.

In addition to accessing information and know-how from external contacts, communication tools such as bulletin boards, listservs, and chatrooms

electronically connect knowledge workers sharing the same profession but who are globally dispersed and typically strangers. In a recent article, Pickering & King (1995) argued that the growth of inter-organizational internet-based communication is likely to be especially rapid between individuals who are interested in establishing ties with individuals outside of the firm based primarily on similar professional interests.

In internet-based electronic networks, individuals are able to share information and know-how through mechanisms that support posting and responding to questions, sharing stories of personal experience, and discussing and debating issues relevant to the professional community (Wasko & Faraj, 2000). Knowledge is continuously created and shared through open discussion and collaboration, regardless of physical distance or organizational affiliation. In one study of a Usenet inter-organizational technical discussion network, it was found that 42% of all messages included programming code (Wasko & Faraj, 1999). Thus, inter-organizational electronic networks advance the knowledge of the professional community as a whole through electronic links. Similar to accessing knowledge through external contacts whom an individual knows, the norms of accessing knowledge from inter-organizational electronic networks also requires that an individual “pay back” to the network by helping others (Lakhani & von Hippel, 2000; Wasko & Faraj, 2000). Thus, we predict the following:

HYPOTHESIS 6: The greater the reliance on external electronic communities to access information, the higher the level of external information trading.

There is limited empirical evidence that links external information trading activities and performance. In one of the few studies in this area, Schrader (1991) found suggestive evidence for a link between informal know-how trading and firm performance, yet beyond this, there is little that investigates the relationship to individual performance. However, research has found that individuals who share the same professional interests may be able to communicate relatively easily across organizational boundaries due to a universal professional language, enabling individuals to access know-how and information from outside the firm’s boundaries (Hauptman, 1986). This know-how and information is more likely to be non-redundant than that found within the organization. Thus, through external information trading, individuals may combine and recombine knowledge from within their organization with new ideas and innovations accessed from individuals outside the organization, resulting in new and creative solutions (Cohen & Levinthal, 1990).

While individuals participating in external information trading share to a certain extent the same professional knowledge and technical language, they do not share the same organizational knowledge or language. Thus, although participation in external information trading brings in new ideas resulting in higher levels of individual creativity, the combination of external knowledge

with a firm's existing knowledge may be time consuming, or may result in solutions that are not tailored to the firm's specific situation (Teigland, 2000). In addition, information trading and reciprocity requires giving advice in return. Helping others solve their problems can be quite time consuming, and can lead to an individual devoting less time working on his or her company-specific work tasks. Thus, an individual may have more difficulty in completing his or her tasks on time and/or according to the task specifications (Teigland, 2000). Thus, we have our next set of hypotheses:

HYPOTHESIS 7A: The higher the level of external information trading, the higher the level of creativity.

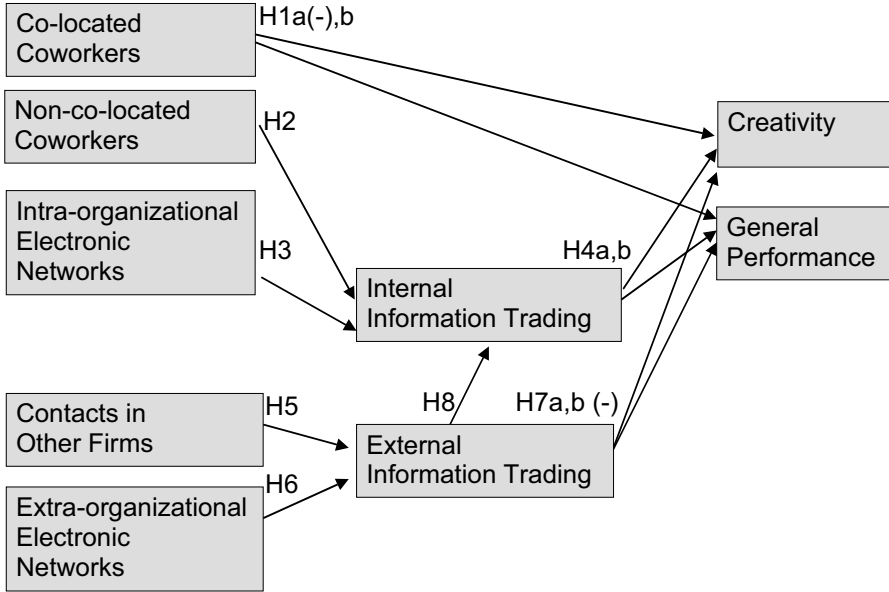
HYPOTHESIS 7B: The higher the level of external information trading, the lower the level of general performance.

Finally, for our last hypothesis, we look at the possible relationship between internal and external information trading. In the stream of research by Allen and colleagues, it was found that in many cases, individuals who had a high degree of external communication activity also displayed a high degree of internal communication activity (Allen & Cohen, 1969). These individuals were labeled gatekeepers. Gatekeepers were found to display characteristics of a buffering role, scanning and filtering information into the organization from the outside world and then directing it as they felt necessary into the organization. These individuals were often found to be in first-line supervisor positions (Taylor, 1975). However, with access to the internet, it is now possible for all individuals to become gatekeepers for their specialized knowledge area, participating in external exchange and then recombining with the specialized knowledge to the firm through internal integration. This brings us to our final hypothesis:

HYPOTHESIS 8: The higher the level of external information trading, the higher the level of internal information trading.

Figure 1 provides an overview of the hypotheses developed above.

Figure 1 Model of Hypotheses



RESEARCH SETTING

This research was undertaken in the Nordic operations (Denmark, Finland, Norway, and Sweden) of Cap Gemini and was performed prior to the merger of Cap Gemini and Ernst & Young Consulting. As a result, the company description takes only the Cap Gemini organization into consideration. At the time, Cap Gemini was Europe’s largest IT services and management consulting company with more than 40 offices and 4,500 employees in the Nordic region alone.

Within the Nordic region, Cap Gemini had numerous networks designed to enhance the company’s knowledge management activities. We chose participants in one electronic network, the NCN MS Community, because it was recognized as a successful, vital conduit of knowledge exchange. This electronic network had 345 members spread across the Nordic countries and the members of this network all worked with applying Microsoft products in their responsibilities with Cap Gemini. This particular population was chosen for the study to ensure that research subjects had access to internal and external sources of information and know-how, and had familiarity using the communication technologies underlying information and know-how exchange in electronic networks. In addition, the job responsibilities of the members of the NCN MS Community required a considerable amount of creativity, as new problem situations constantly arose due to the rapid pace of change in information technology as well as the diversity among client project demands.

This helped ensure that the population chosen for this study had to balance both general job performance and demands for creativity.

Study Design and Data Collection

In November 1999, we began the data collection through five in-depth interviews with people involved in Cap Gemini Nordic's knowledge management operations. Interviews were conducted to better understand the implementation and use of electronic discussion networks within Cap Gemini and to design questionnaire items relevant to this specific organization. We pilot-tested the questionnaire on a group of 15 programmers. Pilot test results indicated that the survey instrument was too long, thus items outside the scope of this research were dropped from the survey. The final survey instrument was sent to each of the NCN MS Community members asking him or her to complete the questionnaire during January 2000. Throughout the data collection process, individuals were assured that their responses would be kept confidential and that all results would be presented only on an aggregate level.

Of the initial 350 individuals, five emails were electronically returned due to an invalid email address. We received a total of 83 usable survey responses from the 345 participants with valid email addresses for a response rate of 24%. The average age of the respondents was 35.6 years with an average of 4.0 years employed at Cap Gemini and 7.7 years of experience in their competence. The sample was 8% women. After consultation with Cap Gemini management, it was found that the demographic characteristics of the group of respondents were representative of those of the entire NCN MS Community.

Measures

All variables were assessed through survey responses. Several different approaches exist for measuring performance, including both self-reported and third party measurements. However, following discussions with Cap Gemini's management, it became apparent that supervisor-rated or other performance measures such as salary would be difficult to obtain due to issues of employee confidentiality. Accordingly, we opted to measure performance via self-reporting measures. Of interest is that a number of previous studies have found self-reporting measures to be superior to third party measurements (Heneman, 1974; Wexley, Alexander, Greenawalt, & Couch, 1980) and not upwardly biased (Churchill, Ford, Hartley, & Walker, 1985). As described earlier, two measures of performance were measured: general performance and creativity.

The survey contained a series of 7-point Likert scale questions. The dependent variables were measured by asking respondents to rate the extent of their agreement on a 7-point Likert scale (1=strongly disagree, 4=agree, 7=strongly agree). The independent variables were assessed by asking respondents to indicate how often they engage in specific knowledge activities (1=several times a day, 2=once a day, 3=once every two days, 4=once a week,

5=once every two weeks, 6=once a month, 7=more seldom). The independent variables were then transformed to convert responses from an interval scale to a ratio scale prior to analysis in order to conform to the ratio scaling conventions of the dependent variables. Actual survey items are provided in table 1.

ANALYSIS AND RESULTS

We tested the hypotheses using partial least squares (PLS), and performed two separate analyses independently for each dependent variable (creativity and general performance). PLS can be used to analyze measurement and structural models with multi-item constructs that include direct, indirect and interaction effects, and has become widely used in IS research (Chin & Todd, 1995; Compeau & Higgins, 1995; Gefen & Straub, 1997). PLS does not assume multivariate normality among sample distributions and takes into account measurement error when assessing the structural model (Wold, 1982). As a result, it is particularly useful for analyzing constructs that include measurement error and covariance. The results are interpreted in two stages – measurement and structural. Because the combined analysis of the measurement and structural models enables measurement errors to be included as an integral part of the model, and factor analysis to be combined in one operation with the hypotheses testing, the result is a more rigorous analysis of the proposed research model (Bollen, 1989).

Unlike LISREL and EQS structural equation modeling techniques, PLS breaks down models into segments, allowing researchers to work with small sample sizes. When determining sample size, theorists suggests that a “rule of thumb” for items is ten times the most complex construct’s number of indicators or the largest number of paths leading to a latent construct. The most complex construct in the measurement model has 4 indicators, and the largest number of paths leading to a latent construct is 3. Thus with 83 respondents (83/4, or 20.75 responses per indicator) the sample size is sufficient for established PLS guidelines to proceed with analysis (Chin, 1998). The theoretical model was estimated using PLS Graph 2.91 (Chin & Frye, 1996).

Measurement Model

A crucial step prior to testing the theoretical model is assessing the accuracy of the measurement model. The goals of assessing the accuracy of the measurement model are to demonstrate that the measures used are valid and that they adequately reflect the underlying theoretical constructs. The first step in PLS is to assess the convergent validity of the constructs of interest, by examining the average variance extracted (AVE). The AVE attempts to measure the amount of variance that a latent variable component captures from its indicators relative to the amount due to measurement error. The AVE is calculated by taking the sum of the squared component loadings to an indicator and dividing by the sum of the squared component loadings plus the sum of the

error variance. It is recommended that the AVE should be greater than .50, meaning that 50% or more variance of the indicators should be accounted for.

Individual survey items that make up a theoretical construct must also be assessed for inter-item reliability. In PLS, the internal reliability and consistency for a given block of indicators can be calculated using the internal composite reliability (ICR) developed by Werts, Linn and Joreskog (1973). The ICR is calculated by squaring the sum of component loadings to an indicator, then dividing by the sum of squared loadings plus the sum of the error terms. Interpreted like a Cronbach's coefficient, acceptable values of an ICR for perceptual measures should exceed .7 (Fornell & Larcker, 1981). Values less than .7 imply that the items underlying the construct may be unrelated, or may be measuring more than one construct.

Discriminant validity indicates the extent to which a given construct is different from other constructs, the measures of the constructs are distinct, and the indicators load on the appropriate construct (Messick, 1980). One criterion for adequate discriminant validity is demonstrating that the construct shares more variance with its measures than it shares with other constructs in the model (Barclay, Higgins, & Thompson, 1995). One measure of discriminant validity in PLS is the average variance explained (AVE). The AVE may be compared with the shared variance among the latent variables (i.e. the square root of the AVE should be greater than the correlation between a construct and any other construct) (Chin, 1998). A second way to evaluate discriminant validity is to examine the factor loadings of each indicator (Chin, 1998). Each indicator should load higher on the construct of interest than on any other factor.

Table 1 presents the factor loadings and cross-loadings for all indicators. Each indicator loaded higher on its theoretical construct than on any other factor, indicating discriminant validity. Table 2 presents descriptive statistics, AVEs, ICRs, and correlations between constructs. All AVE values are greater than the .5 cut-off point indicating adequate convergent validity. The square root of the AVEs are presented on the diagonal of the correlation matrix, and are greater than the corresponding correlations, indicating adequate discriminant validity. All ICR values are greater than the .7 cut-off, indicating adequate reliability.

Similar to findings in prior research, it appears that the knowledge workers in this sample rely to a great extent on co-located coworkers as sources of information. In addition, the survey respondents also reported a fairly high amount of intra-organizational boundary spanning communications and internal information trading. Finally, there are some indications that people engage in boundary spanning activities using the same type of information sources (interpersonal vs. electronic). For instance, there is a strong correlation between the use of non-co-located coworkers as information sources and external contacts. In addition, there is a correlation indicating that people who access information from intra-organizational electronic networks also access advice from inter-organizational networks.

Table 1 Survey Items, Constructs, Item Loadings and Cross-Loadings

Construct and Survey Items										
Knowledge Sources										
<i>How often do you use the below information sources in your everyday work?</i>										
	1	2	3	4	5	6	7	8	9	
1	Coworkers in my location	1.0	.28	.03	.01	-.13	.05	.04	-.17	-.13
2	Cap Gemini colleagues in another location	.28	1.0	.55	.42	.20	.47	.21	.30	.13
3	Cap Gemini electronic communities	.01	.48	.92	.37	.44	.35	-.01	.30	.22
	NCN MS electronic communities	.04	.53	.92	.35	.50	.35	-.03	.28	.26
4	Other contacts outside of Cap Gemini	.01	.42	.39	1.0	.14	.35	.44	.31	.37
5	Internet: Discussion forums/electronic communities	-.13	.20	.51	.14	1.0	.40	.00	.24	.18
Information Trading										
<i>How many times during the past year have the following happened?</i>										
6	You were contacted by someone in Cap Gemini for some specific technical information	.08	.38	.36	.27	.35	.89	.39	.53	.33
	You gave out some specific technical information to someone at Cap Gemini	.11	.34	.36	.31	.39	.90	.40	.47	.31
	You sent <i>formal</i> , written communications in the form of reports or data to someone inside of Cap Gemini	.02	.44	.18	.27	.24	.72	.48	.43	.27
	You sent <i>informal</i> , written communications in the form of reports or data to someone inside of Cap Gemini	-.03	.43	.37	.34	.34	.85	.41	.50	.28
7	You were contacted by someone <i>outside</i> of Cap Gemini for some specific technical information	-.10	.07	-.02	.36	.06	.47	.88	.36	.29
	You gave out some specific technical information to a person working <i>outside</i> of Cap Gemini	-.02	.11	-.09	.32	.03	.40	.90	.24	.23
	You sent <i>formal</i> , written communications in the form of reports or data to someone <i>outside</i> of Cap Gemini	.17	.28	-.04	.43	-.07	.42	.86	.27	.24
	You sent <i>informal</i> , written communications in the form of reports or data to someone <i>outside</i> of Cap Gemini	.10	.26	.05	.45	.00	.47	.91	.36	.29

Performance										
8	My work tasks demand creative and totally new ideas and solutions	-.03	.36	.32	.22	.23	.38	.23	.76	.39
	The others at Cap Gemini think that I am creative	-.13	.19	.14	.13	.03	.42	.31	.79	.39
	My colleagues at Cap Gemini consider me to be a guru	-.21	.21	.30	.35	.30	.55	.30	.84	.63
9	I have a high level of expertise in the technology with which I work	-.14	.08	.30	.31	.27	.39	.29	.59	.91
	Able to meet objectives set by your immediate superior relative to your colleagues at Cap Gemini	-.07	.19	.14	.35	.00	.18	.19	.39	.71
	Able to meet my deadlines relative to your colleagues at Cap Gemini	-.03	.01	-.10	.08	-.14	.02	.12	.26	.60

Table 2 Descriptives, ICRs, Correlations and AVE Values

	Range	Mean	Std Dev	ICR	1	2	3	4	5	6	7	8	9
1 Co-located Coworkers	0-3.7	3.0	1.0	n/a	1								
2 Non Co-loc. Coworkers	0-3.7	1.3	1.2	n/a	.28	1							
3 Intra-Org Nets	0-3.4	1.2	1.1	.92	.03	.55	.92						
4 Contacts at other firms	0-3.7	.80	.87	n/a	.01	.43	.39	1					
5 Extra-Org Nets	0-3.7	1.3	1.3	n/a	.13	.20	.55	.14	1				
6 Internal Info Trading	0-3.1	1.2	.81	.91	.05	.47	.38	.36	.40	.84			
7 External Info Trading	0-3.6	.56	.70	.94	.04	.21	.02	.44	.01	.50	.89		
8 Creativity	1.5-7	4.2	1.2	.84	.17	.30	.32	.31	.24	.58	.35	.80	
9 General Performance	3-6.3	4.6	.88	.79	.13	.13	.26	.37	.18	.35	.30	.61	.75

Structural Model

Table 3 summarizes the PLS structural analysis. Figure 2 provides a graphical representation of the results. To evaluate the models, R² values were calculated for endogenous constructs. Interpreted like multiple regression results, the R² indicates the amount of variance explained by the model (Chin, 1998). The overall model explained 38% of the variance in creativity and 17% of the variance in general performance. In addition, the model explained 44% of the variance in internal information trading and 20% of the variance in external information trading. Specifically, we find support for H1a, workers that rely on co-located coworkers rate lower on creativity (*b* = -.20, *p* < .05). However,

contrary to expectations in H1b, there was no relationship between accessing information from coworkers and general performance ($b = -.15, p \text{ ns}$). We found support for H2, people who rely on coworkers in other locations are more likely to engage in internal information trading ($b = .24, p < .01$), as well as H3, people participating in internal electronic networks engage in internal information trading ($b = .26, p < .01$). Finally, as predicted in hypotheses H4a and H4b, internal information trading results in higher levels of creativity ($b = .54, p < .01$) and higher levels of general performance ($b = .28, p < .05$).

Table 3 Results of PLS Analysis

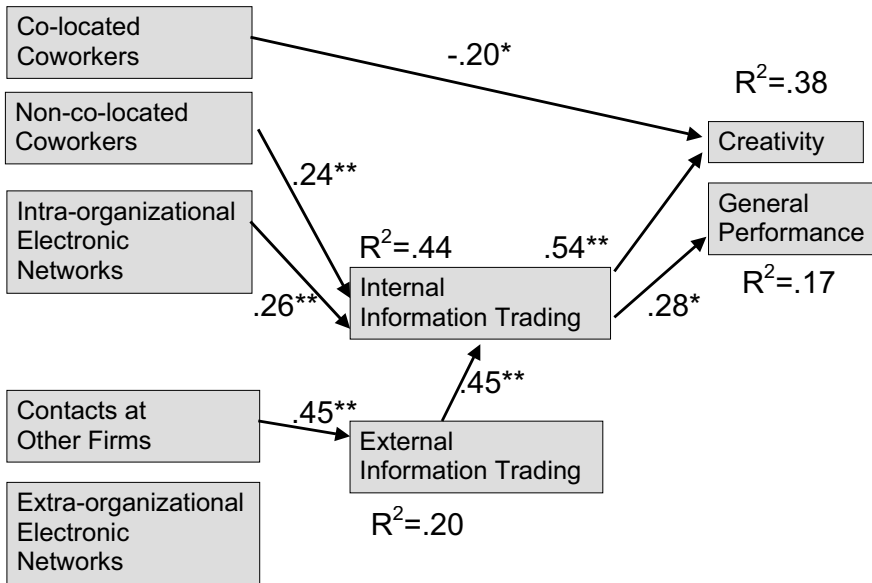
		Internal Info Trading	External Info Trading	Creativity	General Performance
H1a,b	Co-located Coworkers			-.20*	-.15
H2	Non Co-located Coworkers	.24**			
H3	Intra-organizational Electronic Nets	.26**			
H4a,b	Internal Information Trading			.54**	.28*
H5	Contacts at Other Firms		.45**		
H6	Extra-organizational Electronic Nets		-.06		
H7a,b, H8	External Information Trading	.45**		.09	.17
	R^2	.44	.20	.38	.17

* $p < .05$, two-tailed test

** $p < .01$, two-tailed test

As predicted in H5, people who use their contacts at other firms as knowledge sources engage in external information trading ($b = .45, p < .01$). However, we find no support for H6, thus there is no evidence for a relationship between people participating in external electronic networks also engaging in external information trading. Contrary to predictions, external information trading did not directly influence creativity (H7a) or general performance (H7b). Finally, we find support for H8, people who engage in external information trading are also likely to engage in internal information trading ($b = .45, p < .01$).

Figure 2 Model of Results



DISCUSSION AND IMPLICATIONS

This research provides insight into how firms may create organizational structures that balance efficient and flexible knowledge integration among individuals. In terms of internal integration, individuals search for information and know-how located both within and across intra-organizational boundaries and integrate it with their own when performing work-related tasks. However, our findings suggest that the view of the firm as a knowledge integrator needs to be further developed by incorporating a dimension of cooperation. Grant’s theory assumes that individuals are willing to share knowledge with each other without expecting anything in return. Yet our research findings suggest that knowledge integration through boundary spanning activities is supported by informal information trading.

While knowledge can be accessed from co-located coworkers in one’s communities of practice without expectation of reciprocal trading and returns, once intra-organizational physical boundaries are crossed, expectations of returns for knowledge sharing, as exhibited in information trading, appear to come into play. In order for an individual to access knowledge from others outside his or her immediate physical location, it appears that he or she must be willing to give something in return. In addition, our results suggest insights into the importance of flexible knowledge integration structures above and beyond the efficiency of co-location.

Efficiency and Flexibility of Integration: Implications for Performance

In terms of integrative efficiency, we found evidence that a high reliance on co-located coworkers results in lower levels of creativity. This suggests that the knowledge of co-located coworkers and communities of practice may be largely redundant and the integration of this local knowledge, although efficient, may stifle the development of new ideas and innovations. On the other hand, information that crosses intra-organizational boundaries enhances integrative flexibility, as evidenced by the positive relationship between internal information trading and both general performance and creativity. Individuals may either reconfigure existing knowledge to fit their local needs or integrate new know-how and innovative ideas with their own.

One surprising finding, though, is that integrative efficiency did not enhance an individual's general performance as predicted. One potential explanation may be related to the task being performed. In software development there is some degree of standardization and universal technical language since individuals across the firm are typically using the same underlying programming languages. Thus, individuals may trade standardized programming hints or code across organizational boundaries that may simply be "plug'n play", enabling use with current know-how and easier recombination with internal firm knowledge. Thus, in the area of software development and the universal language of standardized programming code, it may be just as efficient to integrate knowledge from co-located coworkers as coworkers across the organization.

In terms of external integrative flexibility, contrary to expectations we found that external information trading has no direct relationship to individual performance, rather it affects creativity and general performance indirectly through its influence on internal information trading. We had expected that knowledge coming from contacts outside of the firm in one's inter-organizational networks of practice would be relatively novel and lead to more creative solutions, but at the same time it would be more difficult to apply to one's task, thus requiring more time to use. One potential explanation for our results may be that knowledge coming from outside the firm may be so novel that it cannot be applied to any immediate solution. Rather its dissemination to others and subsequent recombination with the firm's knowledge is necessary to adapt this knowledge to the firm's specific use. Thus, the ability to develop creative solutions and improve performance may involve combining existing internal knowledge with novel external knowledge.

This finding supports theories of absorptive capacity, which suggest that the firm's ability to assimilate new, external information is largely a function of the firm's ability to internally process that information (Cohen & Levinthal, 1990). In addition, this research potentially offers additional insight: our results suggest that performance is enhanced by the recombination of knowledge that crosses internal organizational boundaries. This provides some

evidence that organizational absorptive capacity is enhanced through intra-organizational cross-boundary knowledge flows, and by recombining knowledge through informal information trading. While there has been a great deal of emphasis placed on the importance of face-to-face interactions and co-location for transferring valuable knowledge, organizations interested in enhancing absorptive capacity may want to establish structures other than long-term co-location that emphasize flexible knowledge integration.

Flexibility of Integration: Role of Electronic Discussion Networks

Our research findings also indicate that creating electronic social networks may enhance integrative flexibility and information trading activities as well. In terms of intra-organizational electronic networks, our findings provide support for previous research suggesting that norms of reciprocity are critical for sustaining knowledge exchange in electronic discussion networks (Lakhani & von Hippel, 2000; Wasko & Faraj, 2000). However, contrary to expectations, we find *no* relationship between participation in extra-organizational electronic networks and external information trading. Thus, it seems that individuals are more likely to engage in information trading with others with whom they have a common bond, such as organizational membership.

One explanation may be found by looking at the relationship between the ability to establish reciprocal exchange and various communication channels. It may be more difficult to build reciprocal relationships with individuals in extra-organizational electronic networks since members generally have not met each other face-to-face and have little social influence over one another due to the voluntary and anonymous nature of the exchange. In addition, when reciprocity occurs in these networks it is typically of a generic and not a dyadic nature (Kollock, 1999). In order for an individual to give to the network, there must be a level of trust across the network members that ensures other network members will “pay back” when requested.

Our findings indicate that it may be easier to build trust and achieve a norm of reciprocity in intra-organizational electronic networks than in extra-organizational ones. This may be because individuals within these networks have a common organizational tie and are thus working for the greater good of the company (Constant et al., 1996). However, there are other aspects to consider. Intra-organizational networks may be more stable in terms of participation, membership, and identification of participants. It is also possible that individuals are not as anonymous as they are in extra-organizational networks. Finally, misbehavior in an intra-organizational electronic network may be more easily “punished” and carry tangible deterrents, while positive behaviors may be rewarded through increases in status and reputation in the organization. As a result, intra-organizational electronic networks may be better able to control their boundaries and member behavior, resulting in more effective flows of knowledge.

Implications for Practice

These findings indicate that organizations concerned with knowledge management may need to rethink their knowledge management strategies and find a balance between reliance on co-located coworkers and the promotion of flexible integration through boundary spanning communication to improve individual performance and creativity. Thus, results from this study suggest an important new use of internet-based communication technologies to support knowledge management. Rather than using technology to replace traditional knowledge management techniques, such as creating document repositories, we need to think of non-traditional ways to leverage these new technologies for improved knowledge flows within and across the firm, by leveraging networks that support the exchange of advice and ideas between individuals.

While intra-organizational trading can be viewed positively without question in terms of enhancing individual performance, and ultimately a firm's competitive advantage, the presence of inter-organizational information trading draws into question the degree to which a company's proprietary knowledge is leaking across the firm's boundaries. The decision to trade or not with external parties is placed in the hands of an individual working for the firm. As such, most economic and management researchers would argue that this informal transfer is a disadvantage for the firm since the individual's actions may not be in line with the firm's objectives, and may lead to a firm being unable to capitalize on the unique benefits from an innovation (Schrader, 1991).

However, the results of this research seem to indicate that external information trading is beneficial for the firm, although indirectly through recombination with existing knowledge. Thus, while an individual may trade away "proprietary" knowledge, the ability of a rival firm to turn this into an innovation lies in its ability to internally integrate the new knowledge into the existing knowledge base of the firm. In addition, trading information across organizational boundaries enhances the inflow of new ideas and innovations. Information trading also ensures that help will be reciprocated at a point where the information seeker is in need of advice. Thus, while information trading implies knowledge leakage across firm boundaries, it also ensures that new knowledge flows back into the firm.

Limitations and Areas for Further Research

We should note the limitations of the study and caution that this study was of an exploratory nature, with the contributions merely acting as guidelines for further research. First, this study only examined knowledge workers focused on developing software solutions in one company, thus limiting the generalizability of our findings. Further research should examine individual information trading across multiple organizations, and across multiple categories of knowledge workers. In addition, the number of participants in this study, although adequate for analysis, is relatively small to make conclusive statements outside of this context. Further research should include

all organizational knowledge workers, the impact of location, and all internal as well as external organizational information sources. Another limitation is our use of self-reported survey measures only, increasing the risk of common-method bias. Further research should include other performance data sources in addition to survey data.

Conclusion

This paper examined the relationship between various knowledge integration activities and individual knowledge worker performance. We found that internal and external boundary spanning through participation in various networks of practice facilitates information trading that in turn results in improved individual performance. Therefore, creating organizational structures that increase the flexibility of knowledge integration may support the creation of new ideas and innovations, leading to sustainable competitive advantage. In addition, this study indicates that people who rely on co-located coworkers as information sources report lower levels of creativity. This indicates that informal organizational structures such as communities of practice that enhance the efficiency of knowledge integration, without regard to flexibility, may “bind and blind” – supporting adherence to the same ideas and information, potentially impeding the creation of new knowledge and stifling performance. Therefore, organizations concerned with knowledge management and creative solutions should focus on balancing knowledge integration structures that support efficiency with flexibility, emphasizing boundary spanning and informal information trading through both personal and electronic networks.

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Article Six

Exploring the Relationships between Participation in Networks of Practice, Centrality, and Individual Performance in a Multinational Firm

Note to Reader on Terminology:

In general, the terminology in this article corresponds to the terminology in this thesis.

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Exploring the Relationships between Participation in Networks of Practice, Centrality, and Individual Performance in a Multinational Firm

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ABSTRACT

Multinational organizations create sustainable competitive advantage based on their ability to effectively integrate knowledge that is increasingly dispersed throughout their global operations. This knowledge resides in specialized form among the organization's individual members, and as individuals perform their everyday work tasks, they participate in activities related to the firm's knowledge integration processes. In so doing, individuals build and participate in emergent networks that have been labeled networks of practice, which spread across the multinational's intra-organizational boundaries as well as across its legal boundaries. Grounded in the knowledge-based view of the firm and in particular theories of knowledge integration, we investigate these individual level activities and their relationship to individual outcomes of centrality and performance. Using survey and social network data from a multinational new media consulting company, we recreated the informal advice networks for the entire multinational of 1698 individuals spread across 28 offices (84.7% response rate). We find results through structural equation modeling that suggest that organizations should support individual level activities that include not only the use of internal knowledge sources but also the use of *informal, external* knowledge sources, such as participation in inter-organizational networks of practice. Research results also suggest that there are different patterns of activities related to knowledge integration depending on whether efficient knowledge integration or flexible knowledge integration is the goal. Implications for theories of the knowledge-based view of the firm, the multinational, and networks of practice are discussed as well as some implications for practice.

Keywords: knowledge, community of practice, network of practice, multinational, social network analysis, structural equation modeling

INTRODUCTION

To achieve competitive advantage, multinational organizations must continuously create, transfer, and exploit knowledge that is increasingly dispersed throughout their global operations (Bartlett & Ghoshal, 1989; Hedlund & Nonaka, 1993; Doz & Hamel, 1997). Knowledge must be created at a rapid pace while it is simultaneously transferred and applied throughout these global operations. Coordination across subsidiaries prevents the duplication of effort while at the same time ensuring the fastest time to market with a product that customers want. Additionally, within the knowledge-based view of the firm, it is argued that the challenge of a multinational is not to divide a given task into activities to be performed efficiently by different subsidiaries but to position the company so that “separate knowledge pieces” from across the organization may be combined to initiate new tasks (Hedlund, 1994). The ability to create a sustainable competitive advantage is then based on the firm’s combinative capability, or the ability to generate new applications through the combination and recombination of existing knowledge (Kogut & Zander, 1992). However, as many multinationals continue to expand their operations and thereby increase the number of geographically dispersed locations, employees, functions, and external partners, the task of effectively making use of knowledge within the firm becomes more difficult. Both the complexity of the multi-unit organizational structure and the differences in language and local culture lead to significant challenges.

Recent research on multinationals is finding indications that *relationships of a more informal nature* are playing an increasingly significant role in the effective use of knowledge in these firms (Hansen, 1996, 1999; Tsai, 2002). In a review of the literature on coordinating mechanisms in multinationals, Martinez & Jarillo (1989) find that since the mid-1970s researchers have been paying considerably more attention to the importance of “informal communication”.⁷² Subsequent research has focused on knowledge sharing through informal communication networks within multinationals and has found a positive relationship between participation in informal intra-organizational knowledge sharing and performance (Hansen, 1996). In these studies, the level of analysis tends to be at the unit or project level with researchers surveying unit managers about their subsidiary’s knowledge sharing and social relations, e.g., socializing during events such as company picnics (Tsai & Ghoshal, 1998). Yet there are few studies investigating the role that the individual plays in the informal knowledge processes in multinationals, despite proponents of the knowledge-based view of the firm arguing for the

⁷² Martinez & Jarillo (1989) define informal communication as communication that occurs through informal networks, personal contacts, intra-subsidiary visits, meetings, conferences and forums, and transfer of managers.

importance of the individual in these processes. For example, Grant proposes that the firm be viewed as an enabler of coordinating action among individuals while Hedlund suggests that one of the major characteristics that makes the firm unique is its ability to transfer knowledge between levels of analysis - e.g. from the individual level to the firm level and vice versa.

One body of literature that has been paying increasing attention to the individual and his or her role in the knowledge processes of firms is that of networks of practice (Brown & Duguid, 2000). Networks of practice are groups of individuals connected together through social relationships that emerge as individuals interact on task-related matters when conducting their work. Researchers have investigated different forms of these networks of practice in several settings, with communities of practice being the most well-known and well-researched network of practice (Lave & Wenger, 1991; Wenger, 1998). This literature argues that networks of practice are vital conduits of knowledge within the firm and that they are the nexus of new knowledge creation (Brown & Duguid, 1991). However, there are few empirical studies focusing on performance issues related to networks of practice or on networks of practice within multinationals. Thus, the purpose of this chapter is to tie the above together by focusing on knowledge integration through networks of practice within the setting of a multinational firm. In particular, we investigate the relationship between an individual's participation in networks of practice, individual centrality, and an individual's work-related performance.

With the above in mind, we performed a unique study of a multinational internet consulting firm, Icon Medialab (Icon). Through the administration of a web-based questionnaire to all employees in the firm, we collected social network data on the emergent work-related networks of all 1698 individuals spread across 28 offices in 16 countries in Asia, the United States, and Europe. With this data, we were able to build a rich picture of the firms' emergent work-related networks as well as the participation of the firm's individuals in networks reaching across the multinational's boundaries. We then linked these patterns to individual performance (creative vs. efficient) in order to provide suggestive evidence of the value of knowledge flows in networks of practice.

Such inquiry makes three important contributions. First, this research empirically examines the trade-offs between individuals accessing knowledge from intra-organizational networks of practice located within their local subsidiary or that span subsidiary boundaries as well as knowledge accessed from inter-organizational networks of practice. Second, this research clarifies how various patterns of individual level knowledge integration are related to individual performance in complex knowledge environments. Finally, this research makes possible more precise theoretical models of how multinational organizations may design their organizations and their knowledge management

activities to support knowledge exchange and the creation of new knowledge to enhance individual and thus organizational performance.

This article is organized as follows. In the following section, we briefly review the relevant knowledge-based view of the firm and network of practice literatures in addition to previous research on technology transfer within multi-unit firms and social networks. These literatures provide the foundation for the conceptual model and the specification of a set of hypotheses related to the relationships between knowledge integration and individual performance. Section three describes the research methodology and provides a description of the research site. Section four reports the results of the empirical study while the last section provides a discussion of the results and the implications of this research for theory and practice.

THEORETICAL BACKGROUND

Recent advances in strategic management thought suggest that organizational resources and capabilities rather than served markets are the principal source of sustainable competitive advantage and that knowledge is the most important strategic resource of the firm. As a result, firms are increasingly being described as distributed knowledge systems (Grant, 1996a,b; Spender, 1996; Tsoukas, 1996). Assuming that knowledge is a critical input to production processes, then organizational capability stems from the higher-ordered organizing principles that structure relationships between individuals and the various groups to which they belong in order to integrate the specialized knowledge of individuals (Kogut & Zander, 1992; Zander & Kogut, 1995; Grant, 1996a,b; Spender, 1996). This increased emphasis on organizational capability and knowledge has led to the development of the knowledge-based view of the firm (Kogut & Zander, 1992, Grant, 1996a,b; Spender, 1996).

Within this view, there is considerable emphasis on the individual. For example, Nonaka (1994:17) states, "At a fundamental level, knowledge is created by individuals. An organization cannot create knowledge without individuals. The organization supports creative individuals or provides a context for such individuals to create knowledge." According to Grant (1996a), competitive advantage results from how effective firms are in integrating the specialized knowledge of their members. He further proposes that this effectiveness depends upon the efficiency, the scope, and the flexibility of knowledge integration. Efficiency refers to how productive firms are in integrating individuals' specialized knowledge. Efficient integration is related to the frequency of interactions between individuals, where higher levels of frequency engender automated responses from each organizational member as well as a common language of discourse. The scope of knowledge integration refers to the different types of specialized knowledge being integrated – the more complex the scope, the greater the difficulty for

competitors to replicate. The flexibility of integration reflects extending existing capabilities through boundary spanning activities in order to access and reconfigure additional knowledge through both internal and external integration.

Grant emphasizes the importance of integrative flexibility. Hypercompetitive conditions in the marketplace drive the eventual erosion of all positions of competitive advantage. Thus, sustaining a competitive advantage requires flexibility and the creation of new capabilities. Firms need to establish knowledge integration techniques that extend existing capabilities by bringing in new knowledge and reconfiguring existing knowledge. However, this need for flexibility to access new knowledge presents complex organizational issues with regard to firm structure, firm boundaries, and the choices between accessing knowledge from internal networks and external networks.

Turning to multinational firms, one of the key issues underlying the knowledge-based view in these settings is to understand how knowledge is integrated across geographically dispersed units to create organizational capability (Hansen, 1996). The literature on organizational coordination refers to coordination as the integration or linking together of different parts of the organization (Van de Ven et al., 1976; Tsai, 2002), and knowledge integration within a multinational context has been defined as “the process of searching for and transferring knowledge through the interunit network” (Hansen, 1996:1). The extant multinational literature has identified two generic types of coordinating or integrating mechanisms in multinationals: (1) formal hierarchical structure and (2) informal lateral relations. As mentioned above, recent research has increasingly emphasized the importance of these informal relations (Martinez & Jarillo, 1986). Hansen (1996) finds in his research of a high technology multinational that the vast majority of relationships between company divisions were informal, with only 20% of the interdivisional contacts more formalized, e.g., licensing agreements, regular technology meetings, etc. Results further reveal that the more central an R&D team is in the multinational’s informal network of units possessing the relevant expertise, the easier the R&D team can conduct searches for the appropriate knowledge and thus the faster the team’s completion time. A final finding is that if a unit has weak relations within the multinational network, then the unit’s projects are slowed down when the knowledge to be transferred is very complex.

We may, however, question these theories of knowledge integration and multinationals on two premises. First, Grant’s theory of knowledge integration represents a paradox: increasing the efficiency of integration may hinder flexibility and the ability to create new innovations. For example, prior research suggests that creating organizational structures that facilitate the increase in efficiency of knowledge integration through common language and frequent interactions may result in knowledge hoarding, less creativity and the

“not invented here syndrome” (Granovetter, 1973; Szulanski, 1996). Second, proponents of knowledge integration seldom refer to issues of “cooperation”. Grant’s theory focuses primarily on issues of coordination (i.e., structuring to enhance the effectiveness of knowledge integration) while Hansen’s theory views the central processes of knowledge integration within the multinational as involving the search and transfer of knowledge through informal relations. They both leave out a key component by assuming that people are willing to share knowledge openly and freely if provided with the structures and opportunities to interact. However, research by Tsai & Ghoshal (1998) suggests that knowledge integration is dependent upon the degree to which individuals develop trusting relationships in informal social interactions.

In addition, prior research on networks of practice that span a firm’s legal boundaries suggests that individuals do not give away help and advice to others in their informal social networks for free (von Hippel, 1987; Schrader, 1991, Macdonald & Williams, 1993; Bouty, 2000). Rather, individuals trade or exchange knowledge with expectations of reciprocity. For example, Macdonald & Williams (1993) find that individuals who are gatekeepers within their organizations informally exchange knowledge with others outside their organization in dyadic reciprocal relationships. In a more recent study, Isabelle Bouty (2000) investigates the knowledge sharing decisions of researchers and finds that individuals share their knowledge only with others with whom they are mutually acquainted, share a high level of trust, and whom they do not consider to be a competitor. Researchers find similar results when investigating electronic networks of practice or groups of individuals who communicate on work-related tasks primarily through computer-based communication technologies, such as bulletin boards, listservs, etc (Lakhani & von Hippel, 2000; Wasko & Faraj, 2000). For example, Wasko & Faraj (2000) investigate participation in three technical usenet newsgroups and find that the most frequent response to why respondents share their knowledge with others is reciprocity. Additionally, the studies by von Hippel and Schrader revealed that individuals participating in these inter-organizational reciprocal knowledge exchanges often trade proprietary firm knowledge with one another.

In summary then, what is essential is that the *expectation of reciprocity* is a key cooperation mechanism underlying knowledge exchange that crosses organizational boundaries. However, few studies focusing on knowledge integration within multinationals have investigated this issue of cooperation nor have they investigated the underlying processes of knowledge exchange at the individual level. Additionally, research into the relationship between individual-level knowledge exchange and individual performance has been extremely limited. As a step in this direction, we develop a set of hypotheses relating individual participation in internal and external networks of practice, knowledge exchange, and individual outcomes of centrality and performance.

RESEARCH MODEL AND HYPOTHESES

In this section, we look at the use of various sources to access knowledge including participation in various networks of practice, internal and external knowledge exchange, and the individual outcomes of centrality and individual performance. We examine two types of individual performance: 1) efficient performance or the ability to meet one's job demands and 2) creative performance or the ability to develop creative solutions. We expect that participation in various networks of practice and the exchange activities performed by individuals will impact their centrality and their general performance and creative performance in different ways depending on whether an individual's activities are reflective of application of current knowledge or concerned with new knowledge creation and innovation.

Efficiency of Integration

Internal Codified Sources. Within the knowledge-based view, competitive advantage is partly dependent upon how efficiently the firm utilizes and integrates its existing knowledge. As a result, firms develop systems for capturing and making explicit the knowledge that is developed as individuals conduct their tasks within the firm. Proponents of the knowledge-based view build on Demsetz (1988) and argue that the firm is better able to do this than the market since the firm provides the continuity of association between individuals participating on the same task. As individuals work together over time, they develop shared mental models and a common language that enable them to codify their tacit knowledge. The firm can then store this codified knowledge for reuse. Relative to individuals outside the firm, employees can then easily access and reuse this codified knowledge as they share the same communication code and mental models as those who codified it (Nonaka & Takeuchi, 1995). Such codified storage is most visibly done using computer databases and a company intranet that includes applications such as project information repositories and skills databases as well as message boards. In addition, due to the majority of work being performed and saved in digital form, individuals have easy access to documents and other codified sources that might not be found on the intranet. Thus, our argument is that at an individual level we would expect to see an association between an individual's use of *internal* codified knowledge sources and their individual *efficient* performance. In other words, an individual who is more inclined to search the firm for already existing solutions and adapt them to his or her task, as opposed to "reinventing the wheel" through developing one's own solution, are more likely to have a higher degree of efficient performance. However, a high reuse of existing codified knowledge is unlikely to lead to the access of new knowledge or the recombination of knowledge, which would affect creative performance. Thus, we have the following two hypotheses:

HYPOTHESIS 1A: The higher the use of internal codified knowledge sources (e.g., intranet, documents, electronic message boards) in task-related matters, the higher the level of individual efficient performance.

HYPOTHESIS 1B: The higher the use of internal codified knowledge sources (e.g., intranet, documents, electronic message boards) in task-related matters, the lower the level of individual creative performance.

Co-located Coworkers. While organizations spend considerable resources on documenting work tasks, research has consistently found that people prefer oral sources to written sources (Allen, 1977). Codified knowledge sources are often too strict to interpret each new situation and thus cannot fulfill the requirements needed to perform the task (Brown & Duguid, 1991). In addition, Polanyi (1962) describes knowledge as taking two forms, explicit and tacit. Explicit knowledge is that which can be easily explained and codified, and tacit knowledge is the additional knowledge that individuals are unable to articulate. Tacit knowledge has a personal quality that makes it hard to formalize and communicate and is deeply rooted in action, commitment and involvement in a specific context (Polanyi, 1962). Some researchers argue that the most effective means to transfer tacit knowledge may actually be *not* to codify it, but to transfer it through an implicit mode (Yanow, 2000). According to Reber (1993), transfer through an implicit mode means that “the acquisition of knowledge takes place largely independently of conscious attempts to learn and largely in the absence of explicit knowledge about what was acquired.” This transfer of tacit knowledge thus requires transfer through word of mouth and frequent interaction with others.

Ethnographic research on work practices finds that this frequent interaction often occurs in communities of practice (Lave & Wenger, 1991; Orr, 1996; Snyder, 1996; Wenger, 1998). Researchers have found that these informal networks emerge over time between individuals working on similar task-related issues located in face-to-face settings. With knowledge-intensive tasks, often no one individual can solve the problem on his or her own due to the inability to know everything. Thus, when an individual becomes stuck in conducting a work-related task, he or she often turns to knowledge sources that are the most easily accessed (such as asking co-located coworkers), rather than searching for and using the best knowledge source (such as codified sources or non-co-located coworkers) (Gerstberger & Allen, 1968; O'Reilly, 1982). Through patterns of mutual exchange and collaboration, individuals share knowledge to help each other reduce the equivocality of problematic issues and build the community's memory (Orr, 1996, Wenger, 1998). Thus, individuals who rely on others in their local setting to a high degree are likely to engage in a high degree of mutual knowledge exchange.

Through this mutual exchange and collaboration over time, individuals become bound together by the context of the situation in an informal manner in communities of practice (Brown & Duguid, 1991). These emergent structures provide the nexus for the sharing and transfer of valuable individual and group tacit knowledge (Kogut & Zander, 1992), resulting in higher performance of the community as a whole (Brown & Duguid, 1991, 1998; Wenger, 1998). Individuals develop a common language, explicit and tacit rules of behavior and coordination, and a shared identity, (Wenger, 1998). Accessing knowledge from others who share the same coding scheme and language is highly efficient (Tushman & Katz, 1980), thus economizing on the amount and intensity of communication needed to achieve knowledge integration. In addition, in many work environments, employees are confronted with information overload. Through asking someone in the community for help, time does not have to be spent sorting through piles of information for relevant documents (Wenger, 1998). This suggests that one of the most efficient sources of knowledge should be co-located coworkers, who are more likely to frequently interact with each other and develop into a community of practice due to their sharing the same physical space. Thus, due to the efficiency of integration, people who access knowledge from co-located coworkers to a high degree should report higher levels of individual efficient performance.

However, prior research argues that individuals within a social clique tend to have strong ties, which have been defined as emotionally intense, frequent, and involving multiple types of relationships, e.g., friends, advisors, and coworkers (Granovetter, 1973). The result is that the knowledge held by the members of a social clique tends to be redundant with that held by other members, providing little additional information over what an individual may already know (Granovetter, 1973, 1983). Thus, the knowledge available through co-located coworkers is likely to be limited and superfluous, impeding the ability to develop new and creative ideas. In addition, the highly efficient structures that support knowledge integration and the exploitation of core capabilities may evolve into core rigidities and competency traps – inappropriate knowledge sets that preserve the status quo and limit new insights, resulting in gaps between the knowledge of the firm and changing market conditions (Levitt & March, 1988; Leonard-Barton, 1992). Therefore, while accessing knowledge from co-located coworkers is likely to be highly efficient and lead to better efficient performance, co-located coworkers are less likely to offer the integrative flexibility needed to enhance creativity and develop new capabilities. The above then leads to our next set of hypotheses:

HYPOTHESIS 2A: The greater the reliance on co-located coworkers as sources of knowledge on task-related matters, the higher the level of internal knowledge exchange.

HYPOTHESIS 2B: The greater the reliance on co-located coworkers as sources of knowledge on task-related matters, the higher the level of individual efficient performance.

HYPOTHESIS 2C: The greater the reliance on co-located coworkers as sources of knowledge on task-related matters, the lower the level of individual creative performance.

Internal Flexibility of Integration

Non-co-located Coworkers. Internal flexibility of integration involves the extent to which existing knowledge within the firm can be recombined and reconfigured to create new knowledge (Grant, 1996). Knowledge that is physically dispersed across a multinational may facilitate integrative flexibility since it is more likely to be non-redundant to that which is found within the same physical location (Granovetter, 1973). Advances in communication technologies have made it easier for people who are working on similar task-related problems yet physically dispersed across a multinational to communicate, thus individuals may relatively easily access knowledge from coworkers who are working in other offices. These new media greatly reduce the cost of communicating with others and thus, the ability of individuals to conduct knowledge integration through emergent networks across a multinational has greatly increased. For example, email greatly increases the possibility for individuals to access unknown people and new social circles within multi-unit firms due to its asynchronous nature, the ability to simultaneously communicate with more than one person at a time, as well as the ability to easily forward messages (Feldman, 1987). As a result, the use of email and other new media lead to new contacts that might not otherwise have occurred, thus expanding the number and variety of people being used as knowledge sources in problem-solving (Kraut & Attewell, 1993).

Previous research on occupational communities (e.g., van Maanen & Barley, 1984) has shown that when people work in a similar occupation, e.g., software programmer, police, etc., they develop similar identities, values, and vocabularies. This shared identity and language allow people to communicate, regardless of whether they work in the same physical location or have a previous history of a relationship. As such, individuals dispersed across an organization working on similar tasks may create emergent networks through which knowledge about practice can both travel rapidly and be assimilated readily (Brown & Duguid, 2000). In this manner, intra-organizational distributed networks of practice are similar to communities of practice in that a shared practice is the substrate that ties members together. However, due to less frequent patterns of interaction and lower intensities of social pressure, non-co-located coworkers may be less willing or committed to exchange knowledge without some type of return (Blau, 1964). People often prefer to

hoard their knowledge because they perceive that sharing knowledge results in reduced status and personal worth (Orlikowski, 1996). This is especially so when knowledge is the basis of a personal competitive advantage over others (Thibaut & Kelley, 1959). Therefore, individuals are more likely to expect reciprocity when engaging in knowledge exchange across internal organizational boundaries, especially in situations where relations are not characterized by frequent interactions and a high level of trust (Nahapiet & Ghoshal, 1998). Thus, accessing advice and knowledge from non-co-located coworkers is likely to result in internal information trading with the expectation of reciprocity in return. This leads to our next hypothesis:

HYPOTHESIS 3: The greater the level of communication on task-related matters with non-co-located coworkers to access knowledge, the higher the level of internal knowledge exchange.

Integration Centrality. Individuals who are more highly central in communities of practice in both local units as well as in the multinational's internal distributed networks of practice facilitate the firm's ability to conduct activities that promote internal integrative flexibility. Research on communities of practice suggests that central individuals are influential in shaping the flow of knowledge within the community as well as the future direction of the development of the community's knowledge since the more highly an individual is embedded in a community of practice, the more others turn to this individual for help and advice when solving problems (Schenkel et al., 2002). In turn, we would expect that individuals central in a multinational's net of distributed networks of practice would also be influential in the efficient and flexible knowledge integration processes of the firm since they influence both the emergent knowledge flows between units and the knowledge integration processes of other individuals. These individuals play the role of brokers (Wenger, 1998) and are comparable to boundary spanners in the technology transfer literature (Tushman & Scanlan, 1981). Through their collaboration with others in distributed networks of practice, brokers gather knowledge from areas across the organization and transfer it to their own physical location while providing knowledge in reciprocation to other members of their network of practice.

Research has shown members have different levels of community participation; central individuals are full participants or "insiders" and are highly embedded in the community while others are peripheral and less embedded in the network of interdependent relations (Lave & Wenger, 1991). Individuals who are "insiders" in communities of practice reach this position through a process of legitimization during which the individual learns the language and values of the community, while most importantly, how to function as a community member (Lave & Wenger, 1991). For example, the

informal language of the practice can only be learned through informal relationships since it is not the technical language of the trade such as that taught in training manuals (Schenkel, 2002). However, an individual's community participation status is *jointly* determined by the community and the individual. In other words, just because an individual wishes to become a central individual does not necessarily guarantee the individual such participation status. Rather, the individual must gain legitimacy within the community. This process of legitimacy occurs *only* through mutual engagement and knowledge exchange between the individual and other community members over time (Lave & Wenger, 1991, Schenkel et al., 2002).

To date, comparable research on participation and membership status within communities of practice has not yet been performed on intra-organizational distributed networks of practice. However, we may hypothesize that the dynamics are similar to communities of practice in that status is jointly determined by the network and the individual. As such, the process of legitimacy required to reach central status would only occur through mutual engagement and knowledge exchange over time. As such, we now have our next hypothesis:

HYPOTHESIS 4: The higher the level of internal knowledge exchange, the higher the degree of integration centrality.

Creative Performance. While research on the relationship between centrality and individual performance is rather limited. Previous research has provided evidence of a link between centrality in a communication network and several important variables that might lead to performance such as influence (Burkhardt & Brass, 1990) and cognition (Walker, 1985) while more recent research provides evidence of a direct positive relationship to individual performance. In a study of business school alumni, Seibert, Kraimer, & Liden (2001) find support for the role of access to information and resources as full mediators of the relationship between social capital and career success. Sparrowe, Liden, Wayne, & Kraimer (2001) find a positive relationship between in-degree centrality (i.e., the number of relationships in which an individual is sought out for advice) within one's workgroup and individual performance at five different organizations. Baldwin & Rice (1997) demonstrate that centrality in the advice network of a sample of MBA students is positively related to student grades. Finally, Mehra et al. (2001) show that centrality within advice and workflow networks within a high-technology firm predicts workplace performance while Ahuja et al. (2003) point out a direct relationship between a central position in virtual R&D groups and individual performance. In these studies, researchers generally find that it is the access to unique or non-redundant knowledge that is an important factor in an individual's performance.

Research in networks of practice also suggests that those individuals who are more central in the networks of practice within an organization also have more opportunity to gain valuable and non-redundant knowledge from others (Schenkel et al., 2002), and thus may exhibit a higher degree of individual creative performance (Teigland & Wasko, 2003a,b). As mentioned above, previous research by Hansen (1996) provides evidence that a central position within a multinational facilitates the search for knowledge. Thus, individuals who are central in a multinational's distributed networks of practice should be able to effectively access redundant knowledge across the organization to help them conduct their own tasks. In addition, people who engage in internal knowledge exchange are not only sending and receiving task-specific knowledge, they are also helping each other by taking the time to work through each other's problems. When an individual works through someone else's problems, he or she often develops insights into new methods and new applications for existing knowledge (Wenger, 1998). Exercising intellect by helping others is also likely to help people maintain and even improve their own technical skills as well as the ability to see new applications of knowledge. In addition, individuals who help others are entitled to reciprocity, gaining access to new ideas and innovations when needed. Thus, we expect integration centrality to have a direct impact on individual creative performance, leading to our next hypothesis:

HYPOTHESIS 5: The higher the degree of integration centrality, the higher the level of individual creative performance.

External Flexibility of Integration

In addition to internal integrative flexibility, firms need to integrate new knowledge found in the external environment to remain competitive (Cohen & Levinthal, 1990). This knowledge may be accessed through either market or relational contracts (Grant, 1996). While relational contracts tend to refer to formal inter-organizational arrangements, these contracts also comprise informal communication exchanges between individuals, and previous research suggests that a high degree of a firm's knowledge is imported through by a firm's members participating in emergent relationships that span a firm's legal boundaries (Macdonald, 1995).

With the rapid spread of the internet, the ability to participate in inter-organizational networks of practice has greatly increased. As a result, individuals throughout hierarchical levels and functional competence groups in the organization are no longer limited to contacting organizational coworkers or to searching within the company walls for knowledge or advice (Cronin & Rosenbaum, 1994; Kettinger & Grover, 1997). Individuals may now just as easily contact friends, ex-colleagues, or other acquaintances who work outside the organization and even in rival firms (Sproull & Faraj, 1995; Faraj &

Wasko, 1998). Through participation in these networks, individuals may integrate knowledge from within their organization with new ideas and innovations accessed from outside their organization.

In addition to acquaintances, individuals may also quickly and effortlessly access numerous networks of knowledgeable individuals with whom they are *not* acquainted through means such as listservs, chat rooms, discussion boards, etc. (Hinds & Kiesler, 1995; Constant et al., 1996). These electronic networks of practice connect individuals sharing the same profession but who are globally dispersed and typically strangers. These electronic networks revolve around numerous technical (e.g., programming) and non-technical (e.g., criminal law) issues, and they generally offer a much broader source of expertise than at the individual's own company due to the numerous participants from many different backgrounds. In these electronic networks, individuals are able to share information and know-how through mechanisms that support posting and responding to questions, sharing stories of personal experience, and discussing and debating issues relevant to the professional community (Wasko & Faraj, 2000).

As mentioned above, prior research on inter-organizational networks of practice demonstrates that reciprocity is one of the guiding principles in these informal exchanges regardless of whether the other individuals are acquaintances working in other firms or stranger in an electronic network of practice (von Hippel, 1987; Schrader, 1991; Lakhani & von Hippel, 2000; Wasko & Faraj, 2000). While previous research suggests that the growth of inter-organizational internet-based communication is likely to be especially rapid in organizations with a high degree of professionals (Pickering & King, 1995), there is no evidence to indicate that this activity is limited to professionals. Thus, when individuals seek help with their work-related tasks, they may easily contact individuals across the globe regardless of time and their demographic characteristics, organizational setting, or local culture (Hinds & Kiesler, 1995; Sproull & Faraj, 1995; Faraj & Wasko, 1998). As a result, individuals may integrate knowledge relatively easily from within their organization with new ideas and innovations accessed through communications with individuals outside their organization. However, due to strong norms of reciprocity within inter-organizational networks of practice, relying on contacts in other organizations for advice obligates the knowledge-seeker to share knowledge in return. Thus, accessing knowledge from external sources requires reciprocation through external knowledge exchange and trading. This leads to our next hypothesis:

HYPOTHESIS 6: The higher the use of informal external knowledge sources for advice on task-related matters, the higher the level of external knowledge exchange.

Knowledge Exchange. For our next hypothesis, we look at the possible relationship between internal and external knowledge exchange. The technology transfer literature finds that there is a significant degree of overlap between communication star, boundary spanning, and gatekeeper activities. Thus, individuals who are communication stars and boundary spanners are more likely to be gatekeepers (Allen & Cohen, 1969; Tushman & Scanlan, 1981). As mentioned above, Macdonald & Williams (1993) provide further evidence of this relationship since they find that individuals who are gatekeepers within their organizations informally exchange knowledge with others outside their organization in dyadic reciprocal relationships. The implication of this is that individuals who conduct a high level of external knowledge exchange are likely to conduct a high level of internal knowledge exchange. While previous research also finds that gatekeepers are often in first-line supervisor positions (Taylor, 1975), with access to the internet, all individuals may now conduct external knowledge exchange within their specialized knowledge area and then recombine this knowledge through internal knowledge exchange. This then brings us to the following hypothesis:

HYPOTHESIS 7: The higher the level of external knowledge exchange, the higher the level of internal knowledge exchange.

Human Capital. We expect that other factors, often referred to as human capital, are associated with individual performance (both efficient and creative) within the knowledge integration perspective. In this study we measure the education level and general work experience. Thus, we have the following hypotheses:

HYPOTHESIS 8A: The higher the level of education, the higher the level of individual performance (both efficient and creative).

HYPOTHESIS 8B: The higher the level of experience, the higher the level of individual performance (both efficient and creative).

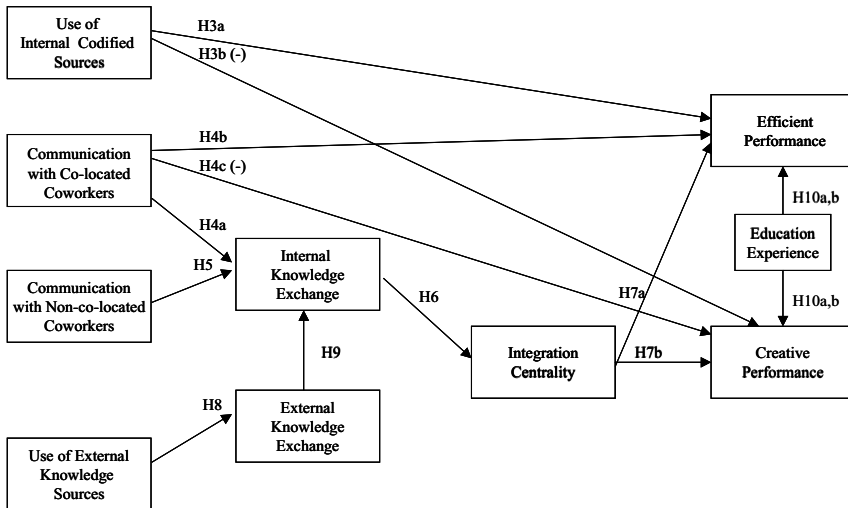
Differences Based on Functional Task. Studies on networks of practice have generally limited their observations to individuals conducting similar tasks. However, we have the rather general proposition that the extent to which the above approaches to knowledge integration affect individual performance will be contingent on the nature of the task being performed. For example, previous research has shown that task knowledge characterized by a more universal nature such as software programming is easier to communicate across a firm's boundaries (Allen, Tushman & Lee, 1979). Space limitations prevent a detailed discussion, but one would expect *ceteris paribus* that the more universal and the more fast-changing the task, the more important it would be for individuals to have ready access to external personal and codified sources

of knowledge. In terms of the specifics of this study, we have separated individuals into three task groups on the basis that these groups rely on knowledge acquisition from different sources to undertake their work effectively: (1) Commercial and Support (CS): administration, sales, management, project management, etc., (2) System and Software Group (SSW): system architects, software programmers, etc., and (3) Design Group (DG): human computer interface specialists, art directors, copy editors, etc. However, it is difficult to speculate *a priori* to what degree and in which manner the relationships hypothesized above will differ. Thus, we have our last hypothesis:

HYPOTHESIS 9: Significant relationships will differ depending upon the individual's work-related tasks within the firm.

Figure 1 presents the fully developed research model with the appropriate hypotheses labeled.

Figure 1 Model of Individual Activities Related to Knowledge Integration



METHODS

Sample and Procedures

We conducted this research in a single firm, Icon Medialab (Icon). The investigation of only one site is common in network studies (see Marsden, 1990; Hansen, 1996) due to the requirements of a closed network when studying individual relationships in social network analysis. The choice of Icon was motivated primarily on the basis that it was a medium-sized multinational that encompassed a wide variety of functional competences, e.g., system architecture, programming, management consulting, art direction, human computer interface, etc., as well as 28 locations across Asia, the US, and Europe. Additionally, one reason for choosing Icon is that its employees in all functions are not only extremely adept at using new internet-based communication media such as bulletin boards, chatrooms, email, etc. but they also use these to a high degree in their everyday work. Finally, we chose Icon since access to this firm was facilitated due to previous research by the author at this firm (Teigland, 2000).

We conducted two phases of data collection and analysis. In the first phase, thirty-five interviews were conducted throughout the firm to gain an understanding of the various networks of practice within the firm as well as the different inter-organizational ones in which Icon individuals participated. Together with human computer interface specialists and a programmer, we then constructed an extensive web-based social network survey in English since English is the official company language. We pilot-tested the survey with one individual across 15 different offices and across different technologies (e.g., PC vs. Mac, Internet explorer vs. Netscape). We then made several changes to avoid misinterpretations of the questions as well as to remove any technical bugs in the survey.

In the second phase, we administered the web-based questionnaire through the company's intranet to all employees of Icon Medialab. Previous research has suggested that electronic surveys using scale-type questions are no less valid than paper surveys (Liefeld, 1988). It has also been found that some subjects prefer electronic surveys to paper (Newsted, 1985), and that email responses may even be more valid (Sproull & Kiesler, 1986). It is important to note here that all employees had access to their own computer and the internet since the majority of their work was performed using the computer. In addition, management placed few constraints on employees regarding the internal or external use of any form of computer-mediated channels.

We placed a hyperlink to the survey at the top of the homepage on the company's intranet such that individuals could easily find the survey. In addition, there were hyperlinks to the survey within the introductory email from the researcher as well as within all reminder emails. Due to the length of

the survey, we designed the survey such that when the individual moved from one survey section to the next, the individual's answers were automatically saved in the survey database. In this manner, an individual could leave the survey and return at any time through the intranet link to find his or her previously entered answers. To administer the survey, several mailings were sent out by email to each individual, including 1) an initial request for participation from the CEO of each office, 2) a request from the researcher with a link to the survey, 3) a follow-up two weeks after the first mailing, 4) and if necessary, a second follow-up three weeks after the first mailing.

Because our research required the complete network, we had to specify a boundary around it. We used the membership criterion (Marsden, 1990; Wasserman & Faust, 1994:31), thus we included those individuals who were formally part of the organization. Individuals who were currently on leave of absence, working only part-time, or were independent consultants working for the company were eliminated from the respondent pool since their networks would not be comparable to those employees who were actively working full-time for the organization. The resulting number of total potential respondents was 1698. We received 1439 completed surveys for a response rate of 84.7%, a level considered to be high enough to perform sociometric network analyses. Throughout the data collection process, individuals were assured that their responses would be kept confidential on a secure server at the company's third party intranet host and that results would only be presented in aggregate form. To encourage responses, we entered all respondents into a drawing for 14 prizes of approximately US \$1600 in total value.

The average age of the respondents was 30.5 years (s.d. 5.82) with an average of 590 (s.d., 409) days employed at Icon. Individuals had worked an average of 3.03 (s.d. 1.02) years in their competence and 73.5% had the equivalent of a university degree or higher. The sample was 39.6% women. In terms of the split between the three task groups, (1) the Commercial and Support Group had together 697 individuals (450 respondents in commercially oriented functions, e.g., project managers, sales personnel, management consultants, and 247 in support functions, e.g., finance, legal, human resources, etc.), (2) 454 in the System and Software Group, e.g., programmers, system architects, etc., and (3) 288 in the Design Group, e.g., web designers, art directors, human computer interaction specialists, etc.. After comparing our sample with the entire Icon population, we find that the demographic characteristics of the group of respondents were representative of those of the entire multinational.

Survey Measures

Knowledge Sources and Knowledge Exchange

The survey contained a series of 7-point Likert scale questions that investigated the use of various internal and external knowledge sources as well as knowledge exchange activity. These independent variables were assessed by asking respondents to indicate how often they used specific knowledge sources (1=few times a day, 2=once a day, 3=few times a week, 4=once a week, 5=few times a month, 6=once a month, 7=less than once a month). The internal knowledge sources constructs included 1) use of internal codified sources (3 items), 2) communication with co-located coworkers (2 items), and 3) communication with non-co-located coworkers (2 items). The external knowledge sources constructs included informal external sources, e.g., electronic networks of practice, friends, colleagues (3 items). Both the internal and external knowledge sources scales were adapted from Teigland (2000) and Teigland & Wasko (2003a,b). The internal exchange scale comprised three items and the external knowledge scale comprised four items. Both scales were adapted from Leifer & Huber (1977) and Teigland & Wasko (2003b). The frequency independent variables were then transformed to convert responses from an interval scale to a ratio scale.

Integration Centrality

While the recall of brief, episodic interactions is highly inaccurate (Bernard, Killworth, Kronenfeld, & Sailer, 1984), people are remarkably able to accurately remember typical interactions and long-term relationships with other individuals (Freeman, Romney, & Freeman, 1987), which are important for our study. Thus, in order to determine integration centrality, we assessed relations by asking respondents two questions: 1) "In general, which persons inside Icon do *you* contact for help or advice when you are not sure what to do with your work, i.e., for help or advice related to your tasks and not your administrative activities?" and 2) "In general, who *contacts you* in the same way?" The lists of individuals on the survey were directly linked to the company's employee database so that it would automatically always be current. However, we found that there was a much larger number ($n=2200$) of individuals listed in the company's database than the number of individuals who were relevant for this study. This was because the company's database included individuals who were on leave of absence, were independent consultants, had quit but not yet been removed, or who were going to be quitting shortly. After several iterations and pilot-testing, we decided to create one web page for each individual office that listed the names of all the individuals within each office alphabetically by first name and not last name since pilot-testing revealed that individuals could recall first names and office to a much better degree than last names. Next to each individual's name and function were eight radio buttons,

four indicating the degree with which the respondent contacted the individual listed and four indicating the degree to which the individual contacted the respondent (1-4 scale indicating daily, weekly, monthly, or less than monthly communication).

We placed a drop-down menu with an alphabetical listing of all the offices within the organization at the top of the screen. In addition, we placed buttons with "Next Office" and "Previous Office" at the top and bottom of the screen. In this manner, respondents could easily move between offices, locating others with whom they had relationships outside of their own office. In order to ensure that people listed others outside of their own location, we wrote the following, "Please think of people in ALL ICON OFFICES, not just those in your own Icon office. To go to another office, click on Next Office or choose another office from the drop-down menu."

Using this network data, we constructed a measure of integration centrality for each individual. Before making any calculations, we went through the network matrices and removed all individuals who were not active, full-time employees, as well as checked and corrected all individual background data (e.g., office, title, competence, hierarchical level, etc.). We then based our measure of integration centrality on two frequently used social network measures: in-degree centrality and closeness centrality. Degree centrality is calculated by simply counting the number of links to (in-degree) and from (out-degree) an actor and this measure was used in the technology transfer studies described above. However, unlike the above studies, our study considers only the *in-degree* relations in the network for the degree centrality measure. In other words, for each focal individual, we counted only those links that other individuals reported that they turned to the focal individual for advice (Sparrowe et al., 2001). In this manner, we determined the degree to which each individual was sought out by others for advice and knowledge. It is important to point out that unlike out-degree, in-degree centrality does not suffer from the limitations of self-reports thus we were able to avoid the potential problems of common method bias with this measure.

In addition to in-degree centrality, we calculated the degree of closeness centrality (Freeman, 1979) for each individual in the firm. Closeness centrality denotes the degree to which an individual is embedded in a network, i.e., how close he or she is to all other individuals within the network, either directly (e.g., a friend) or indirectly (e.g., a friend of a friend, a friend of a friend of a friend, etc.). This measure is calculated by summing the lengths of the shortest paths from one actor to all other actors in the network. It takes into account both direct and indirect links by counting direct links as one step while giving indirect links proportionally less weight. Thus, an individual who is maximally close to all others in the network would have direct, unmediated relationships with all others in the network while individuals who have indirect relations to others have lower levels of closeness depending upon the number of

intervening nodes between him or her and all other individuals in the network (Baldwin & Rice, 1997). In terms of knowledge networks, actors with a higher level of closeness have greater and faster access to the knowledge of all other individuals throughout the firm than those with lower levels of closeness.

Since we were interested in the individual's general embeddedness in the firm's networks of practice and not the direction of his or her relationships (i.e., whether the individual goes to another or vice versa), we used data from both the advice network questions in the closeness measure. First we transposed the second matrix that asked "In general, who *contacts you* in the same way?" in order to make the two advice matrices equal in terms of direction between the individual respondents. We then pooled the two matrices using the average method. The calculation of closeness centrality requires dichotomized (1 or 0) and symmetrical (i.e., non-directional) relations. Thus, our next step was to dichotomize the data by converting all values to either a "1" or "0" with a cutoff point at all values greater than 0.5 in the pooled matrix. In this manner, we removed all values that had an original input as "4" (less than monthly contact recoded as 1 in the network matrix) in the "I contact" section that was not reciprocated by the alter respondent in the "Contacts me" section, i.e., $(0+1)/2=0.5$. Our final step was to symmetrize the data using the maximum rule; 98% of the pairs were symmetric.

Prior research has shown that there is a high degree of overlap between the two measures of centrality that we used, i.e., individuals who have a high level of in-degree centrality are also likely to have a high level of closeness centrality. However, in a firm with many units spread across the globe, there is the possibility that the two might not coincide to the degree that would be found within a single unit firm. For example, an individual may have a high in-degree within his or her own local unit. However, he or she might not have a high level of closeness within the entire organization if his or her local community of practice is not well connected with the rest of the organization. On the same token, an individual who is well embedded in the firm due to a few relationships with individuals who are in turn highly embedded may not necessarily be one to whom a considerable number of others turn for advice. Thus, by combining in-degree centrality with closeness centrality in one measure, we arrived at a construct that we feel provides an adequate description of an individual's integration centrality within a multinational firm. In this manner, we also depart from traditional social network analysis, which generally only uses one measure at a time. We calculated in-degree and closeness centrality scores for each individual using UCINET V (Borgatti, Everett, & Freeman, 1992).

Human Capital

For the human capital variables, respondents were asked to indicate their highest obtained educational degree (1=high school, 2=technical certificate,

3=bachelor, 4=master, 5=Ph.D.) as well as their work experience in terms of the number of years they had worked in their competence or a similar one.

Individual Performance Variables

Individual performance is one of the most central and fundamental constructs of organizational behavior; however, measuring it has proven to be a difficult task. While there exist several different approaches, for example subjective measures (e.g., self, peer, and supervisor ratings) and objective measures based on direct measures of countable behaviors or outcomes (e.g., total sales volumes or sales commissions for salespeople), the correlations between the various measures tend to be less than “perfect” (see Bommer, Johnson, Rich, Podsakoff, & MacKenzie (1995) and Harris & Schaubroeck (1988) for a discussion). Researchers have also come to some agreement that perfectly reliable and valid third party performance ratings are unattainable since they are subject to a variety of biases, such as external conditions, the experience of the rater with the job being evaluated, or the ability of the rater to observe the ratee (Borman, 1978; Weekley & Gier, 1989). Thus, there exists no one “best” measure of individual performance.

In our discussions with management regarding to what extent performance measures were possible to collect, it became apparent that supervisor ratings, peer ratings, or other performance measures such as salary would be difficult to obtain due to issues such as employee confidentiality. Accordingly, we opted to measure individual performance via self-reporting measures. However, previous research at Icon supports this choice of self-reported measures since we found that that supervisors and individuals at Icon were in considerable agreement over the degree of individual performance.

Thus, for the purposes of this study we used two different subjective dependent variables that measure individual performance: creative performance and efficient performance. As discussed above, these measures represent the two dimensions of efficiency of integration and flexibility of integration where efficiency is manifested as the ability to meet deadlines and objectives and flexibility is manifested as the ability to develop and implement new ideas, processes, routines. Interestingly, while it may be somewhat difficult to distinguish between these two measures, we do feel that it is important to measure both since it is often difficult to develop solutions that are highly innovative but that also meet objectives and deadlines.

Efficient Performance. Individuals were asked to answer three questions on their ability to meet objectives and deadlines based on a seven-point scale (1=extremely below average to 7= extremely above average) that created an efficiency scale. This scale was adapted from Teigland (2000) and Teigland & Wasko (2003a).

Creative Performance. Individuals were asked to answer four questions that created a creative performance scale. This scale was taken from a larger individual performance measure that has been used considerably to measure innovative performance (Welbourne et al., 1998). The questions were based on a seven-point scale (1=strongly disagree to 7=strongly agree). These items represent creative performance since they incorporate not only the development of new ideas, routines, and processes, but also their implementation.

ANALYSES AND RESULTS

Analyses

We used structural equation modeling to analyze the data for the entire sample as well as for the three task groups: (1) Commercial and Support, (2) System and Software Group, and (3) Design Group. Our first step was to conduct two analyses in order to investigate any possible effects of method variance: principal component analysis and confirmatory factor analysis. First, we subjected all scale items to a principal component analysis using varimax rotation. From this analysis, the expected factors clearly emerged. In addition, the highest cross-loading of any one indicator on another factor was .203. Table 1 provides the means, standard deviations, and correlations of the variables. Second, we used confirmatory factor analysis and created a single factor model in which all our measures loaded onto one factor, a method variance factor. This single-factor model fit the data very poorly, which is described below (Turban & Dougherty, 1994).

Table 1 Means, Standard Deviations, and Correlations^a

Variables	Mean	s.d.	1	2	3	4	5	6	7	8	9	10	11
1.Efficient Performance	5.09	0.84											
2.Creative Performance	5.44	0.82	.36										
3.Internal Codified Sources	2.38	1.39	.05	.07									
4.Comm. w/ Co-located	4.11	0.95	.07	.07	.33								
5.Comm. w/ Non-co-located	1.39	1.42	.07	.13	.38	.24							
6.External Sources	2.74	1.18	.07	.11	.28	.19	.24						
7.Internal Knowledge Exchange	3.19	1.34	.09	.16	.31	.38	.29	.11					
8.External Knowledge Exchange	1.79	1.35	.09	.14	.17	.10	.21	.29	.38				
9.Integration Centrality	18.88	9.16	.06	.07	.21	.23	.29	.10	.21	.05			
10.Education	2.95	1.04	.08	.10	.01	-.04	.00	-.08	.05	.05	.04		
11.Experience	3.03	1.20	.14	.21	.00	-.02	.16	.07	.03	.14	.10	.09	

^aN = 1439. Correlations greater than or equal to .06 are significant at $p < .05$.

We then examined the hypothesized relationships among the use of knowledge sources, knowledge exchange, integration centrality, and individual performance. The use of structural equation modeling facilitates the

simultaneous examination of the relationships and an assessment of the fit of the hypothesized model to the data as well as a test of the individual hypotheses (Turban & Dougherty, 1994). We assessed model fit using several statistics. It is widely accepted that reliance on the chi-square test alone is not recommended due to its sensitivity to sample size, i.e., models that fit the data reasonably well are often rejected due to medium to large sample size in which the test is conducted (Bentler, 1980; Bentler & Bonett, 1980). Thus, we conducted three additional fit tests that are not sensitive to sample size – (1) the non-normed fit index (NNFI, Bentler & Bonett, 1980), (2) the comparative fit index (CFI, Bentler, 1990), and (3) the root mean square error approximation (RMSEA, Steiger, 1990). The CFI is the most highly recommended fit index (Bagozzi & Edwards, 1998) and this fit indicates the relative improvement of the fit of the hypothesized model over the null model, in which all observed variables are specified as uncorrelated. When the hypothesized model is true in the population, these indices have an expected value of 1.00 (Ashford, Rothbard, Piderit, & Dutton, 1998). A value of .90 or higher is suggested to indicate adequate fit (Bentler & Bonett, 1980). The RMSEA is also a widely used fit statistic, providing an estimate of the discrepancy between the original and the reproduced covariance matrices in the population. RMSEA values of .05 are suggested to represent a close fit while values of less than .08 represent a reasonable fit (Cudeck & Brown, 1983; Ashford et al., 1998).

For the entire sample as well as the three subsets, we estimated several models and compared them to the null model as various authors have discussed previously (Turban & Dougherty, 1994). More specifically we estimated the (1) null model that was used as a baseline model, (2) an uncorrelated-latent-variables model in which we loaded the manifest variables onto the latent constructs and no paths were indicated between the latent variables, (3) the theoretical model presented in figure 1, and (4) the modified theoretical model that provided the best fit for the different samples. For the fourth model, we attempted to find the best fit by both dropping paths as well as relaxing some of the assumptions of the theoretical model by adding direct paths between the independent variables and the dependent variables.

Results for Entire Sample

For the entire sample, the complete model with all the hypothesized relationships has a chi-square of 1917 with 358 degrees of freedom, an NNFI of .89, a CFI of .90, and an RMSEA of .055. Due to the RMSEA being over .05, we decided to attempt to achieve a better fit. After dropping a few paths as well as relaxing a few relationships, we obtained a model with a better fit. This best fit model has a chi-square of 1567 with 359 degrees of freedom, an NNFI of .91, a CFI of .92, and an RMSEA of .048. We therefore retained this modified model as the best fitting model. Table 2 provides an overview of the fits of the different models for the entire sample.

Table 2 Overview of SEM Results for Entire Sample

Model	χ^2 (df)	$\Delta \chi^2$ (Δ df)	RMSEA	CFI	NNFI
Null	15 897 (406)	--	.140	.31	.26
Uncorrelated	3 247 (379)	12 650 (27)	.073	.82	.80
Theoretical	1 917 (358)	1 330 (21)	.055	.90	.89
Best Fit	1 557 (357)	360 (1)	.048	.92	.91

We then examined the standardized parameter estimates to determine whether the hypothesized relationships were significant and in the predicted directions. Figure 2 and table 3 provide an overview of the results for the entire sample.

Table 3 Overview of Results from SEM for Entire Sample

	Entire Sample
Hypothesized Relationships	
<i>Efficiency of Integration</i>	
H1a: Use of Internal Codified sources – Efficient Performance	
H1b: Use of Internal Codified Sources – Creative Performance	
H2a: Comm. with Co-loc. Coworkers – Internal Exchange	.46***
H2b: Comm. with Co-loc. Coworkers – Efficient Performance	.13***
H2c: Comm. with Co-loc. Coworkers – Creative Performance	.13***
<i>Internal Flexibility of Integration</i>	
H3: Comm. with Non-co-loc. coworkers – Internal Exchange	
H4: Internal Exchange – Integration Centrality	.14***
H5: Integration Centrality – Creative Performance	.11***
<i>External Flexibility of Integration</i>	
H6: Use of External Knowledge Sources – External Exchange	.34***
H7: External Exchange – Internal Exchange	.27***
<i>Human Capital</i>	
H8a: Education – Efficient Performance	.06*
H8a: Education – Creative Performance	.08*
H8b: Experience – Efficient Performance	.14***
H8b: Experience – Creative Performance	.20***
Non-hypothesized Relationships	
Use of Internal Codified sources – External Exchange	.12***
Comm. with Non-co-loc. Coworkers – Integration Centrality	.60***
Use of External Knowledge Sources – Integration Centrality	-.11***
Model Fit	
χ^2	1557
Df	357
CFI	.92
NNFI	.91
RMSEA	.048

* p < .05

** p < .01

*** p < .001

Efficiency of Integration. Specifically, Hypotheses 1a and 1b, relating the use of internal codified sources to individual performance, receive no support. However, we receive support for Hypothesis 2a relating communication with co-located coworkers positively to internal knowledge exchange since we find a statistically significant parameter estimate for this relationship ($b = .46, p < .001$). Hypotheses 2b and 2c relate communication with co-located coworkers positively to efficient performance (2b) and negatively to creative performance (2c). We find a statistically significant parameter estimate for efficient performance (2b; $b = .13, p < .001$) and creative performance (2c; $b = .13, p < .001$). However, *the parameter estimate for creative performance is in the opposite direction than predicted* – a positive instead of a negative relationship.

Internal Flexibility of Integration. We find a statistically significant parameter estimate for the path between communication with non-co-located coworkers and internal knowledge exchange ($b = .09, p < .01$), indicating support for Hypothesis 3. Hypothesis 4 is supported since we find a statistically significant parameter estimate for the relationship between internal knowledge exchange and integration centrality ($b = .14, p < .001$). Hypothesis 5 relates integration centrality to individual creative performance, and we find support for this hypothesis ($b = .11, p < .001$), indicating that individuals with a higher level of integration centrality have higher reported levels of creative performance.

External Flexibility of Integration. Respondents who use external knowledge sources to a high degree report higher levels of external knowledge exchange, providing support for Hypothesis 6 ($b = .34, p < .001$). Individuals who report higher levels of external knowledge exchange also report higher levels of internal knowledge exchange, providing support for Hypothesis 7 ($b = .27, p < .001$).

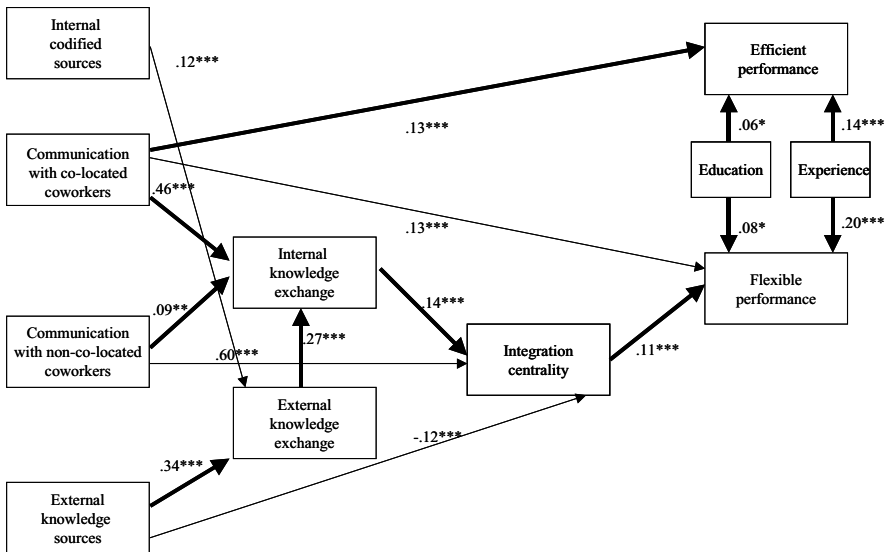
Human Capital. Finally, in support of Hypotheses 8a and 8b, we find statistically significant parameter estimates for the relationships between education and experience with individual performance – education to efficient performance (H8a; $b = .06, p < .05$), education to creative performance (H8a; $b = .08, p < .05$), experience to efficient performance (H8b; $b = .14, p < .001$), and experience to creative performance (H8b; $b = .20, p < .001$).

Best Fit. In addition, although not hypothesized, we find three other significant path estimates. First, a significant parameter estimate is found for the relationship between communication with non-co-located coworkers and integration centrality ($b = .60, p < .001$). Second, we find a negatively significant parameter estimate between external knowledge sources and integration centrality ($b = -.12, p < .001$). Third, results provide a statistically significant parameter estimate for the path between internal codified sources and external knowledge exchange ($b = .12, p < .001$).

Results for Commercial and Support Group

For the Commercial and Support Group (CSG), the complete model with all the hypothesized relationships has a chi-square of 1021 with 358 degrees of freedom, an NNFI of .88, a CFI of .89, and an RMSEA of .054. Since all the fit measures were not above the accepted rate for an adequate fit, we decided to attempt to achieve a better fit. After dropping a few paths as well as relaxing a few relationships, we achieved a model with a chi-square of 902 with 334 degrees of freedom, an NNFI of .90, a CFI of .92, and an RMSEA of .049. We therefore retained this modified model as the best fitting model. Table 4 provides an overview of the fits of the different models for the Commercial and Support Group.

Figure 2 Results of Structural Equation Model for Entire Sample – Best Fit^a



^aFit: $\chi^2 = 1557, df = 357; NNFI = .91, CFI = .92, RMSEA = .048$. Only statistically significant paths are shown. Hypothesized relationships are represented by bold arrows, and relationships that were not hypothesized are represented by light arrows. Hypothesized paths that were not significant were eliminated from the model.

Table 4 Overview of SEM Results for CSG

Model	χ^2 (df)	$\Delta \chi^2$ (Δ df)	RMSEA	CFI	NNFI
Null	7 165 (406)	--	.131	.33	.28
Uncorrelated	1 674 (379)	5 491 (27)	.069	.84	.83
Theoretical	1 091 (358)	583 (21)	.054	.89	.88
Best fit	902 (334)	189 (24)	.049	.92	.90

Looking at the standardized parameter estimates to determine which hypothesized relationships were significant and in the predicted directions, we find a different set of results than for the entire sample. Figure 3 and table 5 provide an overview of the results.

Table 5 Overview of Results from SEM for CSG

	Commercial and Support Group
Hypothesized Relationships	
<i>Efficiency of Integration</i>	
H1a: Use of Internal Codified Sources – Efficient Performance	
H1b: Use of Internal Codified Sources – Creative Performance	
H2a: Comm. with Co-loc. Coworkers – Internal Exchange	.28**
H2b: Comm. with Co-loc. Coworkers – Efficient Performance	
H2c: Comm. with Co-loc. Coworkers – Creative Performance	
<i>Internal Flexibility of Integration</i>	
H3: Comm. with Non-co-loc. Coworkers – Internal Exchange	
H4: Internal Exchange – Integration Centrality	.14**
H5: Integration Centrality – Creative Performance	.15***
<i>External Flexibility of Integration</i>	
H6: Use of External Knowledge Sources – External Exchange	.40***
H7: External Exchange – Internal Exchange	.33***
<i>Human Capital</i>	
H8a: Education – Efficient Performance	
H8a: Education – Creative Performance	
H8b: Experience – Efficient Performance	.13**
H8b: Experience – Creative Performance	.17***
Non-hypothesized Relationships	
Use of Internal Codified Sources – Internal Exchange	.14***
Comm. with Non-co-loc. Coworkers – Integration Centrality	.48***
Use of External Knowledge Sources – Integration Centrality	-.20***
Model Fit	
χ^2	902
Df	334
CFI	.92
NNFI	.90
RMSEA	.049

* p < .05

** p < .01

*** p < .001

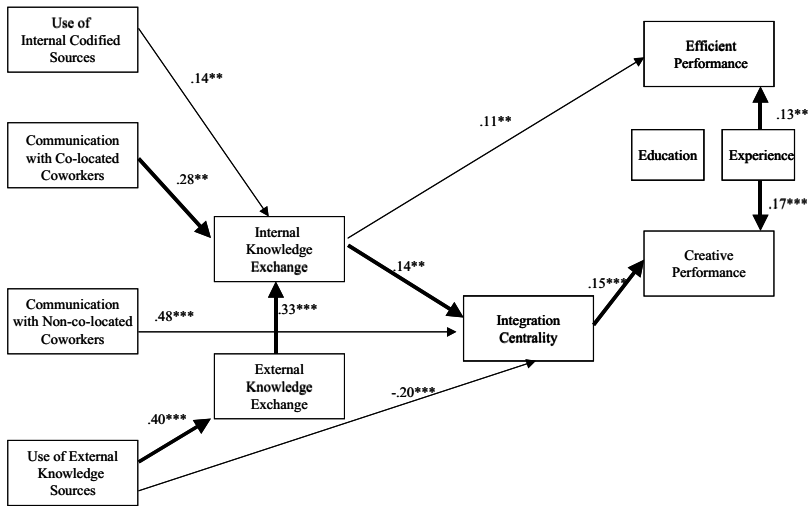
Efficiency of Integration. Specifically, Hypotheses 1a and 1b, relating internal codified sources to individual performance, receive no support. Hypothesis 2a positively relates communication with co-located coworkers to internal knowledge exchange, and a statistically significant parameter estimate is found for this relationship ($b = .28, p < .001$). Hypotheses 2b and 2c relate communication with co-located coworkers positively to efficient performance (2b) and negatively to creative performance (2c). However, no support is found for these relationships.

Internal and External Flexibility of Integration. No statistically significant parameter estimate is found for the path between communication with non-co-located coworkers and internal knowledge exchange, providing no support for Hypothesis 3. Hypothesis 4 is supported since we find a statistically significant parameter estimate for the relationship between internal knowledge exchange and integration centrality ($b = .14, p < .001$). Hypothesis 5 relates integration centrality to individual creative performance, and we find support for this hypothesis ($b = .15, p < .001$), indicating that individuals with a higher level of integration centrality have higher reported levels of creative performance. We find support for the relationship between external knowledge sources and external knowledge exchange, Hypothesis 6 ($b = .40, p < .001$). Respondents who report higher levels of external knowledge exchange also report higher levels of internal knowledge exchange, providing support for Hypothesis 7 ($b = .33, p < .001$).

Human Capital. Finally, for Hypotheses 8a and 8b, we find statistically significant parameter estimates for the relationships between experience and individual performance – experience to efficient performance (8b; $b = .13, p < .01$), and experience to creative performance (8b; $b = .17, p < .001$). However, we find no significant relationship between education and either efficient or creative performance

Best Fit. As for the relationships that were not hypothesized, we find three other significant path estimates. First, the path between internal codified sources and internal knowledge exchange is statistically significant ($b = .14, p < .01$). Thus, those individuals in the periphery who use internal codified sources to a higher degree also report higher levels of internal knowledge exchange. Second, a significant parameter estimate is found for the relationship between communication with non-co-located coworkers and integration centrality ($b = .48, p < .001$). Third, we find a negatively significant parameter estimate between external knowledge sources and integration centrality ($b = -.20, p < .001$).

Figure 3 Results of SEM for Commercial and Support -Best Fit^a



^aFit: $\chi^2 = 902$, $df = 334$; NNFI = .90, CFI = .92, RMSEA = .049. Only statistically significant paths are shown. Hypothesized relationships are represented by bold arrows, and relationships that were not hypothesized are represented by light arrows. Hypothesized paths that were not significant were eliminated from the model.

Results for System and Software Group

For the System and Software Group (SSW), the complete model with all the hypothesized relationships has a chi-square of 821 with 358 degrees of freedom, an NNFI of .90, a CFI of .91, and an RMSEA of .054. Since the RMSEA is over .05, we decided to attempt to achieve a better fit. After dropping a few paths as well as relaxing a few relationships, we achieved a model with a chi-square of 745 with 335 degrees of freedom, an NNFI of .91, a CFI of .92, and an RMSEA of .052. While the RMSEA is over 0.5, the other measures indicate a marginally adequate fit. We therefore retained this modified model as the best fitting model. Table 6 provides an overview of the fits of the different models for the System and Software Group.

Table 6 Overview of SEM Results for System and Software Group

Model	χ^2 (df)	$\Delta \chi^2$ (Δ df)	RMSEA	CFI	NNFI
Null	5417 (406)	--	.148	0.26	0.20
Uncorrelated	1192 (379)	4 225 (27)	.069	0.84	0.83
Theoretical	821 (358)	371 (21)	.054	0.91	0.90
Best fit	745 (335)	76 (23)	.052	0.92	0.91

Looking at the standardized parameter estimates to determine which hypothesized relationships were significant and in the predicted directions, we find yet another set of results. Figure 4 and table 7 provide an overview of the results.

Table 7 Overview of Results from SEM for SSW

	SSW Group
Hypothesized Relationships	
<i>Efficiency of Integration</i>	
H1a: Use of Internal Codified Sources – Efficient Performance	
H1b: Use of Internal Codified Sources – Creative Performance	-.13*
H2a: Comm. with Co-loc. Coworkers – Internal Exchange	.58***
H2b: Comm. with Co-loc. Coworkers – Efficient Performance	
H2c: Comm. with Co-loc. Coworkers – Creative Performance	
<i>Internal Flexibility of Integration</i>	
H3: Comm. with Non-co-loc. Coworkers – Internal Exchange	.13*
H4: Internal Exchange – Integration Centrality	.37***
H5: Integration Centrality – Creative Performance	
<i>External Flexibility of Integration</i>	
H6: Use of External Knowledge Sources – External Exchange	.18***
H7: External Exchange – Internal Exchange	.19***
<i>Human Capital</i>	
H8a: Education – Efficient Performance	
H8a: Education – Creative Performance	
H8b: Experience – Efficient Performance	.12*
H8b: Experience – Creative Performance	.24***
Non-hypothesized Relationships	
Use of External Knowledge Sources – Integration Centrality	.26**
Model Fit	
χ^2	745
df	335
CFI	.92
NNFI	.91
RMSEA	.052

* p < .05

** p < .01

*** p < .001

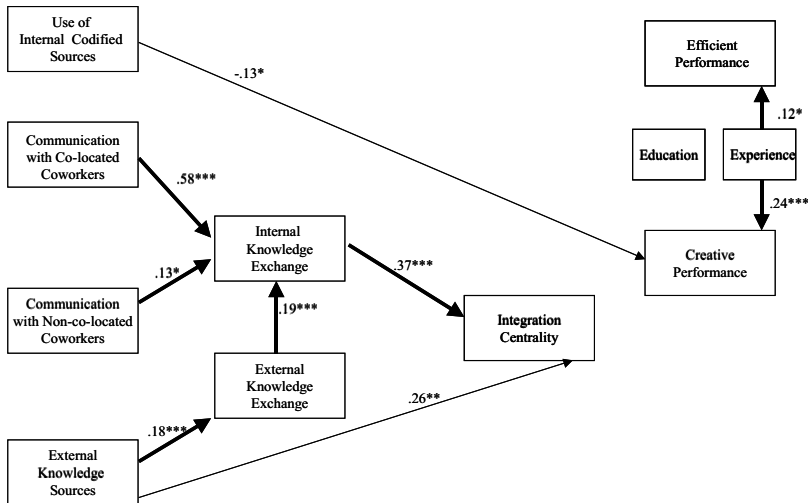
Efficiency of Integration. Specifically, Hypothesis 1a, relating internal codified sources to efficient performance, is refuted. A significant path relating internal codified sources to creative performance is found. However, the direction is a negative one and not a positive one as hypothesized ($b = .13, p < .05$). Thus, individuals in the System and Software Group who use internal codified sources to a higher degree report significantly lower levels of creative performance. Hypothesis 2a positively relates communication with co-located coworkers to internal knowledge exchange, and a statistically significant parameter estimate is found for this relationship ($b = .58, p < .001$). Hypotheses 2b and 2c relate communication with co-located coworkers positively to efficient performance (2b) and negatively to creative performance (2c). However, no support is found for either of these relationships.

Internal and External Flexibility of Integration. Support is found for Hypothesis 3 since a statistically significant parameter estimate is found for the path between communication with non-co-located coworkers and internal knowledge exchange ($b = .13, p < .05$). Hypothesis 4 is supported since we find a statistically significant parameter estimate for the relationship between internal knowledge exchange and integration centrality ($b = .37, p < .001$). Hypothesis 5 relates integration centrality to individual creative performance, but the results failed to support this path. We find support for Hypothesis 6, the relationship between external knowledge sources and external knowledge exchange ($b = .18, p < .001$). Respondents who report higher levels of external knowledge exchange also report higher levels of internal knowledge exchange, providing support for Hypothesis 7 ($b = .19, p < .001$).

Human Capital. Finally, for Hypotheses 8a and 8b, we find statistically significant parameter estimates for the relationships between experience and individual performance – experience to efficient performance (8a; $b = .12, p < .01$), and experience to creative performance (8b; $b = .24, p < .001$). However, we find no significant relationship between education and either efficient or creative performance

Best Fit. As for the relationships that were not hypothesized, we find one other significant path estimate. A significant parameter estimate is found for the relationship between external knowledge sources and integration centrality ($b = .26, p < .01$). Thus, individuals in the System and Software Group who use external knowledge sources to a higher degree are found to have higher levels of integration centrality.

Figure 4 Results of SEM for System and Software Group – Best Fit^a



^aFit: $\chi^2 = 745$, $df = 335$; NNFI = .91, CFI = .92, RMSEA = .052. Only statistically significant paths are shown. Hypothesized relationships are represented by bold arrows, and relationships that were not hypothesized are represented by light arrows. Hypothesized paths that were not significant were eliminated from the model

Results for Design Group

For the Design Group, the complete model with all the hypothesized relationships has a chi-square of 611 with 358 degrees of freedom, an NNFI of .90, a CFI of .91, and an RMSEA of .050. Since the model fit measures could be considered to be marginal, we decided to attempt to achieve a better fit. After dropping a few paths as well as relaxing a few relationships, we achieved a model with a chi-square of 546 with 335 degrees of freedom, an NNFI of .92, a CFI of .92, and an RMSEA of .047. We therefore retained this modified model as the best fitting model. Table 8 provides an overview of the fits of the different models for the Design Group.

Table 8 Overview of SEM Results for Design Group

Model	χ^2 (df)	$\Delta \chi^2$ (Δ df)	RMSEA	CFI	NNFI
Null	3215 (406)	--	.136	.24	.29
Uncorrelated	811 (379)	2 404 (27)	.060	.85	.84
Theoretical	611 (358)	200 (21)	.050	.91	.90
Best fit	546 (335)	65 (23)	.047	.92	.92

Looking at the standardized parameter estimates to determine which hypothesized relationships were significant and in the predicted directions, we find a fourth set of results. Figure 8 and table 9 provide an overview of the results.

Table 9 Overview of Results from SEM for Design Group

	Design Group
Hypothesized Relationships	
<i>Efficiency of Integration</i>	
H1a: Use of Internal Codified Sources – Efficient Performance	
H1b: Use of Internal Codified Sources – Creative Performance	
H2a: Comm. with Co-loc. Coworkers – Internal Exchange	.36***
H2b: Comm. with Co-loc. Coworkers – Efficient Performance	.20**
H2c: Comm. with Co-loc. Coworkers – Creative Performance	.23**
<i>Internal Flexibility of Integration</i>	
H3: Comm. with Non-co-loc. Coworkers – Internal Exchange	
H4: Internal Exchange – Integration Centrality	
H5: Integration Centrality – Creative Performance	
<i>External Flexibility of Integration</i>	
H6: Use of External Knowledge Sources – External Exchange	.32***
H7: External Exchange – Internal Exchange	.37***
<i>Human Capital</i>	
H8a: Education – Efficient Performance	
H8a: Education – Creative Performance	
H8b: Experience – Efficient Performance	.18**
H8b: Experience – Creative Performance	.19**
Non-hypothesized Relationships	
Use of Internal Codified Sources – Internal Exchange	
Use of Internal Codified Sources – External Exchange	
Use of Internal Codified Sources – Integration Centrality	.23**
Comm. with Non-co-loc. Coworkers – Integration Centrality	
Internal Exchange – Creative Performance	.19*
Use of External Knowledge Sources – Integration Centrality	
Model Fit	
χ^2	546
Df	335
CFI	.92
NNFI	.92
RMSEA	.047

* p < .05

** p < .01

*** p < .001

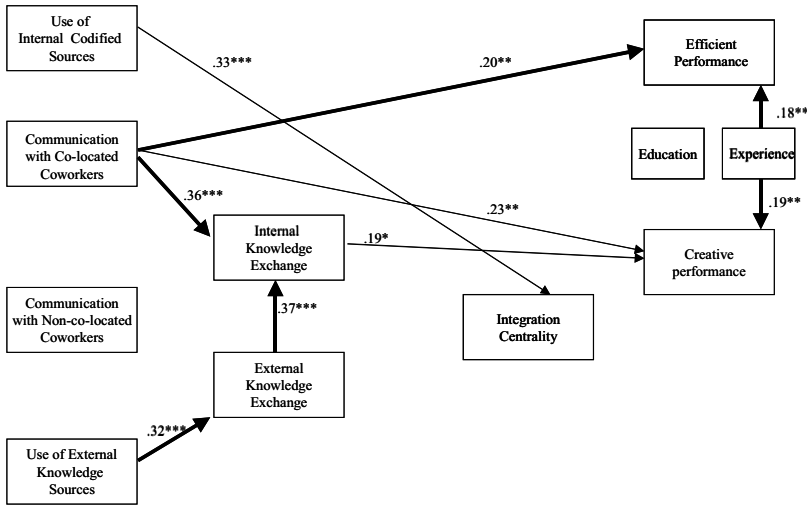
Efficiency of Integration. Specifically, the results fail to provide support for Hypotheses 1a and 1b, relating internal codified sources to individual performance. Hypothesis 2a positively relates communication with co-located coworkers to internal knowledge exchange, and a statistically significant parameter estimate is found for this relationship ($b = .36, p < .001$). Hypotheses 2b and 2c relate communication with co-located coworkers positively to efficient performance (2b) and negatively to creative performance (2c), and this time statistically significant parameter estimates for both of these hypothesized relationships are found. A positive relationship is found between communication with co-located coworkers and efficient performance ($b = .20, p < .01$). The path between communication with co-located coworkers and creative performance is also statistically significant. However, it is in the opposite direction than predicted ($b = .23, p < .01$). Thus, individuals who communicate to a higher degree with their co-located coworkers also report higher levels of creative performance.

Internal and External Flexibility of Integration. No support is found for Hypothesis 3, the path between communication with non-co-located coworkers and internal knowledge exchange, nor for Hypothesis 4, the path between internal knowledge exchange and integration centrality. In the same vein, results fail to support Hypothesis 5, relating integration centrality to individual creative performance. Hypothesis 6, the relationship between external knowledge sources and external knowledge exchange, receives support ($b = .32, p < .001$). Respondents who report higher levels of external knowledge exchange also report higher levels of internal knowledge exchange, providing support for Hypothesis 7 ($b = .37, p < .001$).

Human Capital. Finally, for Hypotheses 8a and 8b, we find statistically significant parameter estimates for the relationships between experience and individual performance – experience to efficient performance (8b; $b = .18, p < .01$), and experience to creative performance (8b; $b = .19, p < .001$). However, we find no significant relationship between education and either efficient or creative performance

Best Fit. As for the relationships that were not hypothesized, we find two other significant path estimates. First, a significant parameter estimate is found for the relationship between internal codified sources and integration centrality ($b = .33, p < .001$). Thus, individuals in the Design Group who use internal codified sources to a higher degree are also found to have higher levels of integration centrality. Second, a statistically significant relationship is found between internal knowledge exchange and creative performance ($b = .19, p < .05$).

Figure 8 Results of SEM on Design Group - Best Fit^a



^aFit: $\chi^2 = 546$, $df = 335$; NNFI = .92, CFI = .92, RMSEA = .047. Only statistically significant paths are shown. Hypothesized relationships are represented by bold arrows, and relationships that were not hypothesized are represented by light arrows. Hypothesized paths that were not significant were eliminated from the model.

DISCUSSION AND IMPLICATIONS

Results for the Entire Sample

An overview of the significant hypothesized relationships as well as those that were not hypothesized is presented in table 10. While we do not find any support for the hypotheses relating to the use of internal codified sources, we do find strong or moderate support for several of the hypotheses involving the use of internal interpersonal communication sources, the use of external knowledge sources, as well as the two human capital variables of education and experience. What is also interesting is the fact that we see such different results for each dependent performance variable as well as for each of the three task groups.

Table 10 Overview of Results from Structural Equation Modeling

	Entire Sample	Comm. &Supp.	SSW	Design
Hypothesized Relationships				
<i>Efficiency of Integration</i>				
H1a: Use of Internal Codified Sources – Efficient Performance				
H1b: Use of Internal Codified Sources – Creative Performance			-.13*	
H2a: Comm. with Co-loc. Coworkers – Internal Exchange	.46***	.28**	.58***	.36***
H2b: Comm. with Co-loc. Coworkers – Efficient Performance	.13***			.20**
H2c: Comm. with Co-loc. Coworkers – Creative Performance	.13***			.23**
<i>Internal Flexibility of Integration</i>				
H3: Comm. with Non-co-loc. Coworkers – Internal Exchange			.13*	
H4: Internal Exchange – Integration Centrality	.14***	.14**	.37***	
H5: Integration Centrality – Creative Performance	.11***	.15***		
<i>External Flexibility of Integration</i>				
H6: Use of External Knowledge Sources – External Exchange	.34***	.40***	.18***	.32***
H7: External Exchange – Internal Exchange	.27***	.33***	.19***	.37***
<i>Human Capital</i>				
H8a: Education – Efficient Performance	.06*			
H8a: Education – Creative Performance	.08*			
H8b: Experience – Efficient Performance	.14***	.13**	.12*	.18**
H8b: Experience – Creative Performance	.20***	.17***	.24***	.19**
Non-hypothesized Relationships				
Use of Internal Codified Sources – Internal Exchange		.14***		
Use of Internal Codified Sources – External Exchange	.12***			
Use of Internal Codified Sources – Integration Centrality				.23**
Comm. with Non-co-loc. Coworkers–Integration Centrality	.60***	.48***		
Internal Exchange – Creative Performance				.19*
Use of External Knowledge Sources –Integration Centrality	-.11***	-.20***	.26**	
Model Fit				
χ^2	1557	902	745	546
Df	357	334	335	335
CFI	.92	.92	.92	.92
NNFI	.91	.90	.91	.92
RMSEA	.048	.049	.052	.047

* p < .05

** p < .01

*** p < .001

Efficiency of Integration. Looking at internal codified sources, we do not find any significant relationship between the use of these and performance for the sample as a whole. Previous research at Icon has shown that when choosing to use a codified source, some individuals at Icon prefer to go outside the firm, and that they find external sources to be more helpful than internal ones (Teigland, 2000). This is despite management having spent considerable resources in building a company intranet. One reason may be due to the quick pace of development of the industry within which Icon is located. Employees may feel that the internal knowledge is “old”, thus it could not help with “new” problems. As interviews in the pilot study revealed, knowledge and solutions developed for use in projects could already be out of date within six months of their development, thus rendering them useless. However, we would argue that there is still a lot of process knowledge such as project management knowledge that could be developed and codified for further reuse internally. This is perhaps reflected in the relatively higher use of internal codified sources by individuals in the Commercial and Support Group than individuals in either the SSW or Design Groups.

If we then look at interpersonal communication, we see the level of communication with co-located coworkers as a predictor of efficient performance. This is in keeping with our *a priori* expectations. A high degree of internal personal interaction with other members of one’s communities of practice who share the same language should be a highly efficient source of knowledge. However, we did not expect to find a positive relationship between communication with co-located coworkers and creative performance. Based on previous research (Teigland & Wasko, 2003a), we had predicted a negative relationship since it is expected that the knowledge of an individual’s local coworkers is largely redundant, thus hampering the creation of new ideas through flexible knowledge integration. One explanation for our present finding may be due to the difference between the two studies. In Teigland & Wasko (2003a), the group of co-located coworkers is characterized by one functional discipline, software programming. Thus, when one individual discusses with other co-located individuals, they tend to share the same functional competence. However, in the Icon study, due to the organization of the company as described above, the group of co-located individuals comprises several functional disciplines. Interviews also revealed that communities of practice could contain a variety of functions as well. In our study, we measure communication with co-located coworkers as based on communication both with those in the same competence as well as with those in another competence. Thus, the more an individual communicates with co-located coworkers, the more likely that these other individuals may be from several disciplines and that his or her communities of practice comprise multiple disciplines. Since flexible integration involves new patterns of integrating existing knowledge, the ability to achieve this through combining different

bodies of functional knowledge is increased the more an individual communicates with individuals from a variety of functional areas, which then may impact creative performance.

A second explanation may lie in the definition of creative performance. As discussed above, flexible integration is not only developing new ideas and processes through the recombination of knowledge, but it also entails putting these new ideas and processes into action. A good new idea is only worth something to the firm if results can be achieved from its implementation. The implementation of new ideas and processes may be dependent upon the ability of an individual to understand how to recombine knowledge for application in a local context, which an individual may only develop through a high level of interaction with co-located coworkers. Previous research by the author merely looked at creativity or the development of new ideas without considering whether these new ideas were implemented (Teigland & Wasko, 2003a), while this research takes into account both angles as is called for by the definition of the flexibility of integration.

Internal Flexibility of Integration. Additionally, we find support for the relationship between integration centrality and creative performance. Thus, our results suggest that efficient performance is dependent upon the ability of an individual to reuse *existing local* knowledge without having to tap into the firm's global knowledge base. However, a higher level of creative performance is partially dependent upon an individual's position in the firm, indicating that flexible knowledge integration is the result of the recombination of knowledge found throughout the firm's geographically dispersed locations. In terms of the drivers of integration centrality, we do find the expected positive relationships between internal knowledge exchange and integration centrality. For co-located individuals, participation in the mutual engagement of sharing and receiving knowledge leads to integration centrality in the firm as a whole. This supports community of practice theory that argues that movement into a central position within a community is dependent upon mutual engagement between the individual and others in the community and that this movement is jointly determined.

However, we also find a *direct* relationship between communication with non-co-located coworkers and integration centrality. This finding is unexpected since we argued that internal knowledge exchange would fully mediate this relationship. Our findings indicate that a central position in the multinational's networks of practice is only partially dependent upon an individual's participation in exchange relationships of sharing and receiving knowledge with others both locally as well as in other locations. In this study, interactions with non-co-located coworkers are not dependent upon exchange relationships to the same degree as interactions with co-located coworkers. Once local organizational boundaries are crossed and interactions occur

primarily through electronic communication channels, mutual engagement expressed in terms of knowledge exchange between geographically dispersed individuals is no longer as important in predicting integration centrality. Thus, we may conclude that for this multinational, norms of mutual engagement are not as strong in non-face-to-face relationships as for relationships based upon face-to-face relationships as a determinant of integration centrality. This finding then suggests that communities of practice and distributed networks of practice may exhibit different norms of behavior.

External Flexibility of Integration. Turning to external integrative flexibility and the use of external knowledge sources, our results support our hypotheses. The use of external knowledge sources does not have a direct impact on an individual's performance. Rather it affects creative performance indirectly through its influence on internal knowledge exchange and integration centrality. In addition to the hypothesized relationships, we also find a *direct negative* relationship between the use of external knowledge sources and centrality. Thus, those individuals who merely use external knowledge sources to a high degree but do not integrate this knowledge with that of others through internal knowledge exchange remain on the outskirts of the firm and by implication achieve lower levels of creative performance. These findings support our previous research (Teigland & Wasko, 2003b). In new-media companies such as Icon, employees are able to communicate across external organizational boundaries with others working on similar problems and as a result, access new knowledge and ideas. Knowledge coming from outside the firm may be so novel that it cannot be applied to any immediate solution without being placed within the context of the firm. Application is then facilitated through a high degree of personal interaction with co-located as well as non-co-located coworkers. Knowledge is disseminated to others as well as recombined with the firm's knowledge in order to adapt this external knowledge to the firm's specific use. Thus, the ability to develop and implement new solutions and improve performance may involve combining existing internal knowledge with novel external knowledge.

Results for the Three Task Groups

In addition to these findings, what also stand out are the differences in patterns for the three group of individuals based on work-related tasks. One of the main differences across these groups is the use of internal codified sources and the relationship of the use of these with knowledge exchange, integration centrality, and performance. These underlying patterns may also partially explain the reason as to why we find no relationship to internal codified sources for the sample as a whole.

Commercial and Support Group

If we look first at the Commercial and Support Group, one primary difference is that there is no direct relationship between communication with co-located coworkers and either creative or efficient performance as predicted and found for the sample as a whole. The relationship to efficient performance is mediated by internal knowledge exchange and the relationship to creative performance is mediated through internal knowledge exchange and integration centrality. In addition, the use of internal codified knowledge sources is of considerable importance for this group. Internal codified sources have a direct positive relationship to internal knowledge exchange while internal knowledge exchange has a direct positive relationship to efficient performance. For this group, efficient solutions could best be achieved by reusing existing solutions that were accessed through the firm's intranet and documents as opposed to "reinventing the wheel" through developing one's own solution. Exchanging knowledge with one's local coworkers makes it easier to find appropriate solutions.

However, the Commercial and Support Group also exhibits a different pattern for creative performance. Creative performance is solely dependent upon an individual's integration centrality, which is in turn predicted by communication with non-co-located coworkers as well as internal knowledge trading with one's co-located coworkers. In addition, the use of informal external knowledge sources also plays a significant role in integration centrality. Individuals who only use external knowledge sources do not move into central positions due to the negative relationship between the use of these external sources and integration centrality. However, individuals who exchange knowledge to a high degree both internally and externally are central individuals. Thus, new solutions and processes are created and implemented through the combination of local internal knowledge with external knowledge and may be facilitated by the access to timely strategic knowledge found through communication with non-co-located coworkers.

Design Group

Looking at the Design Group, the use of internal codified sources is again important for this group, as exhibited by the direct, positive relationship between the use of internal codified sources and integration centrality. Moreover, communication with non-co-located coworkers does not have a significant relationship with any of the other model constructs. This group appears to rely more on the codification of their knowledge than on interpersonal communication with non-co-located coworkers to transfer knowledge between units. Additionally, centrality does not mediate the relationship between internal knowledge exchange and creative performance as hypothesized. Rather there is a direct relationship between internal knowledge exchange and creative performance. As with the entire sample, creative

performance is also dependent upon the use of external knowledge sources as mediated through external and internal knowledge trading.

One explanation for these findings is that individual performance for the Design Group is much more dependent upon the ability to meet local market demands. Creating successful front-end internet solutions is dependent upon how end users behave when using information technology. Usage of the internet has been found to differ across national cultures, thus this might limit the degree to which solutions developed in one unit of the multinational may be transferred to another multinational in the firm. Thus, what may be more important for creative performance than accessing knowledge from other units is the use of local external sources to gather knowledge and then the recombination of this external knowledge with local internal knowledge through internal knowledge trading with co-located coworkers. Integration centrality in the firm as a whole is dependent upon the use of internal codified sources. However, we do not find a negative relationship between the use of external knowledge sources and integration centrality as we do with the entire sample. Individuals in the Design Group who are more central in terms of knowledge integration for the multinational are not those who exhibit a higher level of creative performance. Thus, while they may be useful in terms of knowledge transfer within the organization, this is not a necessary condition for higher performance.

System and Software Group

As for the System and Software Group, this group is in strong contrast to the other two groups of employees in this organization. This group shows a very high degree of dependency on external sources of knowledge and in particular codified knowledge sources. While for the entire sample as a whole, we find a negative relationship between the use of external knowledge sources and integration centrality, this relationship is positive for the System and Software Group. In addition, the use of internal codified sources is related to a lower degree of creative performance.

One explanation for this finding may be linked to the nature of the system and software development field. The pace of change may be so fast within this field that in order for individuals to keep pace with development, they must rely to a high degree on the use of external knowledge sources. Knowledge within the firm may quickly become out of date and the reuse of this "old" knowledge may hamper the ability to develop and implement new solutions and processes. In addition, system and software engineering and design have been argued to be similar to traditional R&D (Hauptman, 1986), which is characterized by a universal language (Allen, Tushman & Lee, 1979). This universal language enables communication across a firm's organizational boundaries, facilitating the acquisition and transmission of knowledge through a codified, textual means with individuals outside of the firm. As a result,

external knowledge used by the System and Software Group may not need to be absorbed through the combination with internal knowledge through knowledge exchange to the same degree as the knowledge used by the Commercial and Support and Design Groups, thus resulting in the direct *positive* relationship between the use of external sources and integration centrality.

Additionally, we find no direct relationship between communication with non-co-located coworkers and integration centrality. Rather this relationship is mediated by internal knowledge exchange. Thus, for this group, a different set of norms may be prevalent for non-face-to-face relationships than for the other groups. Again this may be due to the universal nature of the knowledge used as well as the ability to transfer knowledge through codified sources by technically oriented individuals.

Implications for Theory

We find that high-performing flexible individuals are those who trade knowledge to a high degree with individuals both within the firm as well as outside of the firm in their networks of practice. This activity leads to their being central within the multinational as a whole and thus their ability to combine and recombine knowledge that is geographically dispersed across the firm. However, high performing efficient individuals are those who merely rely on communication with co-located coworkers. Our findings thus raise a number of very interesting theoretical issues.

Knowledge-based View of the Firm and Knowledge Integration

These results have further enriched our view of a firm's knowledge integration processes and provide insight into how firms may create structures that balance efficient and flexible knowledge integration among individuals. We find that individuals throughout the firm perform various knowledge integration activities through participation in networks of emergent relationships and that an individual's activities are related to individual performance. Relying primarily on local knowledge sources may result in higher efficient performance due to the ability to effectively share tacit knowledge while creative performance is related to the ability to recombine knowledge from different competencies as well as the ability to access non-redundant knowledge from across and outside the organization. However, these patterns are contingent upon the task that the individual performs.

Our findings suggest that theories of knowledge integration need to be further developed by incorporating a dimension of cooperation. Grant's theory assumes that individuals are willing to share knowledge with each other without expecting anything in return. In Hansen's perspective, units search for and then receive knowledge from other units through knowledge search and transfer processes. However, our research shows that knowledge flows at the

individual level are not unidirectional as in knowledge transfer. Rather knowledge exchange is a key element of knowledge integration – individuals not only search for and receive knowledge from others but they are integral as providers of knowledge to others as well. Individuals mutually engage with each other in reciprocal knowledge sharing actions. This exchange then leads to the combination and recombination of knowledge within the firm to enhance flexible knowledge integration.

In addition, our research has implications for the boundaries of the firm. The traditional view of organization design proposed that interactions with the environment take place through formal inter-organizational relations or through formal boundary spanning roles. However, our results indicate that individuals are embedded not only in intra-organizational networks of practice, but they are also embedded in networks of practice that extend across the multinational's legal boundaries. Individuals regardless of hierarchical level and task rely to a high degree on their informal external contacts for advice and knowledge in solving their everyday work tasks. This implies that the boundaries of the firm are porous as individuals have access to advice and the latest knowledge within their practice through participation in inter-organizational networks of practice. In the process, individuals access external knowledge and combine it with internal knowledge through internal knowledge exchange.

Our findings also support taking a differentiated view of firms over a unitary one. By moving the level of analysis down to the individual, we find that imposing one view of knowledge integration on an organization masks possible intra-organizational heterogeneity. If we had merely looked at performance in general or at the multinational as a whole, differences in patterns of relationships across the groups of employees as defined by their tasks as well as the relationship between these patterns and the two dimensions of performance would not have been revealed. Our findings provide support then for taking into consideration differences in the knowledge bases of firms. Applying generic theories of knowledge integration across all firms may not be possible, rather the appropriate one may be contingent upon the underlying knowledge bases within the firm.

Theories of the Multinational

Looking at the multinational, our findings support Hansen's work (1996) and suggest that theories of the multinational structure, such as the M-form (Chandler, 1962; Williamson, 1975), may be complemented with theories of knowledge integration. At the local unit level, there are face-to-face communities of practice. However, individuals within these local communities are also members of networks of practice that span the multinational's intra-organizational boundaries. These individuals serve as bridges between the local communities, exchanging and transferring knowledge between them through these emergent relationships. In addition, individuals are also

members of *inter-organizational* networks of practice that tie together individuals from a variety of external organizations. Our findings suggest that the multinational integrates the diverse, specialized knowledge of individuals throughout the multinational as well as accesses and integrates the knowledge of individuals external to the firm. The multinational serves as a vehicle for the storage of codified and tacit knowledge relating to how to integrate the different bodies of specialized knowledge within the firm in order to ensure the continuous *efficient* integration of knowledge. In addition, this storage of knowledge relates to how the firm creates new knowledge through the recombination of existing internal knowledge as well as through the access and combination of external knowledge with existing internal knowledge, ensuring the *flexible* integration of knowledge.

Additionally, our findings provide preliminary evidence that within the multinational's emergent networks, there are central individuals who are critical to the firm's ability to create sustainable competitive advantage. These central individuals are key individuals in the efficient and flexible knowledge integration processes of the firm since they influence both the organization's informal knowledge flows between units and the knowledge integration processes of other individuals. These individuals may provide their own knowledge or provide pointers to relevant experts in the firm or even outside the firm when others from across the multinational come to them for help. As such, they may be one of the primary determinants of the direction of the firm's knowledge development.

Networks of Practice

In terms of the network of practice literature, our results suggest that the relationship between participation in various networks of practice and individual performance is not only contingent upon the strength of the tie but also upon the redundancy of the knowledge in the network. Our findings suggest that the strong ties of communities of practice have a positive impact on members' *efficient* performance. Building on previous research (Teigland & Wasko, 2002), we argue that the redundancy of the knowledge within a community of practice in terms of functional competencies impacts members' *creative* performance. Thus, the more a community of practice is characterized by a diversity of functional competencies, the more likely that this community of practice is able to develop more creative solutions through the recombination of these diverse competencies. However, for communities of practice characterized by the same functional competency, the more likely this community of practice may turn into a competency trap or core rigidity (Levitt & March, 1988; Leonard-Barton, 1992) unless members of this community of practice also participate in distributed or electronic networks of practice in which they may access knowledge that is non-redundant.

Similar to implications for the knowledge-based view of the firm, our findings also support taking a differentiated view of networks of practice over a unitary one. By conducting the analyses on the three task groups separately, we find that imposing one view on a network of practice masks possible heterogeneity. As described above, we find that network of practice centrality is positively related to the use of *external* knowledge sources for the SSW Group, but negatively related to the use of *external* knowledge sources for the entire sample. Thus, applying a generic theory of networks of practice may not be possible, rather the appropriate design may be contingent upon the underlying knowledge base within the network of practice.

Firm Performance

Future research should focus on the relationship between firm performance and the degree to which individuals are linked into the external environment through participation in inter-organizational networks of practice. Previous research suggests that one ramification of the increase in the use internet-based communications is that it is highly likely that the amount of knowledge exchange between organizations will increase substantially (Cronin & Rosenbaum, 1994). The internet facilitates the rapid transmission of large data files across corporate boundaries without any geographic, disciplinary, or professional constraints (Wellman et al., 1996). Recent studies of knowledge exchange are extremely limited, but in a study of one Usenet technical community, it was found that 42% of all messages sent included programming code (Wasko & Faraj, 1999). In our research, we find that individuals using external knowledge sources also participate in external knowledge exchange – sending out the firm’s internal knowledge in exchange for external knowledge. Additionally, our unexpected finding of the positive, direct relationship between the use of internal codified sources and external exchange provides an indication that individuals are accessing codified firm knowledge to exchange with external sources.

As mentioned above, previous research has revealed that this knowledge may even include proprietary firm knowledge (von Hippel, 1987; Schrader, 1991). Thus, the activity of this inter-organizational knowledge exchange by individuals at all levels and positions of the firm draws into question the degree to which a company’s proprietary knowledge is leaking across its legal boundaries (Mansfield, 1985). The decision to exchange knowledge or not with external parties is placed in the hands of an individual working for the firm. As such, economic and management researchers generally argue that this informal “leakage” may be a disadvantage for the firm due to the potential dilution of a firm’s competitive advantage (Schrader, 1991). Individuals may trade valuable knowledge for purely personal objectives or may make a mistake and misjudge the value of this knowledge (von Hippel & Schrader, 1996). Research on the relationship between know-how trading and firm performance

is scant, primarily because it is very difficult for firms to manage and evaluate the benefits since it occurs “off the books” (Carter, 1989). However, there is some initial evidence of a positive relationship (Schrader, 1991).

Our results from this research also suggest a positive relationship since we find that the use and exchange of external knowledge has an indirect relationship to creative performance through their influence on internal knowledge exchange and integration centrality. A potential explanation for our results may be that knowledge coming from outside the firm may be so novel that it cannot be applied to any immediate solution. Rather its dissemination to others and subsequent recombination with the firm’s knowledge is necessary to adapt this knowledge to the firm’s specific use. Thus, the ability to develop and implement innovative solutions and improve performance may involve combining existing internal knowledge with novel external knowledge. This finding supports theories of absorptive capacity, which suggests that the firm’s ability to assimilate new, external information is largely a function of the firm’s ability to internally process that information (Cohen & Levinthal, 1990). As a result, participation by individuals in inter-organizational networks of practice may not necessarily negatively impact a firm’s competitive advantage. While proprietary practice knowledge may leak out in these inter-organizational networks, the ability of another organization to use this knowledge to its advantage then becomes dependent upon its ability to absorb and adapt it to its specific use through internal knowledge exchange.

Implications for Practice

Knowledge Management

One of the primary areas of implications of the results from our research is for the field of knowledge management. Our findings indicate that organizations concerned with knowledge management may need to rethink their knowledge management strategies. First, what do we make of the result that different patterns of knowledge integration are associated with different performance outcomes? The first is the balance between efficient and flexible integrative performance. With the rapid development of the ease of use of the internet (e.g., smart agents, more specialized discussion forums) and the increasing ability of individuals to use the internet and communicate with others in their external networks, this media will become a much more helpful knowledge source. Yet, as we found, it is communication with co-located coworkers that leads to superior efficient performance. The question then becomes how to balance the use of the new media to ensure a productive ratio of flexibility to efficient performance. As we find here, knowledge integration patterns differ depending upon which type of performance is the objective. In some organizations, a focus on efficient performance through systems that promote local communication may be the objective while in others a focus on flexible

performance through systems that promote the development of intra-organizational networks of practice may be the objective. Thus, knowledge management systems should be aimed at facilitating a balance between efficient and creative performance that matches a company's competitive strategy.

Second, what is to be made of the high use of external knowledge sources? To date, knowledge management systems have focused on leveraging knowledge *within* the organization. In some instances, these systems also may include other organizations (extranets); however, these other organizations often fall within the realm of the organization's formal task environment. As we see here, the use of informal external sources is indirectly related to creative performance. A challenge then for management is whether knowledge management systems should be developed that facilitate the use of external sources. In previous research at Icon (Teigland, 2000), interviews with individuals in the System and Software Group revealed that these individuals prefer to go outside the organization to external electronic communities to asking others within Icon for help. Not only can more answers be found to their question but the speed with which answers are given is much faster than using internal knowledge sources.

Third, this research shows that implementing generic knowledge management strategies across an organization may not prove successful. The three groups of Commercial and Support, Design, and System and Software differ significantly in their activities related to knowledge integration and their relationship to individual performance. These differences imply that knowledge management systems tailored to each group of employees based on its practice knowledge may be more successful. For example, for groups such as the Design Group at Icon, resources may be better spent on developing internal document repositories; however, for groups such as the System and Software Group, resources may be better spent on leveraging the use of external knowledge sources as well as ways to improve knowledge flows within the internal network.

Organizational Identity and Commitment

Just as individuals have a certain degree of commitment to their organizations, they also have a degree of commitment to their profession or occupation as several researchers have noted (Arrow, 1974; Saxenian, 1996; Brown & Duguid, 2001). In some professions, the degree of commitment to the profession can be so strong that the norms of the profession even transcend the norms of the organizations that employ the individuals. Members of professions can be separated by great distances and still see themselves as part of the same professional group. Academics have long been examples of individuals with a strong degree of commitment to their profession (Pickering & King, 1995).

The implication from our results is that individuals may then hold multiple identities, as Kogut & Zander (1996) argue. On the one hand, individuals belong to a community within the firm, while on the other, they may belong to a professional community outside the firm, as evidenced through the high use of external knowledge sources. Thus, an individual may be faced with competing allegiances and conflicting objectives. As a result, a challenge for management is to ensure that employees have the right balance between participation in the firm and participation in external networks of practice. If individuals have a higher degree of loyalty to their network outside the organization, this may be at the expense of the company, leading to two ramifications for company performance: 1) an individual spending too much time participating in external networks during working hours and 2) the giving away of proprietary know-how or information.

First, individuals may be too involved with their external community and as a result, spend too much time “working for” their community. While not found here, previous research provides evidence that individuals who spend a lot of time working with others in electronic networks of practice are more likely to have a poor level of efficient performance (Teigland, 2000). Interviews with some of these individuals revealed that they often were so busy helping others outside their organization or striving to create elegant or “bleeding edge” solutions that they were unable to focus on finishing their own tasks according to management’s objectives. It appeared that these individuals had considerable “power” over management. This power resulted from management’s inability to understand in detail what their employees were doing since they were unable to keep up with the rapid pace of technological development. Thus, management often did not know whether employees were working on necessary value-adding activities or were spending time trying to impress their peers. One manager summarized this situation with reference to the software programmers, “Programmers take us (management) hostage. We never know whether they’re working on extra bells and whistles to impress their buddies or whether it’s really a value-adding activity for the customer.” For some individuals it may be worth more for them to develop the “latest and coolest” solution than to complete their work on time and to their supervisor’s requests.

As discussed under the above section, Implications for Theory, the second challenge is more of a threat to a firm’s competitive advantage – the trading of proprietary know-how or information. The development of the internet has greatly facilitated the degree by which proprietary information can be traded between companies without management’s knowledge. In many cases, management is completely unaware that its employees are participating in this behavior. The decision whether to transmit proprietary knowledge is placed within the hands of the individual. If an individual is trying to enhance his or her identity in the external community, then he or she may transmit this

proprietary information without receiving anything of value for the company in return. However, as described above, the results of this research seem to provide contrary evidence, that external knowledge exchange is beneficial for the firm, although indirectly through the recombination with existing knowledge. Thus, while an individual may trade away “proprietary” knowledge, the ability of a rival firm to turn this into an innovation lies in its ability to integrate it with its own existing knowledge bases in the firm.

Third, while some organizations have attempted to stop the cross-boundary flow of knowledge within these groups, these attempts may be counterproductive (Brown & Duguid, 2001). Attempting to block participation in inter-organizational network knowledge flows may only lead to increased loyalty to the external network and decreased loyalty to the organization and potentially a negative effect on individual performance. And as noted above, these flows are two-way, generally characterized by an equal exchange of knowledge. Thus, of importance to the knowledge integration view, cutting off flows to outside of the firm will more than likely risk cutting off flows into the firm (Saxenian, 1996; Brown & Duguid, 2001).

Finally, one implication of this research is that when management hires a person, management is also “hiring” the employee’s external network as well. Thus, management must consider the potential employee’s external network and how active the individual is in this network. If the person is very active in this external network, then the individual’s time may be spent on external activities. As indicated here, individuals who participate to a high degree only in external knowledge exchange and not in internal knowledge exchange, are less central in the firm. Another aspect to consider is which individuals are included in the potential employee’s network and what value these individuals may provide to the organization through external knowledge exchange.

Central Individuals

This research has also provided evidence that management should pay considerable attention to understanding the emergent networks of its organization. Through their activities related to knowledge integration, individuals achieve different levels of efficient and creative performance. Management should focus on developing an understanding of which individuals are the central individuals in the firm’s emergent networks for several reasons. First, as mentioned above, central individuals are influential in developing the common language and norms of the local community and as such determine to what degree the languages and norms vary between the local communities of practice spread across the multinational. Second, central individuals are key players in the future of the multinational. They are one of the primary determinants in the direction of the firm’s knowledge development since these individuals make critical decisions regarding which external knowledge is combined with which internal knowledge. Third, while most

individuals throughout the firm participate in some kind of external knowledge exchange, central individuals have a greater possibility of trading away the firm's more valuable knowledge since they have greater access to the firm's more valuable resources and critical knowledge. Decisions to trade and the ability to obtain valuable external knowledge are based on their own judgment. In summary, since knowledge is argued to be the most valuable resource of the firm and sustainable competitive advantage stems from an organization's capability to integrate the knowledge of its members, central individuals in a firm's emergent networks are critical to the firm's knowledge integration processes and the ability to create sustainable competitive advantage.

Limitations and Areas for Future Research

Despite the strengths of this study involving a large, all-inclusive multinational organization, we should also note the limitations of the study. First, this study only examines individuals within one company, thus limiting the generalizability of our findings. Further research should examine activities related to knowledge integration and their relationship to individual performance across multiple organizations. Second, data were collected at one point in time. Another limitation is our use of self-reported survey measures for performance only. Thus, future research should include objective data sources in addition to survey data as well the collection of data over time to further establish the relationship to performance.

Additionally, in this research, we focus on the full scale of knowledge and do not incorporate the whole scale from tacit to explicit knowledge. We also do not look at the strength of the relationships between individuals in the advice networks. However, previous research suggests that at the unit level the relationship between performance and the position in the firm is dependent upon the type of knowledge being transferred as well as the strength of the tie (Hansen, 1996). Thus, future research should incorporate the different dimensions of knowledge as well as tie strength.

In terms of knowledge integration, Grant (1996a) proposed three dimensions of effective knowledge integration. We investigated two of these: efficient and flexible knowledge integration. However, due to the already complex nature of this study, we did not investigate the third dimension, the scope of integration. Clearly, it would be of interest to look at the effect of the scope of knowledge integration.

Finally, this research has been conducted solely at the individual level. However, as discussed in the Implications section, there are several implications of our research for both the unit and the firm level. Thus, an interesting area for further research would be to understand the relationship between the patterns of individual level knowledge integration and unit level knowledge integration and the effect on unit or firm performance.

Conclusion

In conclusion, this research set out to investigate the activities related to knowledge integration at the individual level within a multinational firm. We find indications that these activities differ depending upon whether efficient or creative performance is the desired outcome and that individual performance is also dependent upon the task performed. Our results provide support for the knowledge-based view of the firm as well as indicate how these theories may be further developed. In terms of implications, one of the most interesting results from this research is the extent to which a firm's external boundaries are becoming porous. Individuals rely on the use of codified external knowledge sources as well as their external informal networks to solve their everyday work-related problems and in the process exchange firm knowledge to gain access to external knowledge. This finding clearly implies that researchers and practitioners alike need to further investigate these inter-organizational knowledge flows and the impact that these have on competitive advantage and firm performance.

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Article Seven

Knowledge Dissemination in Global R&D Operations: An Empirical Study of Multinationals in the High-Technology Electronics Industry

Note to Reader on Terminology:

We use the term, community of practice, to represent networks of practice both within the firm and outside the firm.

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Knowledge Dissemination in Global R&D Operations: An Empirical Study of Multinationals in the High-Technology Electronics Industry

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ABSTRACT

This study is an empirical examination of 1) the mechanisms that three multinationals used to disseminate knowledge within their globally dispersed R&D operations, 2) the impediments that these multinationals experienced when implementing these mechanisms, and 3) the means to overcome these impediments. Management focused considerably on implementing mechanisms that facilitated the flow of knowledge to top management for the coordination of globally dispersed R&D activities. However, little attention was placed on mechanisms to facilitate the flow of knowledge for use by engineers in problem-solving activities. Three types of impediments to knowledge flow were observed: 1) opportunity cost of time, 2) knowledge is power, and 3) not-invented-here. Knowledge flow in an MNC appears to be facilitated by establishing a one-company culture through 1) incorporating teamwork as a company value, 2) evaluating individual knowledge contribution and assimilation in performance appraisals, 3) implementing a goal that promotes overall company improvement, and 4) facilitating extensive personnel rotation.

Keywords: multinational, community of practice, performance, R&D, knowledge

KNOWLEDGE DISSEMINATION IN GLOBAL R&D OPERATIONS

Multinational corporations (MNCs) have largely built their success on their ability to create competitive advantage through technological innovations. Traditionally, MNCs operated with a centralized R&D structure that facilitated the creation of new technology in the home country followed by subsequent technology dissemination to overseas operations. Over the past couple of decades, however, the competitive environment has changed, and as a result, MNCs have had to re-think their approach to innovation and R&D management. Now, it is argued that to achieve competitive advantage MNCs must continuously create, transfer, and exploit knowledge that is increasingly dispersed throughout their global operations (Bartlett & Ghoshal, 1989; Hedlund & Nonaka, 1993; Doz et al., 1997).

The traditional centralized R&D structure that was seen in the post-war years is gradually being eclipsed by the emergence of global R&D networks (Ronstadt, 1977; Terpstra, 1977; Lall, 1979; Håkanson, 1990). Four main reasons seem to be underlying this structural change:

- 1) *Number of knowledge sources increasing.* Companies are establishing R&D centers in multiple locations to tap into and absorb the new knowledge and research produced by universities and competitors across the globe (de Meyer, 1989; Kuemmerle, 1997).
- 2) *Localization of competition.* As global competition increases, the ability to win market share in many industries lies also in the ability to adapt to local needs. Centralized R&D may not be able to provide the locally needed solutions in the most efficient manner (Mansfield et al., 1979; de Meyer, 1989).
- 3) *Shrinking product lifecycles.* As the time from development to market continues to shrink, companies are establishing units in the marketplace that enable the company to rapidly move the product through the commercialization phase (de Meyer, 1989).
- 4) *Diversity of skills and technologies required.* The diversity of skills and technologies necessary to produce a certain good or service is rising. These are increasingly found across the globe at multiple sites. In addition, these multiple sites encourage the development of more ideas due to the varied international backgrounds in global networks (Barth et al., 1995).

Managing R&D Networks

Globally dispersed networks of R&D units create significant managerial challenges to MNCs. The basic challenge is one of maintaining the

responsiveness of individual units to the opportunities and demands of their local environment while at the same time capturing the latent benefits that a large, global network can confer (Bartlett & Ghoshal, 1989). Knowledge, it is argued, must be created at a lightening pace while it is simultaneously transferred and applied throughout the global operations. Coordination across units prevents the duplication of effort while at the same time ensuring the fastest time to market with a product that customers want. However, this quick pace leads to the need for unit autonomy since decisions must be made rapidly over distributed locations (Håkanson & Zander, 1986; Håkanson, 1990).

The task of efficiently making use of R&D knowledge becomes more difficult as many MNCs continue to expand their global R&D operations, and thereby increase the number of geographically dispersed locations, employees, functions, and external partners. Both the complexity of the network and the differences in language and culture lead to significant challenges.

How are MNCs responding to the increased demands on their global R&D operations? The standard argument in the literature is that firms are building “integrated networks” (Håkanson and Zander, 1986), in which task specialization occurs at a group, project, or unit level, but it is overlain with a variety of integrating mechanisms that ensure rapid and effective flow of knowledge across units. However, while such a model is attractive in theory, it is also recognized that effective knowledge flows are hard to achieve (Behrman & Fischer, 1980; de Meyer, 1991, Granstrand, Håkanson & Sjölander, 1992; Nobel & Birkinshaw, 1998).

The aim of this paper, then, is to focus on an applied question: *How are MNCs actually managing the knowledge flows in their global R&D networks?* The question is descriptive, but it builds on our *a priori* expectation that most firms would like to see an increase in both the volume and quality of knowledge flows between and within R&D units. As such, our study considers both the facilitators of and the obstacles to knowledge flow.

It is important to be clear on the positioning of this research *vis-à-vis* other studies in the same broad area. In the R&D management literature, patterns of *communication* have been well studied, both within a single site (Allen, 1977), and between R&D units (de Meyer, 1991; Nobel & Birkinshaw, 1998), but patterns of *knowledge flow* have not. In the rapidly growing knowledge management literature (see below), knowledge flows have of course been studied. However, from our reading of the literature, papers have tended to focus on conceptual models (Hedlund, 1994; Nonaka & Takeuchi, 1995; Grant, 1997) or discrete transfer events (e.g., Szulanski, 1996; Zander, 1991). Relatively little attention has been given to the full scope of knowledge flows that are to be found within a single organizational setting. This paper, then, hopes to contribute to both literatures by providing detailed, multi-level evidence of knowledge flows in the R&D organizations of three MNCs.

KNOWLEDGE MANAGEMENT

The focus on knowledge flows in this paper makes it necessary to briefly consider what we mean by knowledge. We recognize first of all that there is a “software” and a “hardware” side to knowledge⁷³. The hardware side or the articulate form of knowledge is that which is represented explicitly in physical or material objects such as a patent. It is the know-what or information (Kogut & Zander, 1992). Tacit knowledge (Polanyi, 1969; Hedlund & Nonaka, 1993), the software side, is intuitive, non-verbalized, and not yet articulated. It is the “know-how” or the practical skills or expertise that allows a researcher to work smoothly and efficiently (von Hippel, 1988; Kogut & Zander, 1992). Hedlund and Nonaka (1993) claim that the creation of knowledge occurs then when tacit knowledge is articulated through the codification of experience and information into articulate form.

In terms of knowledge flow or dissemination, some local knowledge is more articulated and thus more easily transferable across borders. Mechanisms that lend themselves to the transfer of articulate knowledge are broad channel communication or automated information distribution methods, databases, or groupware. However, research indicates that more than half of the knowledge in organizations is tacit and an even greater portion of the valuable knowledge is tacit (Snyder, 1996, 1997). This tacit knowledge is locally specific and harder to get access to from a distance (Westney, 1993). Thus, it is more costly to be transferred to other parts of the world (von Hippel, 1988; Asakawa, 1995).

How then is it possible to transfer or disseminate tacit knowledge? It has been argued that the most effective means is actually *not* to codify it. Rather than attempt to codify knowledge through IT systems, studies suggest that a more effective means is to involve people in face-to-face interactive activities such as storytelling, dialogue, and peer coaching which facilitate the learning of beliefs (Brown & Duguid, 1991; Snyder, 1996, 1997). Such informal interactive activities are the hallmarks of “communities of practice” which are defined as a set of people who are bound by informal relationships and share a common practice (Snyder, 1996; Wenger, 1998). The people in these communities are often not bound to typical geographic, SBU, or functional boundaries in organizations. Instead they are linked through informal practice and personal-based networks (Wenger, 1998; Snyder, 1997). While there are great benefits to the firm in effectively transferring knowledge internally, there are also risks. Making knowledge easy to transfer is a double-edged sword, because the characteristics that facilitate knowledge transfer inside the firm –articulability, observability, system independence – are also likely to make it relatively easy for competitors to imitate (Kogut & Zander,

⁷³ This division resembles the research conducted by Blakeslee (1985) on brain structures in which he distinguished between those structures used for the memory of the declarative knowledge of facts and those structures used for the memory of procedural knowledge that underlies skills.

1992). This is a critical issue, especially as one gets into the link between firm knowledge and sustainable competitive advantage, but it is not one that we address in detail in this paper. However, Kogut and Zander's (1992) argument that firms outperform markets as vehicles for *tacit* knowledge transfer is one important guard against competitive imitation, and it is also consistent with our findings regarding the importance of a one-company culture.

CONCEPTUAL FRAMEWORK

How MNCs manage their R&D knowledge flows is a broad area of inquiry, so our purpose in this section is to focus the question somewhat and put forward the organizing framework that we used to structure our investigation. Two specific restrictions on our investigation should be made at the outset. First, while knowledge flows can be concerned with both creation and dissemination (voluntary and involuntary), our focus is explicitly on the dissemination process. Second, we do not consider the flows of knowledge beyond the boundaries of the firm. As noted above, this is an important issue but it is beyond the scope of the current paper.

There are numerous ways to classify dissemination mechanisms but for the purpose of this research, a simple matrix was developed (see table 1). The vertical axis refers to the basic type of mechanism used to disseminate knowledge (IT application or organizational measures). Organizational measures are based upon face-to-face interactions such as personnel rotation or cross-functional teams. The horizontal axis of the matrix is based upon the task for which the knowledge that is being disseminated will be used, e.g., problem-solving vs. coordinating.

Table 1 Knowledge Dissemination Classification Matrix

	Problem-solving Individual	Problem-solving Group	Coordinating Organizational
IT Applications			
Organizational Measures			

This matrix allows us to focus our broad research question. The first objective of the study falls straight out of the framework presented in figure 1, namely identifying the various mechanisms that MNCs are using to enhance knowledge flows, as they pertain to individual problem-solving, group problem-solving and coordinating, and organizational coordination. More formally:

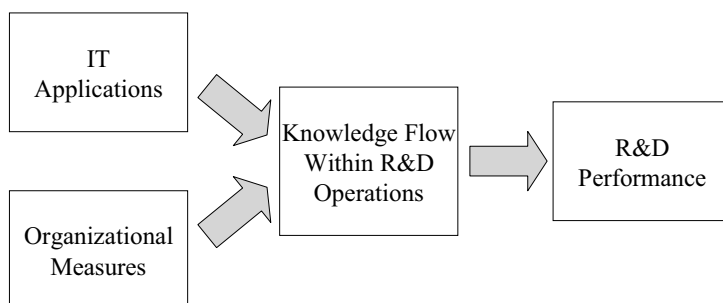
RESEARCH QUESTION 1: What mechanisms are MNCs using to transfer knowledge in their global R&D operations?

The second objective of the study is to give explicit attention to the obstacles to knowledge flows. Achieving the desired level of knowledge flows is not easy. The successful implementation of any knowledge management technique depends on the willingness and enthusiasm of its individual employees to adopt it. Pasmore & Gurley (1991) refer to this as a lack of cooperation claiming that people withhold knowledge if they are in a competitive relationship, feel wronged, could lose political power, or if they feel that the knowledge is not of use to anyone. Davenport & Prusak (1998) discuss the lack of trust and time and the Not-Invented-Here syndrome as frictions in the transfer of knowledge. The impediments to knowledge flow mentioned above exist in any R&D operations, but they are exacerbated in global R&D operations. This area of research has received less attention, thus the second question of this research is:

RESEARCH QUESTION 2: What are the impediments that MNCs experience in their attempts to disseminate knowledge in their global R&D operations and how are they overcoming these?

Finally, it is important to consider the “so what?” question, that is whether knowledge flows have any significant impact on the performance of the R&D organization. Our basic premise, of course, is that those MNCs that are successfully facilitating the flow of knowledge throughout their global R&D operations, and overcoming the impediments, will see a higher level of R&D performance (see figure 1). Obviously, there are many other factors that affect R&D performance such as management, availability of resources, strategic direction, operational effectiveness, competitive environment, etc. Recognizing this, it is still of interest to compare the observed level of knowledge flow with the R&D performance in an organization. Measures of R&D performance might include such things as time-to-market, the rate of new product introductions, as well as the ability to create radical innovations. This leads to the following research question. Figure 1 summarizes our conceptual arguments so far.

RESEARCH QUESTION 3: What impact –if any—does the MNC’s ability to enhance the knowledge flows in its global R&D operations have on its R&D performance?

Figure 1 Research Model

METHODOLOGY

As the purpose of this research was to explore the three research questions above, it was decided to focus on a limited number of MNCs. The selection criteria were based on a number of factors: 1) annual sales greater than USD 15 billion, 2) large, globally dispersed R&D operations, and 3) operating in the high technology electronics sector. Three companies were chosen, Hewlett Packard (HP), one other US company (A), and a Swedish company (B). The latter two are disguised, according to the wishes of the companies. A brief description of these companies is provided in table 2.

We adopted a case research approach to the empirical investigation, because of the importance of studying knowledge flow processes in their real-life context (Yin, 1989). This approach was particularly important given our emphasis on studying what *actual* mechanisms were being employed for managing knowledge flows, rather than the mechanisms intended for knowledge management by top management. A secondary reason for choosing a case study approach was that we felt the existing body of literature did not adequately describe the phenomenon under investigation. As stated by Eisenhardt (1989:548), “There are times when little is known about a phenomenon, current perspectives seem inadequate because they have little empirical substantiation, or they conflict with each other or common sense. In these situations, theory building from case study research is particularly appropriate.”

Table 2 Description of Sample Companies

	Company A	Company B	HP
Headquarter Location	United States	Sweden	United States
1996 Sales	USD 17 billion	USD 15 billion	USD 43 billion
Number of Employees	87,000	93,000	123,000
R&D Operations	US, Canada, France, United Kingdom, Japan	Located in 23 countries in North America, Europe, and Asia	Extensive network in Asia, Europe, and the Americas
Number of Interviews Conducted	25	20	10

At each of these three companies, ten to twenty-five in-depth field interviews were conducted from June 1997 to February 1998 (see table 2). People at different levels of the company: corporate R&D manager, laboratory manager, project manager, and researcher, were interviewed for one-and-a-half to two hours each. Several steps were taken to increase the reliability and validity of the results. For example, two interviewers were present at all the interviews, which were based on a semi-structured interview guide. Also, each interview was taped and transcribed by one of the interviewers. Immediately following each interview, individual impressions were discussed by the interviewers and differences were resolved. Some written material was also collected from the companies. See appendix for the interview protocol. The data analysis proceeded through several stages. First the interview data were reduced and classified based on the R&D matrix. Next the interviews were analyzed for commonalties based on the research question of challenges in knowledge dissemination. Three main categories of challenges were subsequently developed.

Before getting into a description of the findings, it is valuable to provide a brief discussion of the R&D organizations of the three firms, and thus the context in which knowledge flows were occurring. All three firms are major players in the high-technology electronics sector, and this has a number of implications for how they manage R&D. First, the fast rate of technological change in this sector has made time-to-market a critical business imperative, with the result that the development process has become highly structured and streamlined. Research is also becoming more oriented towards the needs of the business units, though in HP the research labs are still funded centrally (rather than through business unit funding). Second, there is an increasing emphasis on software development in all three companies, as high as 80% of the total R&D budget in the case of Company B. This creates on the one hand a very

fertile environment for knowledge sharing, because of the increasing ease with which information is transferred over the Internet, and because of the common tools and languages used by software engineers around the world. However, it also creates some risks and challenges for knowledge management if a reliance on software and computer-based interaction drives out face-to-face interaction.

FINDINGS ON KNOWLEDGE DISSEMINATION MECHANISMS

The knowledge dissemination mechanisms that were most commonly observed have been mapped onto our classification matrix (see Appendix A for a more specific discussion of each mechanism).

Table 3 Most Commonly Observed Knowledge Dissemination Mechanisms

	Problem-solving Individual	Problem-solving Group	Coordinating Organization
IT Applcs.	Competence database (HP) Communication facilitators, e.g., video, email (A,B,HP)	Groupware (A) Best practice database (B,HP)	Patent database (A,B,HP) Project database (A,B,HP) Other databases (HP)
Organ. Measures	Personnel rotation (A,B,HP) Interest groups (A,HP)	Cross-disciplinary teams (A,B,HP)	Strategic review boards (A,B,HP)

Note: A,B,HP represents which company had implemented this measure.

A Focus on Coordinating over Problem-solving Mechanisms by Management

The majority of mechanisms were created by top-down initiatives to facilitate knowledge flow for coordination purposes. The primary goal was to overcome the geographical divisions between the R&D units by encouraging the tracking of and sharing of knowledge on a management level. The companies all had well-developed systems for coordination.

However, in terms of the mechanisms to facilitate the flow of knowledge for the researchers in their everyday problem-solving activities, there was a wide variety of mechanisms that were implemented in differing degrees across the companies. There was not as much support from management for the development of these activities as there was for the coordinating mechanisms. This seems surprising since mechanisms for knowledge flow across the units would enable researchers to work more

efficiently and effectively. Of interest, the few mechanisms that had been implemented by management were not well used by the researchers as management had developed them from their viewpoint and not from the individual researcher's.

Organizational Coordination of Activities

IT Applications

This category primarily included database applications such as databases of invention proposals, patents, and projects. The drive behind these was from management who designed them to provide an inventory of the company's research activities. These enabled management to conduct such activities as tracking headcount or the number of patents by discipline. The patent and project databases were the most well maintained due to management's mandate to keep them up-to-date. In several interviews, it was clear that these were solely for management's use as access was quite limited in most cases. This is presumably because while the flow of knowledge within a company is generally positive, it also increases the ease with which sensitive information can leak to the outside world.

Company B had an extensive intranet with status and operational information on each project across the laboratories. As mentioned above, each project was mandated to enter this information and there was even a handbook with guidelines for entering the information in the proper way. However, few steps to facilitate the search for information had been implemented. It was necessary to search for information laboratory by laboratory, which was a very slow process with 50 facilities.

Other applications of interest in this category are those developed by HP. These included a market research database and an external standards database. The main driver of their creation was to improve the company's efficiency. The market research database was designed to create an online inventory of all market research reports that individuals throughout the company had obtained. This enabled the company to avoid purchasing more than one copy of such reports and save time. The second database was designed with the goal of improving the company's lobbying efforts with official standards organizations. It provided an online repository of information relating to all external standards with listings of the members of various committees (including if a member of the company was on the committee).

Organizational Measures

The measures in this category enabled the companies to coordinate activities of a more strategic nature, such as funding allocation between the labs or project review. In all three companies, research strategy reviews were held annually in

which the top management from the distributed labs met. This facilitated both the reductions of cross-disciplinary boundaries and geographic boundaries while encouraging the sharing of ideas across the labs. Also, despite the extra cost, all three companies had moved to organize their research by research theme rather than geographic location as another high-level means to coordinate the activities across geographic boundaries.

Company A had recently reorganized across five research themes that crossed geographical boundaries. This was a step in the direction of improving knowledge flow. However, due to the strong laboratory sub-cultures, the flow of knowledge still seemed to be hampered. Company B had been organized by research theme for several years. This had greatly increased the flow of knowledge and people across borders as people from different geographical sites had to work together. As mentioned above, HP was in the process of reorganization during the time of this study and this was a result of the need to better manage knowledge within the company and to gain better access knowledge outside the company around the globe.

Another measure of Company A was the establishment of cross-disciplinary invention proposal review boards. These boards were created for two reasons. The first reason was because an increasing number of inventions were cross-disciplinary thus subject experts from several disciplines were required to review the proposal. The second reason was to bring together cross-disciplinary experts around invention proposals to facilitate the cross-pollination of ideas across the labs.

Individual Problem-solving Activities

As mentioned above, the companies had not progressed very far in their efforts to install mechanisms that facilitated the problem-solving activities of the researchers either as individuals or within the group. In most cases when the researchers were asked how they determined whether the company had a specific competence and where it was located, the most common answer was that they asked their project manager or the researcher sitting next to him. The answer was usually found then by email or telephone through a network of people.

IT Applications

Due to fewer efforts placed on implementing mechanisms to facilitate research, there were a wide variety of mechanisms and varying levels of use across and within the companies. These applications could be divided into 1) repositories of explicit knowledge, 2) links to knowledge, and 3) communication facilitators. Of the listed IT applications, no company had implemented all of them. HP was the most advanced in its overall development and use of applications across labs. However, Company A, which allowed the most autonomy, had developed the most potentially useful applications for its

researchers. However, they had not been distributed for use across the organization.

1) *Repositories of Explicit Knowledge.* As mentioned above, it was clear that the companies had not designed the invention proposal and patent databases with the researcher in mind since access to them was quite limited due to the fear of the flight of intellectual capital from the company. Researchers had to ask specifically for permission to access the different databases and this became complicated when asking for access to a database in another laboratory. However, the companies did have document databases where researchers could search for published papers on selected topics of interest.

2) *Links to Knowledge.* Examples of the second group included a competence or expert database and individual or project webpages. HP had implemented an elaborate competence database in which any employee could search the entire company for an employee with a specific competence. In Company B, all project teams were mandated to create webpages describing their respective project, yet no search engine that could search across all labs had been implemented for these. Company A was in the process of developing such an application; however, it was still in its infancy.

3) *Communication Facilitators.* The third group consisted of applications such as email and groupware. E-mail was widely used at all three companies. Video conferencing was also used at all three companies; however, no company used it extensively. One manager at Company B felt that the real take-off of video conferencing would occur when it came to the desktop.

Company A had implemented a new form of groupware that was developed in-house. This application was among the most interesting of any of the observed IT applications. However, due to the poor level of integration among the units, this application appeared to be only well used at one of the laboratories. This groupware was a virtual workspace, enabling researchers to easily share information, collaborate on documents, and connect with fellow researchers through such means as bulletin boards and calendars. Of interest is that there was no central authority or administration for the system as it was community owned and maintained. Individual researchers determined their own level of participation and could designate what level of security they desired for the information that they entered, e.g., "write-only" or "read-only" access. This seemed to be a well-designed application as the number of users increased substantially since its introduction.

Organizational Measures

The organizational measures included such mechanisms as best practice transfer, process documentation, cross-disciplinary teams, and personnel rotation, and they were implemented to varying degrees across the companies.

Company B had the most structured and hierarchical process for the transfer of best practice. Once a year, the managers from each R&D laboratory within the same research area would meet to present to each other what they felt was best practice. The process of transfer between the laboratories was voluntary after this. However, if a laboratory manager did not want to adopt the practice, he or she had to show to management that there was a better way, which was basically the same as management mandating the transfer.

HP had a well-balanced push-pull attitude to best practice. The organization had even established a unit that was responsible for the creation and transfer of best practice in process development across the laboratories. However, each laboratory was not mandated to use this unit. Each laboratory had the right to look anywhere in the company as well as outside the company for ways of improving their processes. Thus, the unit had to market itself to the rest of the company. Both management and the laboratories seemed satisfied with this arrangement since it seemed to work well. The creation of this unit and internal market indicates that the laboratories of HP searched continuously for best practices, thus creating a pull for knowledge flow.

In line with the best practice transfer, only Company B had a formalized process for documenting the knowledge gained during a research project. In fact, no research project was considered completed until this documentation had occurred. Company A had no such process and could give no examples of best practice transfer when asked during the interviews. The interviewees claimed that this was due to the strong subcultures among the labs that led to the Not-Invented-Here syndrome.

One measure that was both top-down and bottom-up at the companies was personnel rotation that served to facilitate the transfer of tacit knowledge across the labs. Company A did have a formal program of personnel rotation; however, it seemed to be used sparingly. Again due to the subculture rivalry, individually initiated rotation seemed to be discouraged. One engineer interviewed said that it took over a year to be transferred to another lab to work on a project there. He claimed that this was due to the lab managers' concerns that it would appear that one lab was being raided by the other and that the lab losing the person would then have to reduce its headcount by one.

Company B had extensive personnel rotation with most employees rotating to new locations every 2 to 3 years. Rotation was either requested by management due to competence needs in another laboratory or by the employee as part of his or her competence development. In fact, even though rotation was not articulated as a requirement for advancement in the company, there was an unwritten policy that this was necessary if one wanted to advance. HP also had an extensive personnel rotation scheme and as one interviewee said, "There are 12 different ways to rotate at this company."

Another means to facilitate knowledge transfer was to use researchers from across several laboratories in one project. Company B used this

extensively as all of its projects involved more than one laboratory on a project. Work was even reshuffled throughout the laboratories as demands for different levels of competence varied across projects. Company A was involved in some cross-laboratory projects although the majority of projects were within each laboratory. HP had initiated a virtual R&D laboratory project two years prior. Unfortunately, it was not possible to gather any data on this project at the time.

In addition to the above, there were some grass-roots efforts such as technology conferences or technology interest groups. The goal of these efforts was to bring together people with similar interests and competencies from across the organization. The level of encouragement from management differed across the companies. HP fully encouraged these conferences and groups and provided resources for these activities. One of the purposes of the technology interest groups was to provide funding for back-burner research as well as to promote the creation of networks across the company. These efforts worked very well and participation within the interest groups was high. Company A did not discourage such groups; however, no resources were allocated to enable such efforts. This was mirrored in the low participation rates. Company B did not have any such grass-roots group. However, one interviewee at Company B stated that his unit felt that there was a real need for such cross-border groups. Although no sponsoring was given for internal groups, management did sponsor the creation of groups between a laboratory and its environment. In such groups one or two researchers joined two to six people from outside the company in the same location who had the same expertise. When interesting ideas developed, the researchers made a formal presentation to the management of the laboratory who then decided on any actions to be taken.

Identifying and Overcoming Impediments to Knowledge Dissemination

The second aim of this research was to pay explicit attention to the obstacles to knowledge flows within the global operations. The findings of interest concerned the knowledge flows occurring at the level of the researcher and not at the level of the organization. This is primarily because management focused on implementing and mandating the use of these mechanisms. Since less attention had been placed on the individual researcher's needs for problem-solving activities, considerable impediments were found to exist to cross-laboratory knowledge flows. The main challenges observed were of a behavioral nature, implying that even if all the structural channels existed, knowledge would still not flow due to the employees' lack of willingness to disseminate or assimilate knowledge. A discussion of these impediments as well as the means to help overcome these is provided below.

Table 4 Impediments to the Dissemination of Knowledge

	Individual and Group Problem-solving	Organizational Coordination
IT Applications	Opportunity cost of time	Keeping up-to-date Linking databases geographically Linking IP with patent with project
Organizational Measures	Knowledge is power Not-invented-here	Strategic agreement across laboratories

Organizational Coordination

For the IT applications which facilitated management's tracking of research activities, the underlying challenge was to ensure that up-to-date information was entered and that the databases across the labs were linked. In addition, links had to be made across the different types of databases. For example, when an invention proposal was patented, then this should be entered in the invention proposal database. In all companies, administrative procedures had been implemented to ensure information input into the databases, thus overcoming any challenge to keeping them up-to-date. Interestingly this was a considerable challenge at HP due to the frequent movement of its employees.

With respect to the organizational measures, the main challenge was more on a strategic level. In other words, with respect to the review boards, management at each laboratory had to agree to the overall strategic direction of the laboratories and the allocation of resources among the laboratories. In addition, significant coordinating challenges are raised when the laboratories are organized based on research theme as opposed to geographic location; however, these challenges become more operational as opposed to the transfer of knowledge.

Problem-solving Activities

The more interesting challenges from this paper's perspective arose when discussing the mechanisms to facilitate the everyday activities of researchers. In an ideal knowledge-flowing world, researchers would have instantaneous access to all information and know-how dispersed throughout the company. However, even if an infrastructure were implemented, several impediments to the flow of knowledge would still be present. Three major categories were observed in the analysis: Opportunity Cost of Time, Knowledge is Power, and Not-Invented-Here. In this study, the individual researchers were seen as both givers and receivers of knowledge, and opportunity cost of time was a challenge on both dimensions. However, Knowledge is Power was seen to be a

challenge on the giver side while Not-Invented-Here was a challenge on the receiver side.

Opportunity Cost of Time. The successful implementation of the IT applications is partly dependent upon having up-to-date and relevant information. When discussing with the interviewees the implementation of these systems, it was often stated that they had not entered their own information because it was too time consuming, they were unsure of what benefit they would receive for doing so, and they did not want to be bothered with telephone calls from people finding them in the database.

In order to surmount these challenges, several different ideas were developed. One idea was to create a nag feature that prompted the user every time he or she logged onto the system. A message appeared stating how many days it had been since the information had last been updated. Another idea was to encourage the use of the system through bonus features. At one company when the user entered the appropriate data for the project database, an automatic email distribution list of project members was created. For another system, updating information was rewarded with a coffee coupon. For those concerned with being contacted too often for their expertise, a feature was added which allowed them to specify by which means they were to be contacted or during what times, e.g., by email only.

Opportunity Cost of Time was also mentioned when discussing organizational measures, however, to a lesser degree. Attending technology conferences or participating in technology interest groups also might be constrained by time. Participation in these was low in Company A due to the lack of support from management. On the other hand, HP had the most active cross-geography technology interest groups of the three. This seemed to be due to the fact that management showed its support for these groups and that they were of a grass-roots nature. People who were interested in a technology or a subject were free to attend those that were of interest.

Knowledge is Power and Not-Invented-Here (NIH). Knowledge is Power and Not-Invented-Here seem to be opposite sides of the same coin. A researcher does not want to reveal certain knowledge as he or she feels that this ensures a certain amount of power. On the other hand, a researcher may not want to assimilate someone else's knowledge as he or she might feel that this would represent lesser intelligence. However, it was important for researchers to get over these feelings and work together since new inventions at Company A, for example, normally required at least two inventors due to the increasingly complex technical nature of the product. In fact, the company had an average of 2.3 inventors per patent. HP seemed to have a completely different attitude among researchers that mirrored the general philosophy that the company would take an idea from anywhere as long as it was a good one. This

contrasted with Company A that had a history of developing everything in-house. At Company B researchers seemed open to new ideas from others and open to sharing. However, Company B was more open to ideas from within the organization than from outside.

One observed means to overcome these knowledge flow barriers was to base the researcher's performance appraisal not only on individual performance but also on the individual's contribution to the knowledge of the company. This practice is quite common in management consultancies where an "up-or-out" policy often reinforces self-interest, thus the addition of knowledge sharing criteria helps overcome knowledge sharing challenges. In Company A, the performance appraisals did not include any contributions to the company's knowledge base. One researcher who had made a big attempt to facilitate the cross-pollination of ideas across labs did not feel that there was much response from management concerning this effort during his performance review. Company B took a different approach as it encouraged personal development in their performance appraisals; however, the company did not consider the individual's contribution to the company's knowledge base. HP had created a push-pull system in the manner it structured its performance appraisal. Half of an individual's performance review was based on individual results while the other half was based on how the results were achieved, i.e., the efficient use of resources (pull) and the contribution back to the company (push).

In addition to the above, management actively attempted to show its support for knowledge sharing activities. Company A with the least amount of interlab knowledge dissemination suffered from a lack of management support. Ideas that crossed laboratory boundaries received little support from management. In addition in Company A, technology councils which were formed to bring together those with similar technology interests were poorly supported by management thus the level of commitment and participation was low. At HP management stood firmly behind such interest groups, providing financial resources as well as encouraging participation in such groups.

Moving away from the level of the individual, Knowledge is Power or NIH was also observed at the level of the project team or even of the lab. In Company A, the different laboratories were resistant to ideas from the other laboratories due to the strong subcultures observed. Also, the laboratories seemed to be concerned that sharing ideas between laboratories might affect the allocation of resources between the laboratories. Both Company B and C had laboratories that were more open to new ideas that seemed to stem partly from the setting of goals by each company. Company B established the goal of each of the laboratories reaching the level 5 of the "Capability Maturity Model". Under this model, the laboratories conducted quality audits of each other to determine the level of each laboratory. This system encouraged the searching for ideas by the individual laboratories and mirrored the aspect of personal development on the individual performance appraisals at the company. HP had

established the goal of becoming the “World’s Best Industrial Labs” for all of the laboratories as a whole. This also facilitated openness and sharing between the laboratories.

DISCUSSION AND CONCLUSIONS

From the above findings, successful knowledge dissemination in global R&D operations appears to be dependent on a two-part knowledge management system. The first part of this system includes a supporting infrastructure of IT applications and organizational measures. However, even if all the support and infrastructure are in place, there is no guarantee that knowledge will flow smoothly and efficiently between the laboratories due to the challenges that were identified above, especially at the individual level. Thus, management must grease the wheels of knowledge flow through the implementation of behavioral mechanisms that help create a one-company culture.

Supporting Infrastructure

The underlying element of the knowledge management system is a supporting infrastructure of both IT applications as well as organizational measures that facilitate the transfer of knowledge. IT applications for the repository of knowledge such as a competence database are useful for finding articulated knowledge or links to the knowledge source in an efficient manner.

In order to ensure the efficiency of these databases, our research suggests that they must be up-to-date as information changes rapidly. This is not an easy task due to the impediment of the individual’s opportunity cost of time. The means to achieve up-to-date entries ranged from management mandates to a voluntary basis. From the findings on databases, it seems that management has to consider the tradeoff of mandating the upkeep of its databases that requires policing or administrative resources or allowing it to be voluntary which does not require resources.

Company A’s groupware that created a virtual community workspace to coordinate activities and facilitate communication was a very interesting application and it was surprising to see that it was not implemented in all of the company’s laboratories. This was most likely due to many subcultures within the company. This type of groupware was not seen at the other companies. The use of this groupware was not mandated and researchers contributed of their own free will. The person contributing information had control over the use of these documents by being able to limit who had access to the documents or whether the document was for read-only or write-only. Participants seemed to respond positively to this self-control.

Another means of facilitating the spread of knowledge was through the implementation of a best practice database. It would be expected that within R&D operations that the knowledge gained during a project would be

documented so that future projects could gain from this knowledge. Both Company B and HP had developed such databases. Company B had a strict policy, mandating this documentation at the end of all projects. Company A claimed that since projects never really ended, there was never any clear time to document the knowledge gained; however, this seemed to be an easy way out of performing a time-consuming activity.

One challenge with documenting project knowledge is that the researchers have difficulty determining what knowledge is valuable to others as well as codifying it so others understand. HP facilitated the transfer of best practice through the creation of a unit whose task was to ensure that knowledge was captured and transferred successfully. This unit sent people to the different laboratories to facilitate the transfer of the more tacit knowledge as well.

Even though the companies are spending significant resources on the creation and implementation of IT applications, it was observed that researchers still only communicated largely with those whom they already knew. This may be because the systems were not very well developed or too difficult to use. In Company A one researcher (who was one of the star researchers) showed a real lack of interest in the company intranet. When asked if he used it, he said that he only did so for communication through email and to find out about company policies such as vacation days. He claimed that the intranet did not provide any "high-bandwidth information" and that it was more effective to speak with one of his fellow researchers sharing offices next to his. This supports the research on communities of practice. When attempting to solve a problem, a researcher asks someone else within his or her community of practice for help. This person may be next door or across the globe. A common language and trust within the community have already been established which thus facilitates the flow of knowledge.

Thus, management acknowledged the need to encourage the interaction of people who work on similar problems, especially those who would not normally meet, to facilitate knowledge flow. Discussion of ideas as well as the narrating of stories encourages the pull of knowledge from one laboratory to another. This feat is difficult to achieve through any IT application so the best means of achieving this are the organizational measures discussed above, e.g., personnel rotation, global conferences on specific themes, technology interest groups, wired coffee rooms, and cross-functional project teams. Even arranging the offices in an open layout encourages communication. Again HP had implemented many of these features while at the same time providing both financial and management support.

One-company Culture

Organizational culture is the set of values and resulting practices, concerning relationships among people and the world around them, that is shared by people in an organization. Further, as Meyerson (1991:256) noted, "Organizational

culture is the code word for the subjective side of organizational life.“ Organizational culture is difficult to measure and therefore traditionally quantitative methods have been avoided as organizational culture is normally best studied through qualitative methods (e.g., observation and interviews) (Schein, 1985). While we certainly only touch upon investigating case-study firms’ organizational cultures in this study, by following Schein’s recommendations we feel that we have been able to obtain a reasonable assessment of the firms’ organizational cultures through the interviews we conducted and through observations made while visiting the case study firms.

A central issue that emerged as an important determinant of knowledge flow was the extent to which a company had established a one-company culture as opposed to having several sub-cultures. Building the supporting infrastructure creates the channels for knowledge flow; however, behavioral challenges can restrict the knowledge flow through these channels. Company A was characterized by strong sub-cultures and thus had the least amount of knowledge flow across the laboratories of the three companies. For example, interviewees made comments on a number of occasions about how differently things were done at the company’s different geographical locations. The interviewees also appeared to feel more pride in their laboratory affiliation than their company affiliation. Also, significant differences in the physical design, dress, and style of people were clearly apparent to the researchers at the different labs. There was little pull for knowledge as there seemed to be a sense of rivalry among the laboratories. This also led to the lack of push of knowledge.

Company B had succeeded in building somewhat of a one-company culture through a high level of personnel rotation. However, there seemed primarily to be pull for knowledge within the operations due to the personal development aspect of the performance appraisal and the internal rivalry of reaching level 5 in the capability maturity model. Thus, the company had a better degree of knowledge flow than Company A.

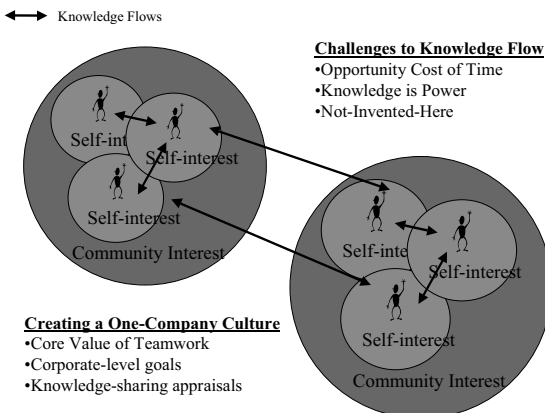
HP had built a one-company culture to the greatest degree of the three companies and perhaps as a result, it had the greatest flow of knowledge within its global operations. The HP culture encouraged the sharing of ideas with others as well as taking the time to help others. When asked why there was such a sharing culture, several interviewees mentioned that this was partly due to the core values of the company, one of which was teamwork. One interviewee stated that if she were to stop at someone’s desk anywhere in the company to ask for help, she felt that 99.9% of the time, the employee would take the time to help. Another means which HP used was the company-wide goal of becoming the “World’s Best Industrial Labs”. Management encouraged the generation of ideas to improve the R&D operations in any manner, e.g., process improvements, environmental concerns, etc., through providing resources to the best ideas. This goal seemed to work better than the

goal set by Company B since the ideas presented in HP often were improvements that spanned laboratory boundaries as opposed to improvements for each lab.

Referring to the community of practice literature, these findings support the discussion concerning identity (Wenger, 1998). In HP a strong common identity among employees across the global operations had been built. Employees felt that their identity was tied to the company as a whole and not just to their division, thus creating a balance between firm identity and division identity. This enabled the acceptance of ideas that were from outside the lab as they were not seen to be threatening to the identity of the lab. In addition, the one-company culture encouraged the contribution of ideas as employees were interested in improving the whole of the company. Both self-interest and community-interest were overcome as the betterment of the entire company meant the betterment of each employee and laboratory.

Company A, on the other hand, seemed to suffer from divisions with which employees identified more with their laboratory than with the company as a whole. This led to the feeling of fiefdoms within the company, thus laboratory interest or community interest was stronger than interest in the whole company. As mentioned, this was exhibited when discussing personnel rotation between the laboratories. Managers were afraid of losing someone to another laboratory, which might mean a reduction in headcount and resources. In addition, there was resistance to ideas coming from outside the division due to the subcultures. This was clear as each division had developed its own knowledge sharing tools for within the division; however, these had not been adapted by the other divisions even though they were aware of them. In addition, employees seemed to have a higher degree of self-interest than those at HP. They exhibited more concern with their time as well as a higher degree of Knowledge is Power and Not-Invented-Here.

Figure 2 Overcoming Knowledge Flow Impediments



From these observations, a one-company culture helps reduce the behavioral impediments to knowledge flow. This one-company culture can be encouraged through several means: instilling a feeling of teamwork as one of the core values of the company, overcoming community interest through goals aimed at the improvement of company as a whole, and overcoming self-interest through adapting performance appraisals to reflect an individual's contribution to the company's knowledge base. In addition, a high level of personnel rotation can be seen to contribute to a one-company culture through the building of a common language and shared values and cross-border networks.

Linking to R&D Performance

It was proposed at the beginning of the paper that a high degree of knowledge flow within global R&D operations would be linked to high R&D performance. To examine whether this was the case, we administered a brief questionnaire to interview respondents to get their perceptions of their company's performance. The company averages are listed in table 5.

Interviews suggested that Company A had the poorest internal R&D knowledge flow, and this is consistent with their relatively weak ratings on time to market, revenues from products developed in the last three years, and impact of R&D on the emergence of successful products. While we know from the interviews that Company A has historically been very good at developing radical innovations, they have clearly struggled to commercialize these innovations, which at least in part seems to be a function of their poor internal knowledge flow. Interestingly, Company A scored the highest on articles published per technical employee, which is consistent with their apparent focus on idea creation, rather than commercialization.

Company B had a considerably better knowledge flow than Company A. It scored very well on time to market, and impact of R&D on emergence of successful products, but it scored lowest on end customer satisfaction and articles published per technical employee. These numbers suggest a very impressive R&D performance, but one that is achieved through focusing knowledge flows on one thing (getting products to market fast) with a possible loss of concern for building longer-term effectiveness.

HP had the most balanced performance assessment, rating almost as high as company B on the emergence of successful products, highest on customer satisfaction, and highest on quality of R&D work. On no measures did they score the lowest. These findings follow logically from our assessment of HP as having the most effective systems for managing internal knowledge flows. The usual caveats regarding self-rated performance and subjective indexes apply, but the performance data is at least consistent with our interpretation of the internal knowledge flows in the three companies.

Table 5 Knowledge Management Mechanisms and Performance

	Co. A	Co. B	HP
<u>IT Applications</u>			
Coordinating			
Patent database	1	2	2
Project database	1	2	1
<u>Problem-Solving</u>			
Best practice database	--	1	2
Competence database	--	--	1
Project web pages	1	2	1
Groupware	1	--	--
Email	2	2	2
Video conferencing	1	1	1
<u>Organizational Measures</u>			
Coordinating			
Cross-lab review boards	2	2	2
<u>Problem-solving</u>			
Personnel rotation	1	3	2
Technology interest groups	1	--	3
Cross-disciplinary teams	2	1	1
<u>Behavioral Impediments</u>			
Opportunity cost of time	2	1	1
Knowledge is power	2	1	1
Not-invented-here	2	1	1
<u>One-Company Culture Measures</u>			
Teamwork in company values	--	--	2
Performance appraisal – knowledge dev.	--	1	2
Company goals established	--	1	2
<u>Overall Knowledge Flow</u>			
Intralab	3	2	3
Interlab	1	2	3
<u>R&D Performance Measures</u>			
Impact of R&D on emergence of successful products (B > A)	2.9	3.8	3.3
% Revenue from products developed in the last three years (B > A, HP > A)	2.8	4.0	3.7
Speed, time to market (B > A, HP > A)	2.0	2.7	2.7
End customer satisfaction (HP > B)	3.3	2.9	3.8
Quality of R&D work (HP > A)	3.0	3.3	4.0
Articles published per technical employee (A > B)	3.6	2.7	3.4

- Note for knowledge flow performance measures: Numbers refer to researcher's subjective assessments where: -- Non-existent, 1 – Poor performance, 2 – Good performance, 3 – Excellent performance.

- Note for R&D performance measures: Each person interviewed was asked to complete a very brief questionnaire. They were asked: "Estimate the performance of your division over the last three years, in comparison to competitor firms in your industry where 1= much worse and 5= much better". Responses listed in the above table are average responses from each firm. Parentheses indicate which pairs of numbers are statistically different at 0.05 level using the Kruskal-Wallis ANOVA test.

Finding the Balance

Both building the IT infrastructure as well as encouraging interaction through organizational measures require significant resources. Finding the right balance between the two is a significant challenge for management. However, the most important component in facilitating knowledge transfer among global R&D operations is to create a knowledge sharing culture that promotes curiosity for and openness to new ideas. This then creates a pull for knowledge which management can support through creating channels for knowledge flow. A push or desire for knowledge contribution is also an important factor in creating successful knowledge flows.

Like all studies, this study has some limitations. We have explicitly focused on the mechanisms of knowledge transfer in this paper. Future research would benefit from a deeper exploration of innovation processes. In addition, we have chosen a deep exploration of several case study firms to obtain rich detail and because of the exploratory nature of this study. This obviously inhibits our ability to generalize, which is left for future large sample research.

From the companies observed in this research, it appears that management has primarily focused on developing and implementing knowledge management flow systems aimed at fulfilling their coordination activities. Less attention has been paid to the individual researcher; however, this is the main resource of a company's R&D operations. Management should be more interested in implementing measures that would enable the researcher to work more efficiently while at the same time more innovatively. Thus, one future research direction would be to focus on better understanding the individual researcher, actually studying the way in which the researcher works and the means that the researchers uses to obtain knowledge for problem-solving activities. What knowledge does the researcher need? Where is it located and how does the researcher access it? What are researchers' preferences for individual control, job security, and reward structure, and how do they in turn affect knowledge dissemination? What can firms do to align individual and group goals in R&D organizations? Such research would enable management to better understand the requirements for successful knowledge transfer mechanisms and thus, enable companies to improve knowledge flow within their global R&D operations.

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APPENDIX A – OVERVIEW OF KNOWLEDGE DISSEMINATION MECHANISMS

Coordinating	Purpose	Challenges to Successful Implementation	Co.
IT Applications			
Invention Proposal Database	To create online inventory of submitted invention proposals	Fear of flight of intellectual property, defining who has access	A
Patent Database	To create online inventory of all patents obtained by company	Keeping up-to-date: 1) adding new proposals, 2) connection to patent	A,B,C
Project Database	To create online inventory of all current projects, descriptions, and participants	Keeping up-to-date: 1) adding new patents Linking across laboratories	A,B,C
Market Research Database	To create an online inventory of all market research reports obtained by the company	Defining who has access	C
External Standards Database	To create an online repository of all information relating to external standards - company members on standards committees	Motivating people to enter information and keep up-to-date Motivating people to keep up-to-date	C
Org. Measures			
Cross-Disciplinary IP Review Boards	To create board of cross-disciplinary experts to evaluate invention proposals	Motivating people to keep up-to-date	C
Cross-Disciplinary Strategy Reviews	To facilitate the diffusion of ideas across laboratories To create cross-disciplinary forum for discussion of overall research direction To facilitate the diffusion of ideas across laboratories	Ensuring interest from the different laboratories Ensuring that panels include representatives from different sites Ensuring consensus over direction among the laboratories	A A,B,C
Problem-Solving			
IT Applications			
Idea Board	To facilitate the connection of ideas while still in the formulation phase	Fear of others stealing ideas	A
Employee Competence Database	To create an online database of employees and their competencies	Degree of formal structure	A
Guide to Databases	To create an online listing of all personal databases	Definition of competence	A
Employee Webpages	To give overview of each project by laboratory To facilitate the spread of ideas and tools	Motivating people to enter information – lack of time and interest Keeping up with employee movements and competence development	C
Invention Proposal Review Groupware	To provide researchers with the status of invention proposals – date of review, feedback, decision, etc.	Definition of database – personal rolodex vs. research test results	A,B,C
Community Groupware	To create bulletin board and calendar To facilitate the sharing of documents	Motivating people to keep up-to-date Motivating people to enter information	C
Library Groupware	To facilitate the communication between librarians and library research analysts	Defining who has access and to what	A
Org. Measures			
Project documenting	To document knowledge gained in research project	Defining who has access and to what	A
Best Practice Processes	To promote the transfer of best practices across the laboratories	Motivating people to participate Motivating people to participate	C
Technology Conferences	To bring together researchers with common interests To access knowledge from external speakers	Motivating people to take the time Not-invented-here syndrome Motivating people to take the time to contribute Encouraging people to participate Securing resources from management	B,C B,C A,B,C

Problem-Solving	Purpose	Challenges to Successful Implementation	Co.
Technology Interest Groups	To create the sense of communication across the laboratories	Encouraging commitment	A,C
Library Research	To assign one researcher to each research group	Securing resources from management	C
Analysis Liaisons	To facilitate knowledge flow across research groups through liaisons	Ensuring communication among research analysts	
Personnel Rotation	To facilitate the transfer of know-how across research laboratories	Providing incentives and support for researchers to move	A,B,C
Cross-Laboratory Teams	To bring together people from across the laboratories	Coordination and communication between laboratories	A,B,C
	To help create one-company culture		

APPENDIX B

Knowledge Management - Challenges in R&D Organizations

Interview Protocol

Questions Directed to Corporate Management / R&D Center Directors

1. Please describe your company's R&D organization. In particular,
 - Where are the main units located, and what are their primary responsibilities?
 - How much interaction is there between R&D units, e.g., in terms of frequency of visits, exchanges of personnel, video conferencing, email, faxes, etc.
 - To what extent are these different units' activities coordinated? E.g., do you have any joint projects between units?
 - How many people are involved in a typical research project?
2. To what extent do you see the following aspects of knowledge management being undertaken in your company's R&D organization:
 - Knowledge transfer, i.e., from one unit to another
 - Knowledge acquisition, i.e., where one unit seeks out and gets hold of knowledge from other places
 - Knowledge dissemination, i.e., where one unit makes knowledge available to multiple other units
 - Knowledge combination / creation, i.e., where two or more units get together and create something new
3. What aspects of knowledge are most relevant in your R&D organization? Please indicate the extent to which the following types of knowledge are relevant:
 - "Intellectual property", e.g., patents, blueprints, proprietary technologies
 - "Public domain" knowledge, e.g., about industry standards, technical questions
 - Process management technology, e.g., how you make things, how you do things
 - Market knowledge, e.g., what customer needs are in various locations
 - Knowledge about specific people or contacts
4. What are the major obstacles to knowledge management in your company's R&D organization? Specifically, to what extent is each of the following a problem:
 - A secretive culture, people "hoarding" knowledge, lack of trust?
 - A lack of time?

- Difficulty in making knowledge explicit?
 - The Not-Invented-Here syndrome?
 - A lack of awareness of what knowledge is out there?
 - A difficulty in retrieving and adapting knowledge?
5. What systems does your company use to facilitate the transfer of knowledge within its R&D operations?
- IT systems, e.g., intranets, knowledge databases?
 - For your IT systems, what information is included in these? Who has access to these? Who is responsible for updating these?
 - “Structural solutions”, e.g., committees, centers of excellence, cross-functional teams, knowledge brokers, financial compensation for transferring knowledge?
 - Informal networks, e.g., “communities of practice”, socialization mechanisms?
 - Formalized activities, e.g., conferences, internal memos? Who attends these or receives these?
 - What incentives exist to promote the use of these systems?
 - What barriers do you see to the effective use of these systems?
6. How are the researchers in your R&D units evaluated? How often is this evaluation?
7. Please describe a recent case that you are aware of where knowledge was effectively transferred from one R&D unit to another.
8. Do you think the knowledge management in your company’s R&D organization is effective? How could it be improved?

Questions Directed to R&D Project Managers

Please answer the following questions keeping in mind how knowledge management was used in one particular R&D project you are/were involved with.

1. Please identify a specific R&D project that you have worked with/work on (ideally one that has been in existence for some time).
2. To what extent has your R&D project undertaken the following aspects of knowledge management:
 - Knowledge transfer, i.e., from one R&D project to another
 - Knowledge acquisition, i.e., where one R&D project seeks out and gets hold of knowledge from other places
 - Knowledge dissemination, i.e., where one R&D project makes knowledge available to multiple other R&D projects
 - Knowledge combination / creation, i.e., where two or more R&D projects get together and create something new
3. What aspects of knowledge have been most useful to your R&D project? Please indicate the extent to which the following types of knowledge have been useful:
 - “Intellectual property”, e.g., patents, blueprints, proprietary technologies
 - “Public domain” knowledge, e.g., about industry standards, technical questions
 - Process management technology, e.g., how you make things, how you do things
 - Market knowledge, e.g., what customers needs are in various locations
 - Knowledge about specific people or contacts
4. What are the major obstacles to knowledge management that people involved in your R&D project have faced? Specifically, to what extent is each of the following a problem:
 - A secretive culture, people “hoarding” knowledge, lack of trust?
 - A lack of time?
 - Difficulty in making knowledge explicit?
 - The Not-Invented-Here syndrome?
 - A lack of awareness of what knowledge is out there?
 - A difficulty in retrieving and adapting knowledge?
5. What systems have been used by your R&D project to facilitate the transfer of knowledge?
 - IT systems, e.g., intranets, knowledge databases?
 - For your IT systems, what information is included in these? Who has access to these? Who is responsible for updating these?

- “Structural solutions”, e.g., committees, centers of excellence, cross-functional teams, knowledge brokers, financial compensation for transferring knowledge?
 - Informal networks, e.g., “communities of practice”, socialization mechanisms? How do these get started? Who is involved in these?
 - Formalized activities, e.g., conferences, internal memos? Who attends these or receives these? What is the frequency of these?
 - What incentives exist to promote the use of these systems?
 - What barriers do you see to the effective use of these systems?
6. How are your researchers evaluated? How often is this evaluation?
 7. If you are interested in learning more about a certain area within your company’s R&D operations, how do you proceed?
 8. Please describe a recent example when your R&D project was involved in transferring knowledge from one location to another.
 9. Do you think the knowledge management in your company’s R&D organization is effective? How could it be improved?

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KNOWLEDGE NETWORKING

The recently developed knowledge-based view of the firm argues that knowledge is the firm's most valuable resource, yet as managers are discovering, valuable firm knowledge can easily leak across the firm's legal boundaries just as it can get stuck within them. Research on work practices has consistently shown that social relationships are an important factor in these knowledge flows (or lack of them). However, the twist is that individuals generally form these relationships not according to what the formal organization dictates, but based on personal biases and preferences for others who may be either inside or outside the firm. These relationships are the basis for informal, naturally occurring networks or "networks of practice". A tension then arises because much of the knowledge within organizations is controlled by individuals who make discretionary choices about the sharing of their knowledge, and as a result, management is finding that knowledge cannot be "managed" using the same tools that once were appropriate for dealing with physical goods.

The overarching goal of this thesis is to improve our understanding of networks of practice from a business firm's perspective, and in particular to investigate issues of structure and performance, two important areas generally left by the wayside in previous network of practice research. The study incorporates seven empirical studies in organizations including business firms, such as the more traditional Cap Gemini and Hewlett-Packard and the "less" traditional internet-consulting multinational, Icon Medialab; a large infrastructure project led by Skanska; and an online discussion community, consisting of U.S. lawyers nationwide. Using concepts, such as collective action, public goods, weak ties, and knowledge integration, and methods including a social network analysis of 1698 individuals across 16 countries, surveys, and case studies, this thesis supports taking a differentiated view of networks of practice over a unitary one. For example, our results reveal difficulty in applying a common set of structural properties to all types of networks of practice and that levels of efficient and creative performance vary depending on the network of practice.

Thus, this research contributes to an expanding inter-disciplinary field that examines the creation and sharing of knowledge in organizations as a source of competitive advantage. The results have theoretical implications for research fields such as networks of practice, social networks, and the knowledge-based view of the firm as well as empirical implications for managers striving to encourage knowledge creation and sharing within their firms.

