COMMUNITIES OF PRACTICE OR COMMUNITIES OF DISCIPLINE

MANAGING DEVIATIONS AT THE ØRESUND BRIDGE

Andrew J. Schenkel

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PREFACE

This report is a result of a research project carried out at the Center for People and Organization (PMO) at the Economic Research Institute at the Stockholm School of Economics.

This volume is submitted as a doctor's thesis at the Stockholm School of Economics. As usual at the Economic Research Institute, the author has been entirely free to conduct and present his research in his own way as an expression of his own ideas.

The institute is grateful for the financial support provided by Skanska AB, ITBF 2002, HHS, ALI, FENIX and BFR. The present volume would not have been possible without the organization that participated in this study. The Economic Research Institute wishes to warmly thank all involved for their generosity and openness.

Stockholm, November 2002

Bo Sellstedt
Director of the
Economic Research Institute
at the Stockholm School of Economics

Bengt Stymne
Professor at the Center for
People and Organization
at the Stockholm School of Economics

To Nicola and Alastair

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This dissertation was conceived of when I was obtaining treatment for cancer. At that juncture, the idea of completing this thesis was more than an intellectual pursuit, but one that represented the very essence of life. Today, five years later, this study represents not only an understanding of how problems are managed in a large complex project, but evidence that my treatment at the Karolinska Hospital has been successful.

Research and writing are only possible because of the support that one receives. This support can take on different facets ranging from financial sponsorship, the ability to access data, as well as the support of colleagues, friends and family.

Without the generous financial support of Skanska AB, ITBF 2000, FENIX, BFR and HHS this research would not have been possible. Thomas Bley and Per Westlund, both formerly of Skanska AB, as well as Kyösti Tuutti of Skanska Teknik have all been supportive of this endeavor. Mats Williamson and the employees of Sundlink offered their time to answer my many questions.

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I have had the opportunity to spend one year at Harvard. At Harvard, I would like to especially thank Associate Professor Amy Edmondson for her comments and interest in my work. As part of the Boston scholarly community I came in contact with three academics who assisted me in my scholarly voyage. Associate Professor Stephen Borgatti of Boston College introduced me to the world of social network analysis, while, Professor Georg von Krogh then a visiting professor at MIT from St. Gallen University, introduced me to the knowledge-based view of the firm. My good friend Sarah Kaplan of MIT was a vital source of creative energy and constructive comments. I would like to express my special thanks to Linda Johanson, managing editor of ASQ for teaching me the craft of article writing.

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At the Center for People and Organization, the colleagues in my close proximity provided me with insightful comments as well as support. To Andreas, Johan, Jesper, Pär and Jan, I say thank you. The remaining members of PMO all commented on my work at various stages and I would like to express my gratitude to Pernilla, Peter, Sophie, Markus, Gunnar, Svante, Annika, Ulrika and Frida. Anita assisted with various aspects of this dissertation and for that I am very grateful. There are several other people at the Stockholm School of Economics to who I am thankful for the comments that they made on various papers: Ulf Essler, Charlotte Holgersson, Mats Edenius as well as Associate Professor Per-Olov Edlund.

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Lastly, any errors of fact or judgment remain of course, entirely my own.

Stockholm, November 2002

Andrew Schenkel

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THE SETTING: THE ØRESUND BRIDGE

For thousands of years large infrastructure projects have been an important part of society. The Great Wall of China is one such project that had a profound effect on society. In the twentieth century, several infrastructure projects stand out as fantastic feats of engineering that have also had a significant impact on the flow of goods, services and people. Two of the more noteworthy are the Panama Canal and the tunnel under the English channel linking Great Britain and France. In the 1990s Scandinavia had its first project of this magnitude, the construction of the Great Belt Link, a combined bridge and tunnel that connects the island of Funen (Fyn) and Zealand (Själland) in Denmark. In 1991 inspired by the technical feasibility of the Great Belt Link and a favorable political climate between the countries, the governments of Sweden and Denmark decided to construct a bridge and tunnel link that would connect the two countries. The following year, the two governments formed the Øresund Consortium and assigned it the responsibility for designing, constructing and operating the link. In 1995, against international competition, Sundlink Contractors AB, the multinational consortium led by the Swedish construction company Skanska AB, was awarded the multi-billion dollar contract to construct the 7.8 kilometer bridge.

Known as the Øresund Bridge, it actually consists of three bridges. The largest of these, the eastern approach bridge, is over 3,739 meters long. The cable high bridge, 1,092 meters long, spans the Fleet channel and rests on massive pylons measuring over 200 meters high, making it one of Sweden's tallest constructions. The western approach bridge, the third structure, is 3,014 meters long and rests on massive concrete columns.

Building a bridge of this size is a technically challenging and complex operation that involves a high degree of coordination and control. The work sites of this project were spread out from the north of Europe in Malmö, Sweden, to the southern tip of Spain, in Cadiz. In the Malmö area there were more than 10 geographically separate work sites spread out over a 10-kilometer radius. Further, these work sites were located both on land and out at sea, where harsh weather conditions and sub-freezing temperatures are not unknown. This resource-intensive project required over 310,000 m3 of concrete, 2,300 tons of cable, 82,000 tons of steel, and 60,000 tons of reinforcement in its construction. Over 1,300

blue- and white-collar workers were involved in the actual construction, with many more indirectly involved through subcontractors.

Large infrastructure projects, of which this bridge is one example, are not well known for being completed on time, or on budget, meeting prescribed quality requirements or even serving their intended purpose (Morris and Hough 1987, Flyvbjerg et al. 2003). The tunnel between Great Britain and France serves as an example of a project that was constructed neither on time nor within the stipulated budget (Fetherton 1997). The tunnel was £ 600 million over budget and its completion was delayed by over three years (ibid.). Similarly, the Hallandsås tunnel in Sweden, a project designed to shorten travel time between the second and third largest cities in Sweden, Gothenburg and Malmö, is a project in which time, cost, and quality constraints, as well as the criterion of usability, have not been met (Danielsson and Holmberg et al. 2002). As this paper is being written, that project is still uncompleted. In contrast to these projects, the Øresund Bridge was a successful project according to traditional project performance measurements: time, cost and quality, since it was completed ahead of schedule, to the stipulated budget and fulfilled prescribed quality requirements.

The research problem: Managing deviations

Building a bridge or any large infrastructure project for that matter, is an example of the realization of a preplanned activity. First, the project is designed and thereafter it is constructed. Due to the high degree of specialization, often the organization that designs the product is not the same as the one that produces it. Since no plan can foresee all events due to our limited ability to anticipate and prescribe how to manage all events that can occur (Simon 1957), deviations from plans or requirements have to be managed, as they unfold during the actual construction. Further, it is only once production is initiated that it is found whether all requirements are satisfied or not.

In the context of a large complex project one critical strategic challenge is the management of the daily stream of problems that have not, and could not have, been dealt with in the design phase. Docherty (1971) describes for example the critical activity of the site manager at building projects as

dealing with all the contingencies that constitute his or her daily work. In this dissertation problems are operationalized as *deviations*, which are instances of non-compliance to prescribed procedures, processes or requirements. To this extent deviations are viewed as synonymous with problems. They have been chosen because such instances of non-compliance were officially recognized and recorded by the Sundlink Contractors as part of their ISO 9000 based quality standard as well as strategically important.

Deviations are of strategic importance because how they are managed impacts directly, or indirectly, on the achievement of project goals in terms of fulfilling prescribed time, quality and cost requirements. The tunnels between Great Britain and France and through the Hallandsås are both projects in which contingencies or unexpected events led to "deviations" that affected project performance (Fetherton 1997, Danielsson and Holmberg et al. 2002). This suggests that even though more than a decade has passed since Morris and Hough (1987) conducted research focused on large infrastructure projects, their conclusion that large infrastructure projects are poorly understood, and all too often inadequately managed, is still valid. It also shows that this area is worthy of further research. **The purpose of this dissertation is to investigate an organization's ability to manage deviations from prescribed requirements.**

The management of deviations at the Øresund Bridge is of strategic importance because how they are managed impacts on the project's total costs and overall completion time, as well as quality. The reason is that deviations often entail repair or replacement, with attendant additional costs. Further, repairing and replacing deviant products can result in delays – for every day that the bridge was delayed beyond the stipulated deadline, financial penalties were to be levied on Sundlink. For the Øresund Consortium, a delay would mean a loss of income because of both a delay in the collection of tolls and increased financing costs. Further, if deviations were not repaired or replaced properly, or even detected, this could affect the quality of the bridge, and thus its usability and useful life. The bridge is supposed to have a useful life of 100 years, and the financial viability of the project is based on this assumption. During the construction of the bridge, 1996-2000, there were over 2,000 reported deviations.

Reason to conduct a study on managing deviations at a bridge

The Øresund Bridge, the focus of this dissertation, was chosen for study because bridge building is recognized as a dynamic environment characterized by a set of unique problem situations. This suggests that that the deviations occurring in this project are of a strategic nature, and also that this project offers an environment in which one would expect problems to be solved both through the formal and informal knowledge-based capability.

MANAGING DEVIATIONS: A FORMAL AND INFORMAL STRATEGIC KNOWLEDGE-BASED CAPABILITY

During the last decade there has been an emergent understanding that knowledge is the firm's most precious asset and that through managing this asset firms can improve their performance (Drucker 1991, Spender & Grant 1996). In the strategic-management literature, the knowledge-based view of the firm offers insight into the firm's knowledge-related activities; not least, it helps to explain differences in firm performance. One central premise of the knowledge-based view of the firm is that interactions among individuals and groups impact on the sharing and creation of knowledge, and ultimately on the competitive advantage of firms (Grant 1996, Szulanski, 1996). These interactions are noted as fundamental to the development of knowledge-based capabilities (Kogut & Zander 1992, 1995). A capability is the capacity to accomplish an intended action and serves as the means to connect an intention with an outcome (Dosi et al. 2000).

The management of problems, of which deviations are a specific type, is recognized as one of the premier knowledge-based capabilities of the firm, and it has been argued that the firm should be considered a problem-solving institution (Loasby 1976, 1991) specialized in solving problems relating to local production activities (Foss 1999). Through the detection and correction of problems, the firm applies its problem-solving capability, and in the process it adds to its store of knowledge for use in other problem situations (Nelson and Winter 1982, Teece et al. 1991, Foss 1993). The management of problems therefore represents a dynamic

capability that is based on, and contributes to, the organization's knowledge. Through exercising this capability, the firm becomes a repository of technological and organizational knowledge that can learn and grow (Dosi et al. 1992).

This dissertation explores one particular knowledge-based capability, the ability to manage deviations and does so from two lenses: the formal and the informal capability. The informal capability is conceived of in terms of communities of practice and the formal one is exemplified by ISO 9000, a quality standard.

Communities of practice: The informal means of managing deviations

Deviations can be managed informally through communities of practice or informal groups of people that are contextually bound in a work situation applying a common competence in the pursuit of a common enterprise (Brown & Duguid 1991, Lave & Wenger 1991, Wenger 1998, Teigland 2000). Researchers have noted several benefits of communities of practice and these include: (1) an incremental source of innovation (Brown and Duguid 1991), (2) a source of problem identification, learning and knowledge production (Lave and Wenger 1991, Brown and Duguid 1991, 2001, Wenger 1998), (3) a repository of tacit knowledge (Brown and Duguid 2001), (4) the nexus of individual and organizational learning (Lave and Wenger 1991, Brown and Duguid 1991, Wenger 1998), (5) as providing firms with lower communication costs (Kogut and Zander 1992, 1995) and (6) as having protective capability because of the community's reliance on tacit knowledge (Kogut & Zander 1992, 1995, Liebeskind, 1996).

Communities arise for two interrelated reasons: (1) the inability of formal routines to deal with dynamic problems (Brown and Duguid 1991), and (2) difficulties associated with codifying certain routines (Liebeskind 1996). Firstly, in dynamic environments it is difficult to anticipate all problems that can occur and to prescribe how they should be managed (Brown and Duguid 1991). This would assume perfect rationality. As Simon (1957) pointed out, we strive to be rational, but inherent cognitive limitations impede us from having perfect predictive skills and interpretations. As a result, we are not able to predict every possible

problem or to formulate appropriate routines to deal with these problems. Further, even if we could codify routines, it is not certain whether they would be "perfectly" interpreted by the people using them. Secondly, even if our bounded rationality could be overcome, there are inherent challenges in formulating explicit routines. The difficulty in codification lies in the frequently tacit character of the knowledge on which routines are based, or in the fact that this knowledge is embedded in the individual. Since individuals are not necessarily aware of the knowledge that they possess, the question of what and whose knowledge should be codified arises (Polanyi 1967). This suggests that communities of practice and deviations arise for similar reasons. In addition, there are several other reasons as to why organizations may not want to articulate all of their tacit knowledge. It is a costly process (Liebeskind 1996), and once knowledge is codified it can more easily leave the boundaries of the firm and thus lose much of its strategic value (ibid.).

The communities of practice that emerge represent a specific type of informal group that is distinct from work groups and teams. One major difference between communities of practice and work groups is that work groups focus on the accomplishment of tasks and produce a measurable outcome (Hackman 1990), while communities of practice owe their existence to the development of their practice and the overall problem-solving capability. Although solving problems may contribute to the accomplishment of tasks, in communities of practice, it is the development of practice that is most important and the task that is secondary. A further difference is in terms of membership; in teams and work groups membership is prescribed, while in communities of practice membership is determined by, and in conjunction with, other community members (Brown and Duguid 1991). Lastly, communities have a different time span than teams and groups. The time horizon of teams and work groups is formally determined and closely connected with the task at large, while communities of practice are dependent upon the presence of three components that constitute and define communities: **joint enterprise, mutual engagement** and **shared repertoire** (all discussed below). Thus, as long as the conditions for a community of practice are present, the group will exist as a community of practice. This means that communities can have both shorter and longer time spans than work groups and teams.

A ***shared repertoire*** represents the community's routines, ways of doing things, gestures, artifacts, vocabulary and causal maps (Wenger 1998). In this respect the shared repertoire can be viewed as the means through which the community's problem-solving capacity is developed and disseminated as well as a manifestation of the accumulated tacit and explicit knowledge of the community (Boland and Tenkasi 1995). Brown and Duguid (1991) in their seminal article on communities of practice noted that a shared repertoire is formed, maintained and reproduced through three communication-based processes – narration, collaboration and social construction. This section summarizes and discusses these three processes largely based upon the work of Brown and Duguid (1991).

Narration describes how people create and tell stories in order to improve their understanding of events. This is done through transforming incoherent accounts of events into a coherent story. Stories have an advantage over codified routines in that they are flexible and can therefore be adapted to each particular situation. The "richness" of stories fills in the gaps left by manuals. Brown and Duguid further suggest that through story telling, people develop an understanding of the situation that encompasses cause and effect. This should not be viewed as neutral since it can both bind and blind communities if their underlying assumptions are not questioned (Mezirow 1991, Schein 1985).

Collaboration, the second communicative process, refers to the joint character of the shared narratives; these are collaborative to the extent that they involve both storytellers and listeners. Through this interactive process, insights leading to the development of the community's and the individual's knowledge are formed, developed and exchanged. Further, given the collaborative nature of stories, the individual member need not know everything about how to solve problems, but can draw upon the cumulative knowledge of the community (Wenger 1999). This is of particular importance in the context of knowledge-intensive tasks, which are often of a complex character and require the cumulative knowledge of the group (Teigland 2000, Cross et al. 2002).

The second function of collaboration is to reduce equivocality, or situations in which there are multiple conflicting meanings and people are not certain of the relevant questions to ask, or what are considered to be

the right answers (Weick 1979, 1995). Researchers have suggested that through collaboration community members are able to reduce equivocality (Pava 1983, Purser et al. 1992, Teigland 2000). The reduction of equivocality can be viewed as involving a series of iterative cycles in which "the community" discusses the problem at large and come to some type of shared understanding of the situation (Weick 1979). Equivocality arises because meanings the meaning that people attach to situations are not a singular objective phenomenon, but are subjective, socially constructed and therefore multiple (Weick 1979, Berger and Luckman 1966).

Social construction is the third element of a shared repertoire and refers to how meanings of one's activities are negotiated through dialogue with others to become accepted as knowledge (Berger and Luckman 1966). Social construction takes place through narration and collaboration, the other two communicative processes. Brown and Duguid (1991) suggested that there is a second feature of social construction, identity, or how a person or group views and presents himself or herself. When individuals identify with a group, of which the community of practice can be considered one specific type, they adopt the dominant attitudes and values of the group (Ashforth and Mael 1989). In communities of practice, this can take the form of adopting the behavior of other members in terms of the shared repertoire that defines the community. By being identified as a community member, he or she can access the cumulative knowledge embedded in the community (Brown and Duguid 1991).

The second component of communities of practice is ***joint enterprise***, or the common purpose that binds the group together (Wenger 1998). It is through joint enterprise that community's practice and shared repertoire is developed. The development of joint enterprise is the foundation for the mutual accountability that emerges between the individual and the community (ibid.). Mutual accountability refers to the two-way commitment that forms between individual community members and the community. This commitment obliges members to contribute to the shared repertoire, while at the same time providing them access to it. If joint enterprise is not present, the overall development of the community and of the community's shared repertoire that defines it will stagnate since people will not contribute to it.

Mutual engagement, the third component of communities of practice, refers to the amount and pattern of interaction among community members. Through engaging with each other in the context of solving problems, communities are able to develop, maintain and reproduce their shared repertoire. Mutual engagement serves a second purpose as well: through mutual engagement, individuals can acquire the ability to behave as a community member and to participate in the community (Lave and Wenger 1991, Wenger 1998). Within the community there are different levels of participation (ibid.) distinguished by the ability of the person to perform as a community member as well as the degree to which a person is accepted as a community member. Levels of participation range from fully integrated participating membership in the community to total exclusion from it.

The current conceptualization of ***mutual engagement*** is largely limited to differences in levels of participation, but it is argued that communities are both a special type of network and have specific interaction patterns. However, the concept of communities of practice as a network is mentioned only by Wenger (1998: 74, 126, 287, 298). From a social network approach, all actors are interlinked in a network, and, as a result, actors' actions can be both constrained as well as facilitated by those links (Wasserman and Faust 1999). By drawing on literature in the field of social-network analysis, and conceiving communities of practice as a special type of network, it is possible to conceptualize the structural properties of communities of practice. This leads to the first research question:

R.Q.1: What are the structural properties of communities of practice?

Conceptualizing structural characteristics of communities of practice provides an avenue for studying different aspects of communities of practice in a more focused manner, including the performance of communities of practice. To date, much of the literature on communities of practice assumes a positive relationship between performance and groups displaying characteristics of communities; however, there are few studies to support this relationship (Liedtka 1999, Storck and Hill 2000). The question whether communities of practice display improved performance is not only academic; it is also relevant because

organizations are investing resources in the development of communities of practice (Storck and Hill 2000). Investments in strategic communities are made with the underlying assumption that there is a relationship between improved performance and groups exhibiting properties of communities of practice.

In part, the difficulty of studying performance in communities of practice is related both to identifying communities and to finding a suitable measure of performance. The development of structural properties of communities of practice offers a means to identify and analyze communities; however, this still leaves the question of finding a suitable measure of performance for communities. One relevant measure of problem solving in communities of practice are learning curves that reflect the community's ability to solve problems. The basic principle behind learning curves is that productivity is linked to the volume of production -- a higher volume of production results from productivity increases due to learning (Li and Rajagopalan 1997). This leads to the second research question:

R.Q.2: How well do communities of practice perform?

It has been argued that the focal point of communities of practice is solving problems. Not all problems are of the same character, however, and one way to characterize the variability of problems is by their level of equivocality. The concept that problems vary in degree of equivocality is not widely recognized in current literature on communities of practice such as Wenger (1998), Brown and Duguid (1991), Wenger et al. (2002).

It is argued that solving problems efficiently requires a certain minimum level of understanding, since without this, it is difficult to devise actions to correct the problem. This suggests that the reduction of equivocality is critical to the formulation of actions to prevent problems from recurring as well as actions focused on remedying the actual problem. By extension this also suggests that situations characterized by high equivocality require a reduction of equivocality if effective action is to be realized. It can be argued that the communication-based processes such as collaboration and narration not only help in forming a shared repertoire, but serve as the primary means to reduce equivocality.

A shared repertoire can be developed and disseminated through different media. Media richness is a concept taken from communication theory. It suggests that media have different qualities and that these in turn influence the degree of equivocality since media vary in their ability to convey understanding (Daft and Lengel 1986). The terms richness and leanness connote the extent to which a medium can convey understanding. A rich medium conveys a high degree of understanding, and a lean medium, a low degree of understanding. However, in community of practice literature (Brown and Duguid 1991, Wenger 1998, Wenger et al. 2002), the idea that problems vary in their equivocality and media in their ability to reduce equivocality is not widely recognized. The idea that communication media influences the ability to solve problems in communities of practice has implications for learning and leads to the third research question:

R.Q.3: How does media richness influence learning in communities of practice?

ISO 9000: The formal means of managing deviations

Communities of practice have considerable advantages as previously mentioned, however, they also have two disadvantages: a low degree of management control and uncertain quality of practice. Firstly, because such communities are outside of management control, it is not certain that the shared repertoire that defines the community is homogeneously spread (Teigland 2000), which may result in the uneven application of practice. This is not desirable if customers require uniform processes or products. Secondly, a shared repertoire is socially determined and as such it does not necessarily represent best practice, but rather one that has evolved over time. Whether communities of practice do display improved performance is still an empirical issue.

To ensure the homogeneous application of practice and regular outcomes that meet customer requirements, organizations are increasingly turning to ISO 9000, a formal quality standard used by over 350,000 (International Standards Organization, 2002) organizations. The main principle behind ISO 9000 is that through a continuous cycle of formally defining customer requirements, planning activities to attain these

requirements and thereafter controlling and correcting to ensure that specified requirements are met it becomes possible to fulfill customer requirements (Johnson 1993).

Formalization refers to roles, relations and rules (Scott 1992) as prescribed and described in manuals (Hall 1977). Formal routines are a set of procedures that solve a set of problems internal to the organization (Egidi 1992). Further, these procedures are routinized to the extent that a given stimulus elicits a fixed response (March and Simon 1958). As routinization takes place, regular and predictable patterns of behavior reflecting these routines are developed (Nelson and Winter 1982). A high degree of formalization suggests that the management of deviations is prescribed in manuals. One manifestation of the formal problem-solving capability is ISO 9000, a quality-system standard.

Researchers have noted that the structure of informal organizations is influenced by the degree of formalization. For example, Salancick (1995) pointed out that the structure of informal networks is shaped through formal rules and institutions. While Brunsson and Jakobson (2000) have argued that standards create similarities and homogeneity among different peoples and organizations. As a formalized quality standard, ISO 9000 can be expected to affect the structure of communities of practice. Until recently this question has been difficult to explore owing to insufficient conceptualization of the structure of communities of practice. Further, if ISO 9000 does influence the structure of communities of practice, what processes within ISO 9000 influence the development of communities of practice? This leads to the fourth research question:

R.Q.4a: How does ISO 9000 influence the structure of communities of practice?

R.Q.4b: Through what processes does ISO 9000 influence the structure of communities of practice?

It is argued that ISO 9000, a quality standard, is a special type of technology. Scholars have shown that the implementation and use of new technology has both first and second-level effects on organizations (Sproul and Kiesler 1991). First-level effects refer to effectiveness, or productivity gains, associated with the adoption and use of new technology. This type of effect is functional and is often expressed in

terms of increased output, some measure of time, or financially, as a return on investment (Blau et al. 1976, Kraut et al. 1988). Second-level effects are considered to be the indirect effects of technology on social systems in the form of interdependent events, behaviors, and people (Sproul and Kiesler, 1991). First-level and second-level effects are related to each other to the extent that investments made with the purpose of obtaining first-level effects have offsetting second-level effects.

Thus far, the research on second-level effects (Chandler 1977, Orlikowski 1992, Barley 1988, Sproul and Kiesler 1991, Edmondson et al. 2001) has been mainly devoted to the impact of technology on social practice. This stream of research has led to an extensive understanding of the second-level effects of technology in terms of social practice; however, its focus on practice has been narrow and one-dimensional. As a result, other types of second-level effects have remained both theoretically and empirically unexplored. This leads to the fifth research question:

R.Q.5: What are the second-level effects of ISO 9000?

ORGANIZATION OF THE DISSERTATION

This dissertation consists of six papers (Papers I-VI). Paper I provides the point of departure for examining the formal and informal management of deviation, namely, the knowledge-based view of the firm. The knowledge-based view of the firm offers insight into the manner in which a set of decisions governing knowledge, capabilities and resources influence and account for differences in firm performance. This paper conducts a review and critique of the knowledge-based view of the firm. The remaining papers, II-VI, correspond to the five research questions as previously discussed. Papers II-IV focus on the informal management of deviations as conceptualized by that of communities of practice. In Paper II, the structural properties of communities of practice are developed; thereafter, Sundlink is analyzed to ascertain the extent to which its various networks display these properties. Paper III examines the performance of groups displaying attributes of communities of practice. In particular, four communities of practice at Sundlink are analyzed in terms of their ability to solve deviations. Paper IV, the last with solely a community of practice focus, studies the relationship between media richness and learning in a community of practice. This question is

examined through the impact that an organizational change has on performance in one community. Paper V acts a bridge between communities of practice and ISO 9000 through exploring two interrelated questions: (1) how does ISO 9000 influence the structure of communities of practice, and (2) what are the processes in ISO 9000 that influence the structure of communities of practice? Finally, Paper VI focuses first on conceptualizing the second-level effects of ISO 9000 and thereafter applies this framework to Sundlink.

RESEARCH SITE AND METHODS

This section describes the research site of this study, Sundlink Contractors AB, and methods used to explore the five research questions.

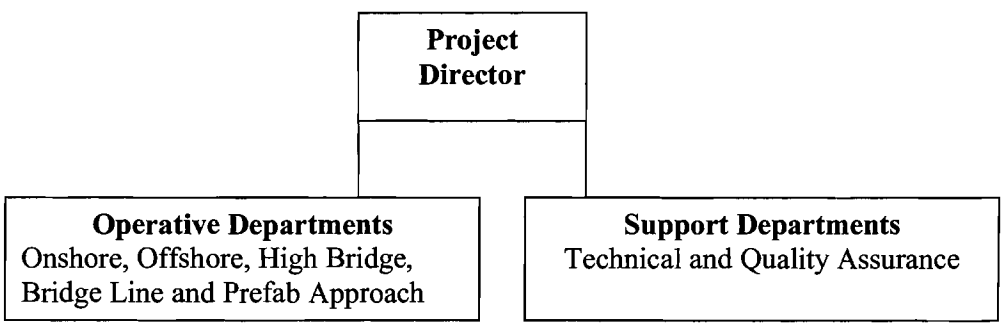
Structure of the Sundlink organization

Sundlink Contractors AB is a company formed and jointly owned company by Skanska AB, Hochtief, Höjgaard & Schultz, and Monberg & Thorsen for the sole purpose of constructing the Øresund Bridge. Sundlink has a functional organization composed of ten departments, evenly divided between support and operations. The support departments provide administrative and technical support to the operative departments. This study covers only two of the support departments: the Technical Department and the Quality Assurance and Development Department (Quality Assurance Department). The Technical Department works with matters relating to design and surveying, as well as issues of a technical nature. The Quality Assurance and Development Department is responsible for constituting, implementing and monitoring the ISO 9000 quality standard. These two departments are included in this study because they are directly involved in the management of deviations, the focus of this dissertation.

The operative departments at Sundlink are: the Onshore, Offshore, High Bridge, Bridge Line and Prefab Approach Bridges, all of which are included in this study. Two of them, the Offshore and Onshore Departments, conducted similar activities, the production of large prefabricated concrete structures called caissons and piershafts. Cumulatively, caissons and piershafts provide the massive columns upon which the bridge rests. The second major activity for which the Onshore

Department is responsible is the construction of the concrete and steel decks for the high bridge. In addition to furnishing support, these decks provide the surface of the bridge used by cars and trucks. The High Bridge Department is responsible for building the high bridge and the two large pylons that support it. The Bridge Line Department is charged with the construction of the east island, the man-made island that forms the entrance to the tunnel to Copenhagen as well as the overpass to the approach bridge. The Prefab Approach Department is to supervise the construction of the components that form the steel-based approach bridge. Prefab Approach Bridges was the only department not located in Sweden; this part of the bridge was constructed in Cadiz in southern Spain. Further, this department was the only operational department not directly involved in production since a sub-contractor built the approach bridges. A simplified organization chart of Sundlink is included in Figure 1.

FIGURE 1
Organization Chart of Sundlink



As for the *organization of the departments*, each department was headed by a department manager who reported to the project director. The departments had a small support staff directly under the department manager. In the operational departments, the function of the departmental support staff was to provide administrative services as well as limited technical and quality-focused services. The size of the departments (excluding craftsmen) ranged from about 10 people in the Technical Department to around 30 in some of the larger production departments. The departments were divided into three to five specialized sections, often corresponding to different parts of the bridge. Each section had a section head that reported directly to the department manager. The

operative sections were staffed by professional craftsmen who reported to lower-level managers in the form of supervisors and superintendents. These managers reported to the section head. An organization chart of the departments and sections of the project is included in Appendix 1.

The mean age of the population included in this study is 41.3 years (s.d. = 11.5), and the typical education level is equivalent to that of a high-school diploma. The respondents had worked in the construction industry for a mean of 17.0 years (s.d. = 12.5) and on this particular project for a mean of 2.2 years (s.d. = 1.1). The standard deviation clearly shows variance in age, and experience.

Research methods

A set of multiple methods was used in this study. This section describes the three methods used: qualitative case studies, secondary data and a questionnaire.

Qualitative case studies were used to ascertain and understand what a deviation is, how deviations are managed, who is involved in their management, and communication patterns associated with their management. Descriptive case studies are the method recommended for studying large construction projects (Morris and Hough 1987). A descriptive case study enables the researcher to observe different aspects of the phenomenon to be explored (Yin 1993). The case studies were conducted longitudinally, allowing for subtle differences to be observed and understood as events unfolded. The case studies were conducted from March 1998 to May 1999. I constructed a series of nine case studies of deviations. The cases were selected according to the following criteria: (1) to enhance accuracy, reported deviations could not be over two weeks old and, (2) there had to be a diversity of individuals and formal organizational groups involved in the deviation. For the case studies, I conducted a total of twenty-eight interviews of 40-60 minutes each. I generated the list of interviewees for each case study through a "snowball" sampling. Based upon these case studies, selected interview data from these were used as the basis for several of the papers. This essentially meant a repackaging of interview data according to the

relevant research question as opposed to analyzing the data on solely a case basis.

Secondary data were collected from two sources. Firstly, documentation of the ISO 9000 based system was described in two Sundlink documents: *Sundlink's General Procedure for the Control of Non-Conformities* and the two-part *Operations Manual.* Working methods, a part of the *Operations Manual*, describes in detail how work should be conducted. The second part of the *Operations Manual* defined the control procedures used to check whether targets were attained and procedures followed. When deviations from targets and procedures were found, these were managed according to the *General Procedure for the Control of Non-conformities.*

The other source of secondary data used in this study was records of the number of repair deviations over time. To measure performance, the learning curves (Yelle 1979) were produced through calculating and plotting the cumulative total of deviations, divided by the cumulative total output in terms of concrete produced. Since improvements are more difficult in absolute terms once a previous improvement is made, a period of constant learning plotted logarithmically is shown as straight line with a negative slope (ceteris paribus). The learning curves were constructed from deviations that occurred from June 30, 1996 to June 30, 1998. A representative of the Technical Department classified the deviations, since the researcher did not possess the necessary technical competence. Reliability was increased through regular audits conducted by members of the Quality Assurance Department and the client (Øresund Consortium). In addition, there was a quality controller responsible for ensuring that all deviations were identified and reported.

A questionnaire was used to capture communication patterns as well as socio-demographical data. The 39 open- and closed-ended questions on media attitudes and frequency of use were distributed to 137 people (87.6% response rate) during a nine-month period ending in May 1999. 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, and a later point might have been subsequent to their

devolution. The survey included all managers, engineers and supervisory personnel involved in the management of deviations. Craftsmen were excluded from this study in view of their limited role in the actual management of deviation.

The UCINET network analysis software package was used to analyze network data from the question to whom do people turn for advice in a deviation situation (Borgatti et al. 1999). The data were imported into Krackplot (Krackhardt et al. 1994), a program for graphical analysis of networks. Statistical data from the questionnaire were analyzed through the use of SPSS, a program for statistical analysis.

SUMMARY OF PAPERS

This section provides a summary of the six papers that form the basis of this dissertation. Table 1, presents a summary of the research question, paper number as well as research methods utilized.

TABLE 1
Summary of Research Question and Methods

Research Question	Paper	Research Methods
R.Q.1: What are the structural properties of communities of practice?	II	Network analysis
R.Q.2: How well do communities of practice perform?	III	Network analysis, selected qualitative interview data from the case studies, secondary data (learning curves), questionnaire data
R.Q.3: How does media richness influence learning in a community of practice?	IV	Selected qualitative interview data from the case studies, secondary data (learning curves), questionnaire data
R.Q.4a: How does ISO 9000 influence the structure of communities of practice? *R.Q.4b: Through what processes does ISO 9000 influence the structure of communities of practice?*	V	Network analysis, selected qualitative interview data from the case studies, secondary data (documentation of the ISO 9000 based system)
R.Q.5: What are the second-level effects of ISO 9000?	VI	Selected qualitative interview data from the case studies, and secondary data (documentation of the ISO 9000 based system)

Paper I. Knowledge Based Theories of the Firm in Strategic Management: A Review and Extension

The overall purpose of strategic management theory and research is to explain how and why there are differences in the performance of firms. Since strategy scholars have a collective interest in understanding the fundamental nature of the firm, therefore theorizing about the origin, structure, boundaries, and performance of the firm has assumed an increasingly important role in this field. During the last half a century strategy researchers have made progress in understanding the interaction between firms and their competitive environment. Contributions have been based on various approaches including a behavioral theory of the firm, an attention-based view of the firm, a transaction-cost-based view, and lately, a knowledge-based view of the firm.

Of all these developments, the knowledge-based view of the firm has distinctive features that are particularly appealing for understanding firm performance. Firstly, it draws on and/or encompasses many of the insights developed in the behaviorally oriented theories of the firm, like the interplay between action, cognition, and a shared identity of organizational members, as well as the resource-based view on the nature of competence and assets that enable a firm to sustain its competitive advantage. If developed sufficiently, it could also offer a complementary view to the explanation of firm boundaries on the basis of transaction-cost economics. Secondly, it adds knowledge at the group and the firm levels of analysis to what had been a construct only at the individual level of analysis. By so doing, it puts particular emphasis on the interaction among individuals and groups in the sharing and creation knowledge, and ultimately on the effect of these interactions on performance. Thirdly, it reflects an emergent understanding among managers and academics that knowledge is their most precious asset. The knowledge-based view of the firm provides novel analytical tools and approaches for understanding knowledge-intensive firms. Fourthly, a knowledge-based view of the firm connects well to a parallel stream of knowledge management in practice. Recently, managers have become increasingly aware of the importance of managing the information and the knowledge of their employees, and various techniques and instruments have been developed to this end. A knowledge-based theory of the firm might explain this movement, as well as the possible implications of knowledge

management activities for firm performance.

Yet, in strategic management the knowledge-based theory of the firm is still a contested and unmapped terrain. In fact, as of this writing, no unified, clear-cut theory exists. There are many partial explanations, each building on its own set of assumptions ranging from methodological individualism to social-psychological identity theory. Consequently, the concepts and their relationships vary considerably, and no comprehensive predictions can be made.

This paper reviews current contributions to the knowledge-based theories of the firm in strategic management and suggests that any proposed theory in this area should account for the following aspects of the firm: existence, boundary, structure, behavior and performance. A selected review of the literature shows that progress has been made in understanding critical components of a knowledge-based view of the firm, but taken separately the theories are incomplete, and viewed collectively they are contradictory. They neither meet all requirements of a theory of the firm, nor do they elucidate the mechanisms that link knowledge with performance. To address these criticisms, an integrated model of the knowledge-based view of the firm that encompasses and extends previous contributions is provided. The components of the model are: knowledge, resources and capabilities. This model treats knowledge as extending throughout the firm and beyond its boundaries, as well as something distinct from resources and capabilities. Further, knowledge interacts with both resources and capabilities, and this interaction accounts for the effects of knowledge on firm performance.

Paper II. Theorizing Structural Properties of Communities of Practice: A Social Network Approach

Increasing competition and complexity have led scholars and practitioners to recognize the value of knowledge. On a strategic level, many have chosen the knowledge-based view of the firm. The concept of communities of practice is a complement to the knowledge-based view of the firm and can be seen as describing the informal knowledge-based problem-solving capability of the firm. Research on communities of practice is still at an early stage of development, however, with the

majority of the research consisting of anecdotal accounts of communicative processes. Researchers have paid little attention to conceptualizing the *structural* properties of communities of practice. This gap is surprising because structure is closely related to communicative processes that form, and constitute, a shared repertoire.

This study conceptualizes the structural properties of a "well-functioning" or "ideal" community of practice by drawing on social-network literature and synthesizing it with existing literature on communities of practice. Based upon this synthesis, four structural properties of a community of practice are proposed on a network level: 1) connectedness, 2) graph-theoretic distance, 3) density, 4) core/periphery structure. In addition, one structural property is proposed on an individual level: coreness.

The usefulness of these properties is shown through applying them on the informal advice network at Sundlink. It was found that the informal advice network of the project as a whole did not possess the structural properties of a community of practice. Although the network was fairly well connected with few isolates; however, the density that one would expect of a well-functioning community of practice was low. Although there were no significant sub-groups in the network, the low density resulted in a weak core/periphery structure that was not consistent with the conception of a well-functioning community of practice.

On an inter-departement level, the informal advice network displayed the structural properties of a community of practice. The support departments (Technical Department and Quality Assurance) formed the community's core, and the operative departments, the periphery. The operative departments were not directly connected with each other as interactions are brokered through connections with the Technical and Quality Assurance Departments. The lack of direct contact between operative departments is noteworthy since four out of five of the operative departments were performing similar activities involving concrete. The investigation of the advice network on an inter-departmental level parts with Lave and Wenger's (1991) conceptualization of communities of practices composed of individuals and at the same time it is a small network with few nodes.

A deeper investigation of the organization, analyzing three individual departments, two operative and one support, shows that only the Technical Department satisfies the structural properties for an ideal community of practice on a departmental level. This means amongst other things that members were "tightly" connected with each other, and there was a clear core and periphery. The most central individual actors in the Technical Department were the concrete and design section heads.

Paper III. Investigating the Relationship Between Communities of Practice and Organizational Performance: A Case Study in the Construction Industry

In recent years, scholars have turned their attention to the emerging theoretical concept of communities of practice in the hope of better understanding knowledge-based work. This stream of literature suggests that groups with these attributes show better performance than those without them, but few studies have empirically examined the relationship between communities of practice and organizational performance. This research attempts to fill that gap through examining the relationship between several communities of practice consisting of engineers, managers and supervisors within Sundlink, and performance. Using the concept of learning curves, the study showed that communities of practice that operated under stable conditions exhibited improved to static performance over time. Specifically, we found that the Piershaft Section showed improved performance and the Caisson and High Bridge Deck/Girder sections static performance to the extent that the level of errors was constant. However, the Pylon Section initially had a positive rate of learning followed by a period of negative learning, with an increase in the number of deviations. In other words, the period of positive learning was broken.

It is proposed that both this break in the learning curve at the Pylon Section, and the decline in performance, were indirect effects of an organizational change that affected the use of communication in this community. The organizational changes that occurred consisted of moving the production of pylons from the dry dock out to sea and dividing the pylon section into two separate production units. This change meant that the units were separated not only from each other, but also

from the department's technical and support staff located on land as well as from the Technical Department, a source of advice. Moreover, the changes in communication affected the ability of that specific community to access, and develop, its shared repertoire, a manifestation of the community's cumulative knowledge. This knowledge-base serves as a memory and is essential to solving complex problems. This study cautiously suggests that the change in performance in this community was indirectly influenced by changes in available communication media that resulted from the organizational change, and moreover, the ability of this particular community to access and develop its memory.

Paper IV: Investigating the Influence of Media Richness on Learning in a Community of Practice: A Case Study at the Øresund Bridge

How organizations prevent and manage problems is critical to organizational performance and long-term competitiveness. Through solving problems, firms develop and draw upon a repository of technological and organizational knowledge, but problems vary in character and in degree of equivocality. To reduce equivocality, communities of practice employ two communication-based processes: narration and collaboration. However, in current literature on communities of practice, little distinction is made between different media and their inherent richness, and potential to reduce equivocality. The fact that media vary in their capacity to convey understanding suggests that media impacts on the learning in communities of practice. This study investigates the influence of media richness on learning in communities of practice.

This study found that an organizational change at the Pylon Section resulted in an increase in the number of deviations at that section. The organizational change meant that formal and informal face-to-face communication, telephone, telefax and email communication were impeded. The impediment of face-to-face and telephone communication is noteworthy since these were considered the "richest" media used at the Pylon Section. This suggests that when the option of rich communication is removed in groups displaying characteristics of communities of practice, equivocality cannot be reduced and that consequently learning is

impeded. This study illustrates how learning in communities of practice, the detection and correction of problems (Argyris and Schön 1995), requires that media be matched to the degree of equivocality presented by problem situation. Situations high in equivocality call for rich media; conversely, lean media should be used in situations of low equivocality. Furthermore, this study suggests that planned organizational changes need to be evaluated in terms of their impact on communication patterns, or more specifically, in terms of the media available for use in communication.

Paper V. Exploring the Influence that ISO 9000 has on the Development of Communities of Practice

Organizations are increasingly using ISO 9000, a formalized quality standard whose purpose is to help organizations obtain desired outcomes by following prescribed procedures. It has been noted, however, that formal procedures, such as those that are the basis of ISO 9000, are often unable to cope with the management of problems, particularly those associated with codification. Therefore, it has been suggested that informal groups such as communities of practice arise to manage these problem situations. In this respect, two types of organizations – formal and informal – are actually operating concurrently within a single organization. However, the development of informal groups does not take place in a vacuum, but is affected by formal rules, positions and institutions. This paper explores the influence that an ISO 9000 based quality standard has on the development of communities of practice as well as the underlying processes within this quality standard that influence the development of communities of practice.

The network data from the questionnaire indicates that there is a 71% overlap between the reported informal advice network and the formally prescribed advice network. This finding was further supported by the qualitative interview data. On the whole, it could therefore be concluded that there did not exist much of an informal advice network at Sundlink, rather an advice network that was patterned on formal procedures. In this network, the Quality Controllers, a formal position responsible for administering the quality standard and checking that procedures are followed, occupied the most contacted position in the informal advice

network.. This finding is of interest in the study of problem solving, since the Quality Controllers were relatively inexperienced, with only one year of similar working experience. It is proposed that the strong relationship between the formal and informal networks, as well as the structure of the networks, is explained by the disciplining and surveillance elements embedded in ISO 9000. Surveillance was exercised by the formal hierarchy, more specifically actors such as the Quality Controllers responsible for ensuring that procedures were followed. Over time, disciplining became a natural part of work as people followed prescribed procedures and left them largely unquestioned. The maintenance of records to identify deviations served as the means of distinguishing what was normal from what was deviant. This study showed how formal practice is imitated as well as reinforced through the discipline and surveillance provided by ISO 9000. To this extent, formal practice is not necessarily chosen by those who do the actual work. Further, this study suggests that through ISO 9000 experts are created and their position reinforced. Thus they, become part of the problem impeding the development of informal communities of practice.

Paper VI. Conceptualizing and Exploring the Second-Level Effects of ISO 9000 in the Construction of the Øresund Bridge

ISO 9000 is a quality standard consisting of formal rules to ensure that materials, products, processes, and services are fit for their defined purpose. Although, ISO 9000 has been primarily viewed as a quality standard, it can be argued that it is a special type of technology. Scholars have shown that the implementation and use of new technology has both first and second-level effects on organizations and in particular on organizational practice. To date, the conceptualization of second-level has been narrowly defined and limited to effects associated with social practice. To study second-level effects as defined in such a limited manner leaves important questions unexplored, and to a large extent, unexplorable.

This paper develops a framework for understanding second-level effects of ISO 9000 based on the concept that changes in practice do not occur in isolation. It is suggested that social practice reflects, and develops in conjunction with, underlying thought figures and -- indirectly -- with

discourse (rules governing dialogue). Thought figures serve as the mediator between discourse and social practice. The analysis of ISO 9000 through the framework developed in this paper demonstrates how ISO 9000 affects the very way that people communicate, think and work in a large, complex project. Communication effects were found in terms of who can speak/write, what people can speak/write about and when they can speak/write. In this case, staff from the Technical Department -- in contrast to operative personnel who would be conducting the actual work -- were able to establish the relevant working methods used to construct the actual bridge. ISO 9000 influenced thought figures in terms of what was considered normal and deviant; in this way, normality was constituted through ISO 9000. Social practice was influenced by this quality standard in terms of the conduct of work, tasks and roles as well as patterns of interaction. More specifically, the informal interaction patterns in the context of deviations resemble those of the formal organization.

DISCUSSION AND CONCLUSIONS

The purpose of this dissertation was to investigate an organization's ability to manage deviations. In particular, how deviations at a large bridge project are managed, with the primary emphasis on examining different facets of the informal knowledge-based capability of managing deviations was explored. This capability was conceived of in terms of communities of practice. The first article (Paper I) on which this dissertation is based elaborated a critique of and developed further the knowledge-based view of the firm. The conclusion drawn from this review was that there are many partial contributions to the knowledge-based theory of the firm but there is currently no complete knowledge-based theory of the firm. Further, there exists tensions amongst current contributions, and therefore, one of the key contributions of this paper is a model that reconciles these. The model is of interest because of not only the obvious and prominent role conferred on knowledge, but also its relationship to resources, capabilities and performance.

The remaining papers supporting the dissertation were devoted largely to investigating how the concept of community of practice can provide insights into the capability of managing deviations. To explore the concept of communities of practice, it was necessary to first define and

depict what is a community of practice. Therefore, Paper II focused on R.Q.1 (*What are the structural properties of communities of practice?)* and developed a framework for analyzing structural properties of what can be considered a "well-functioning" community of practice. The development of structural properties of a community of practice allows for communities to be detected and analyzed.

The emergent advice networks at Sundlink were analyzed based on these properties. On a project-wide level, the emergent advice network did not display structural properties of a community of practice, but instead strongly resembled the formal prescribed network structure for the management of deviations. However, the inter-department advice network did display structural attributes of a community of practice. It is proposed that the structure of these networks can both be explained by the disciplining and surveillance elements embedded in ISO 9000. This raises the strong possibility of committing the error of concluding that the interdepartmental level was a community of practice. Further, this highlights one of the limitations of taking solely a structural perspective when analyzing communities of practice.

Although the disciplining elements of ISO 9000 constrained the formation of communities of practice on the project level, they facilitated the development of communities to a limited extent on the departmental level. The Technical Department was the department analyzed that best displayed structural properties of a community of practice. Thus in response to R.Q.4a (*How does ISO 9000 influence the structure of communities of practice?)* it is suggested that ISO 9000 impeded the development of a community of practice on a project level, while facilitating the development of them in the case of the Technical Department. In response to R.Q.4b (*Through what processes does ISO 9000 influence the structure of communities of practice?)* it is suggested that the formalization of the informal advice network was due to the disciplining and surveillance processes embedded in ISO 9000.

The formation and development of communities of practice were clearly influenced not only by ISO 9000, but also by the availability of communication media. The communities of practice that formed largely consisted of groups that could interact on a regular basis with face-to-face communication, an example of rich media. The groups that did show

structural attributes of communities of practice tended to consist of sections and departments that were geographically united since regular face-to-face interaction is highly dependent upon co-location. Conversely, departments with geographically dispersed sections failed to show structural features of a community of practice because their ability to communicate with rich media was impeded.

Paper III focused on R.Q.2 (*How well do communities of practice perform?)* and the findings were mixed as to whether groups displaying attributes of communities of practice showed improved performance in terms of the incremental ability to solve problems. Performance improved at the Piershaft Section, while there was no change in performance at the Caisson and High Bridge Deck/Girder Sections – i.e., their ability to solve problems neither improved nor deteriorated.

One of the more noteworthy observations was that in the Pylon Section, the performance tendency changed from positive to negative. The reason proposed for this was that an organization change impaired the ability of this community to communicate and thus to develop and disseminate a shared repertoire, a form of organizational memory. A further investigation into the performance of the Pylon Section was conducted in Paper IV which focused on R.Q.3 (*How does media richness influence learning in a community of practice?),* and it was suggested that the learning in this section was impaired because of the inability to reduce equivocality, another critical function of the shared repertoire, and one that is dependent upon rich media in situations of high equivocality. However, rich media in and of itself is not sufficient for improved performance communities of practice and is seemingly only a prerequisite to avoid negative performance. Thus in response to R.Q.3, media richness does indeed influence performance in the communities of practice studied. Nevertheless, the findings in response to R.Q.2., and R.Q.3., have to be carefully interpreted since the question of what is a community of practice is cognitively determined by its members.

Paper VI focused on R.Q.5 (*What are the second-level effects of ISO 9000?)* and began by developing a framework for understanding the second-level effects of ISO 9000. This was applied at Sundlink, where it was found that through ISO 9000, targets and procedures are planned as well as codified. In the process these form the standard of normality.

Activities are judged against this standard, and situations that do not comply with this are viewed as deviant, and as such, a problem. To this extent, deciding what is normal and what is deviant becomes a subjectively constituted concept as well as an expression of power. However, the role of power is not limited to defining what constitutes a problem; it also influences the actions taken in problem situations and the realm of possible solutions. In both cases members of the Technical Department were apparently at the center of these networks and played a critical role in determining what was considered normal and in finding appropriate solutions. The articulation of norms, deviations and solutions affects the knowledge drawn upon and accumulated during problem-solving activities. The constitution of norms through ISO 9000 extended to a specific way of thinking, acting and talking about problems. In other words, not only procedural knowledge was acquired in conjunction with ISO 9000, but also influenced discourse, thought figures and social practice, all second-level effects of technology. Thus in response to R.Q.5., ISO 9000 does indeed have a profound and wide-ranging affect on an organization. When these effects are combined with a disciplining and surveillance system the body and the unconscious are penetrated as people normalize their behavior. The means by which these norms were enforced was that of active surveillance conducted within the context of ISO 9000.

Was Sundlink more of a community of discipline than a community of practice?

This dissertation has developed and explored concepts related to communities of practice in the context of a large infrastructure project and found that their formation and development were influenced by formal procedures related to ISO 9000. It is argued that the emergent advice network at Sundlink did not fulfill the criteria of a community of practice because the management of deviations was to a large extent handled formally. However, it is suggested that formal procedures facilitated the development of the Technical Department as a community of practice. The reason suggested lies in their formal mandate to solve problems as well as in the type of problems that they were encountering, which required the collective knowledge of the department. Their problem solving ability was seemingly enhanced through the surveillance apparatus embedded in ISO 9000 that disciplined the periphery to follow

procedures. The more the procedures were followed, the more the Technical Department learned. In this way, the conditions for a virtuous circle for problem solving were created; with each deviation, the Technical Department became more knowledgeable and capable of solving problems. In essence, members of the department had a license to learn. This license explains not only why this particular department presented features of a community of practice, but also -- in part -- why the Technical Department formed the core of the interdepartmental advice network. In sum, formal procedures allowed for certain communities to develop, while adversely affecting the development of others. Thus, it is suggested that there were both communities of practice as well as communities of discipline at Sundlink.

Linking the problem solving capability and performance

The management of deviations at Sundlink should be put in a strategic perspective. In other words, what was the actual project performance? As suggested in the introduction, according to traditional metrics of performance -- time, cost and quality -- the project was a success since it was completed ahead of schedule and within the stipulated budget in addition to achieving the desired quality. By extension, this suggests that the project goals were reached through having a small core that functioned as a community of practice (Technical Department) with a highly disciplined periphery that followed formal procedures. This type of structure allowed for the core to learn and develop its cumulative knowledge-base. This is of interest since community of practice literature would have suggested a more tightly connected network based on informal relationships than the one that was observed at Sundlink. Yet, the performance of this project suggests that a small community of practice that forms the core of a network and a disciplined periphery can indeed obtain satisfactory results according to traditional metrics of performance. This possibly suggests that some communities are more strategically important to organizations than others when it comes to managing deviations.

An overarching question of whether communities of practice constitute a knowledge-based capability that positively influences performance in a large complex infrastructure project, has not received unconditional

support. On the one hand, the Technical Department displayed structural aspects of a community of practice and deviations appeared to be dealt with in an efficient and effective manner as suggested by the overall project performance. On the other hand, many departments and the wider project network did not display structural aspects of communities of practice. Even the performance data with respect to section displaying attributes of communities of practice were mixed. Therefore, the view of communities of practice as a panacea for enhancing learning and improving performance in a large complex project cannot be maintained.

LIMITATIONS OF THIS STUDY

The results presented in this study should be interpreted with some caution, since this dissertation is based on one special type of case study, the construction of a large, complex infrastructure project where the penalties for not meeting time and quality specifications were severe. To this extent, many of the analyses, conclusions and implications are of a local rather than general character. Further, the data collected in this study represent a snapshot picture of Sundlink at one specific point in time; had the data been collected at another time, different results might have been obtained. Nonetheless, in the remaining sections we will try to interpret our results and speculate what they could imply for the strategic capability of organizations devoted to project realization.

MANAGERIAL IMPLICATIONS

This dissertation has examined the construction of the Øresund Bridge by focusing primarily on the informal means of solving problems, a strategic knowledge-based capability and to a limited extent the formal one. As previously indicated the project was considered a success based upon traditional metrics of project performance; however, traditional metrics do not include the knowledge-based capability of solving problems or for that matter activities such as the creation, dissemination and embedding of knowledge. The question of what would have happened to project performance had knowledge-based metrics received more attention is a point of conjecture. However, it would seem reasonable that if knowledge-based activities were improved, this would have positively impacted on overall project performance. This section discusses

managerial implications in terms of several actions that could have been taken to improve the knowledge-based capability of managing problems.

Using communities as a means to enhance the capability of managing problems

While the evidence of the performance of communities of practice is mixed, the concept of managing problems through communities remains a useful and powerful way of viewing this capability. If the development of communities is to be encouraged, this requires a community-based strategy and policies that support community development. A community based strategy means making problem solving an opportunity for learning that extends beyond the narrow focus of problem solving confined to a few members of the Technical Department and one specific section. To support this new strategy, the role of the Technical Department should be redefined to include acting as a problem-solving broker rather than just a problem solver. Further, a community-based strategy requires policies focused on community development. Such policies should amongst others things focus on providing resources and legitimacy for communities.

Utilizing the partial emergence of communities of practice as a means of knowledge transfer and development

The key role that the Technical Department played in solving problems as well as the structural characteristics of their advice network clearly has implications in terms of developing the organization's ability to solve problems. This study showed that the Technical Department played a major role in solving deviations and displayed structural attributes of a community of practice. From a community of practice perspective learning occurs through acting as a member of a community in the context of solving problems. This suggests that an effective means of knowledge transfer and development would be for people to work in the Technical Department and in the process they would learn how to act as a community member and gain access to the knowledge that is embedded in the practice of the community. In addition, this has the consequence of disseminating knowledge over a wider knowledge base, and in turn,

makes the organization less vulnerable if certain key actors leave the project.

Is it possible to organize projects as a community of practice?

The key role that the Technical Department played in solving problems suggests that it is important to maintain this unit as a community of practice after the project is completed. The reason for this is that communities of practice take time to develop and often it is during the early stages of the construction phase that deviations occur. At the same time, the community of practice literature (Wenger 1998) suggests that the development of communities is dependent upon the recurrence of problems. This suggests that there is a lag in the formation of communities of practice and that their formation does not coincide with the time point in which they are most needed, the beginning of projects. Therefore, one of the implications of this study is that the project's overall project solving capability can be enhanced by policies focused on maintaining the Technical Department as a community of practice after the project has been completed.

In terms of policies this means providing people with resources in the form of time and money to interact as well as a context in which practice may continually be developed. Such policies should also focus on identifying, recognizing and rewarding people who form the core of communities as well as people on the periphery who act as brokers to other communities. Rewards act as the lever of change (Beer and Nohria 2000) and as of writing, the question of rewarding knowledge development and dissemination as well as learning should come much higher on the management agenda.

Extending the boundaries of knowledge: Developing networks outside of the organization

At Sundlink the external advice network was not particularly well developed as suggested by the limited extent of external contacts, approximately 3 per cent of all contacts. This can be taken to indicate that advice networks are active only during the life of the project, with few

external contacts after the project has been completed. The development of networks that go beyond the bounds of particular projects would mean that organizations through their members could gain access to knowledge, which they could not otherwise have obtained. Firms would then be presented with opportunities to absorb knowledge from outside the firm's boundaries and to combine this knowledge with that residing inside the firm to create new knowledge. Therefore, policies focused on sustaining networks after projects have been completed should be given priority. This in turn requires policies similar to those that were recommended for the development of communities of practice. In practical terms this includes providing resources for people to interact, incentive systems that encourage the use of knowledge gained from these networks as well as management support for the informal practice that is developed by these communities.

Using ISO 9000 as an opportunity to enhance the capability of managing problems

Quality standards such as ISO 9000 can facilitate the creation, development, dissemination and embedding of knowledge that underlies the problem solving capability if its constitution is used as a starting point, as opposed to an end point. This was not the case at Sundlink, where the formulation of the ISO 9000 based processes and procedures was carried out by a few people and thereafter adopted by the rest of the organization. In other words, people who were supervising the work and very close to the actual production were not largely involved in formulating working methods, control procedures or even procedures for managing deviations. It is therefore suggested that the formulation of quality standards and routines should be co-determined by people carrying out and supervising the work and by members of the Technical and Quality Assurance Departments. This type of interaction presents an opportunity to absorb, combine and develop existing knowledge.

This also suggests that the implementation of ISO 9000 should remain in the domain of people who will be dealing with problems and not with external consultants. This is a reasonable strategy since Beer and Eisenstat (2000) pointed out that the use of consultants could inhibit change and learning. Thus if one of the purposes of implementing ISO

9000 is to facilitate learning in terms of developing and disseminating knowledge, than the absence of consultants is desirable.

Communication media: A necessary ingredient for problem solving and the development of communities

This study has highlighted the effect that communication media have both on learning and on the development of communities of practice. Managers therefore need to consider the availability of rich media as well as how organizational changes can affect this. In this study the lack of rich media was caused by an organizational change and was associated with negative performance in a community of practice. Thus, providing rich media as well as opportunities to interact with these media would seem to be essential to problem solving.

FURTHER RESEARCH

In the field of communities of practice, one area worthy of further development is research focused on the relationship between communities of practice and performance. The tentative evidence provided in this study was mixed as to whether communities of practice display improved performance over time. Thus, identifying variables that influence performance in communities of practice is one possible avenue for further research. To facilitate this research, the focus should be on developing more precise measures of the structural properties of communities of practice as opposed to relying on experiences of individual researchers. The advantage of such measures is that they would offer a means of identifying and analyzing communities.

In the area of communities of practice this dissertation has highlighted the existence of a community of practice (Technical Department) in a highly disciplined system. This type of hybrid community in which an informal community is surrounded by a formal periphery is worthy of further research since it questions the very notion of emergent communities of practice. It also brings into question the issue of designing communities.

This research has examined different facets of ISO 9000 and has laid a preliminary foundation for understanding second-level effects. Further

research could focus on fine-tuning these concepts and on their interrelationship. Lastly, the formal and informal means of solving problems are not unrelated and seemingly co-evolve; that is, ISO 9000 seemingly affected the formation of communities of practice. For this reason, research focused on the co-evolution of problems solving networks would be of interest.

References

Allen, T.J. (1977). *Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information within the R&D Organization*. Cambridge, MA: MIT Press.

Ashforth, B., and Mael, F. (1989). Social Identity Theory and the Organization. *Academy of Management Review.* 14, 20-39.

Barley, S.R. (1988). Technology, Power, and The Social Organization of Work. *Research in the Sociology of Organizations*, 6, 1988: 33-80.

Beer, M. and Eisenstat, R. (2000). Overcoming the "Silent Killers" to Strategy Implementation and Organizational Learning. *Harvard Business School Working Paper Series*, No. 00-076.

Beer, M., and Nohria, N. (2000). *Breaking the Code of Change.* Boston: Harvard Business Press.

Berger, P. and Luckman, T. (1966). *The Social Construction of Reality: A Treatise in the Sociology of Knowledge.* London: Penguin Publishers.

Blau, P.M., Falbe, C.M., McKinley, W. and Tracy, P.K. (1976). Technology and Organization in Manufacturing. *Administrative Science Quarterly.* 21, 20-40.

Borgatti, S., Everett, M.G., & Freeman. L.C. (1999). *UCINET 5 for Windows.* Natick, MA: Analytic Technologies.

Brown, J.S., & Duguid, P. (1991). Organizational Learning and Communities of Practice. *Organization Science*, 2, 40-57.

Brown, J.S., & Duguid, P. (2001). Knowledge and Organization: A Social – Practice Perspective. *Organization Science*, 12, 2: 198-213.

Brunsson, N., and Jakobsson, B. (2000). *A World of Standards.* Oxford : Oxford University Press.

Buchel, B., and Raub, S. (2001). Media Choice and Organizational Learning. In Handbook of Organizational Learning and Knowledge. Edited by Meinolf Dierkes. Oxford: Oxford University Press.

Chandler, A. (1977). *The Visible Hand: The Managerial Revolution in American Business.* Boston: Harvard University Press.

Conner, K.R., & Prahalad, C. K. (1996). A Resource-based Theory of the Firm: Knowledge versus Opportunism. *Organization Science*, 7, 477-501.

Cross, R., Borgatti, S. & Parker, A. (2002). Making Invisible Work Visible: Using Social Network Analysis to Support Human Networks. *California Management Review.* 44(2), pp 25-46.

Daft, R. L., & Lengel, R. H. (1986). Organizational Information Requirements, Media Richness and Structural Design. *Management Science*, 32(5): 554-571.

Daft, R. L., Lengel, R. H., & Trevino, L. K. (1987). Message Equivocality, Media Selction, and Manager Performance: Implications for Information Systems. *MIS Quarterly*, 11(3): 355-366.

Danielsson, A., and Holmberg, I. (2002). *Ledarskapets Olika Skepnader - Exemplet Hallandsås.* Lund: Studentlitteratur.

Docherty, P. (1971). *The Management of Contingencies.* Stockholm: EFI.

Dosi, G., Winter, S., and D.J. Teece (1992). Towards a Theory of Corporate Coherence, in G. Dosi, R. Giannetti, and P.A. Tonininelli, (Eds), Oxford: Clarendon Press.

Drucker, P. (1991). *Post-capitalist Society.* Oxford: Butterworth-Heinemann.

Egidi, G. (1992). Organizational Learning, Problem Solving, and the Division of Labour, in Egidi, Marris (editors) *Economics, Bounded Rationality and the Cognitive Revolution.* Brookfield: Edward Elgar.

Edmondson, A., Bohmer, R., and Pisano, G., (2001). Disrupted Routines: Team Learning and New Technology Implementation in Hospitals. *Administrative Science Quarterly.* 46, 685-717.

Everett, M.G., & Borgatti, S.P. (1999). Peripheries of Cohesive Subsets. *Social Networks.* 21, 397-407.

Fetherton, D. (1997). *The Chunnel.* New York: Times Books.

Flyvbjerg, B., Bruzelius, N., and Rothengatter, W. (2003). *Megaprojects and Risk: An Anatomy of Ambition.* Port Chester, NY: Cambridge University Press.

Foss, N. (1993). Theories of the Firm: Contractual and Competence Perspectives" (1993). *Journal of Evolutionary Economics 3 (2)*: 127-144. (Reprinted in Nicolai J Foss, ed. 2000. *The Theory of the Firm: Critical Perspectives in Economic Organization.* (4 vols.). London: Routledge.

Foss, N, (1999). Networks, Capabilities and Competitive Advantage. *Scandinavian Journal of Management.* 15 1-15.

Grant, R. 1996. Toward a Knowledge-Base Theory of the Firm. *Strategic Management Journal.* 17(Special Issue): 109-122.

Hackman, J., (Ed.) (1990). *Groups that Work (and those that don't): Creating Conditions for Effective Teamwork.* San Francisco, CA: Jossey-Bass.

Hall, R.H. (1992). *Organizations: Structures, Processes, and Outcomes* (5th edn). Englewoods Cliffs, NJ: Prentice Hall.

Johnson, P. (1993). *ISO 9000: Meeting the New International Standard.* New York: McGraw Hill.

Kogut, B., & Zander, U. (1992). Knowledge of the Firm, Combinative Capabilities and the Replication of Technology. *Organization Science*, 3, 383-397.

Kogut, B., & Zander, U. (1995). Knowledge of the Firm and Evolutionary Theory of the Multinational Corporation. *Journal of International Business Studies*, 26, 625-644.

Krackhardt, D. and Blythe, J. and McGrath, C (1994). Krackplot 3.0: an improved network drawing program. *Connections*, 17(2):53-55.

Kraut, R., Koch, S. and Dumais, S. (1988). Computerization, Productivity, and Quality of Employment. *Communications of the ACM,* 32, 2, 220-238.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate Peripheral Participation*. Cambridge: Cambridge University Press.

Li, G., and Rajagopalan. S. (1997). A Learning Curve Model with Knowledge Depreciation. *European Journal of Operational Research.* 105, 1, 143-154.

Liebeskind, J.P. (1996). Knowledge, Strategy and Theories of the Firm. *Strategic Management Journal*, 17, 45-62.

Liedtka, J. (1999). Linking Competitive Advantage with Communities of Practice. *Journal of Management Inquiry*, 8, 5-16.

Loasby, B.J. (1991). *Equilibrium and Evolution; An Exploration of Connecting Principles in Economics.* Manchester: Manchester University Press.

Loasby, B.J. (1976). *Choice, Complexity and Ignorance.* Cambridge: Cambridge University Press.

March, J., and Simon, H. (1958) *Organizations. New York: Wiley.*

Mezirow, J. (1991). *Transformative dimensions of Adult Learning.* San Francisco: Jossey-Bass

Morris, P., and Hough, G., (1987). The Anatomy of Major Projects : a Study of the Reality of Project Management. Chichester: Wiley.

Mohamed, S. (1995). Benchmarking, best practice – and all that. Paper presented on the 3rd workshop on lean construction, Albuquerque, New Mexico.

Nelson, R.R., & Winter, S. 1982. *An Evolutionary Theory of Economic Change*. Cambridge, MA: Harvard University Press.

Nonaka, I. and H. Takeuchi (1995). *The Knowledge Creating Company*. New York, Oxford University Press.

Orlikowski, W.J. (1992). The Duality of Technology: Rethinking the Concept of Technology in Organizations. *Organization Science*. 3, 3, 398-427.

Orr, J. (1990). *Talking about Machines: An Ethnography of a Modern Job*. Ithaca, NY: Cornell University.

Pava, C. (1983). *Managing New Office Technology* , New York: Free Press.

Purser, R.E., Pasmore, W.A. and Tenkasi, R.V. (1992). The Influence of Deliberations on Learning in New Product Development Teams. *Journal of Engineering and Technology Management* 9 , 1-28.

Reber, A.S. (1993). *Implicit Learning and Tacit Knowledge*. New York: Oxford University Press.

Schank, R. (1990). *Tell Me a Story: Narrative and Intelligence*. Evanston: Northwestern University Press.

Schein, E. H. (1985). *Defining Organizational Culture*. San Francisco: Jossey Bass.

Scott, W. R. (1991). *Organizations: Rational, Natural, and Open systems* (3rd edition). Engelwood Cliffs, NJ: Prentice Hall.

Simon, H. (1947). *Administrative Behavior*. New York

Snyder, W. (1996) Organizational Learning and Performance: An Exploration of Linkages Between Organizational Learning, Knowledge, and Performance. University of Southern California. Ph.D.

Spender, J.-C., & Grant, R.M. (1996). Knowledge and the firm: Overview. *Strategic Management Journal*, 17, 5-9.

Storck, J. & Hill, P.A. (2000). Knowledge and diffusion through "strategic communities". *Sloan Management Review*, Winter, 63-74.

Suchman, L. (2000). Organizing Alignment: A case of Bridge-Building. *Organization*, Vol. 7 (2):311-327

Szulanski G. 1996 Exploring Internal Stickiness: Impediments to the Transfer of Best Practice within the Firm. *Strategic Management Journal*. 17:27-43

Teigland, R. (2000). Communities of Practice in an Internet Firm: Netovation vs. On-time Performance. In Lesser, E. (Ed.), *Knowledge and Communities.* Newton, MA: Butterworth-Heinemann.

Teigland, R & Timlon, J. (1998). The Knowledge Acquisition Process of Software Programmers in an Emerging Digital Communications Company: From Communities of Practice to Information Technology. Working paper. Stockholm: Institute of International Business.

Wasserman, S., and Faust, K (1999). *Social Network Analysis.* Cambridge: Cambridge University Press.

Webster, J., & Trevino, L. K. (1995). Rational and Social Theories as Complementary Explanations of Communication Media Choice: Two Policy Capturing Studies. *Academy of Management Journal,* 38(6): 1544-1572.

Weick, K. E. (1995). *Sensemaking in Organizations.* Thousand Oaks, Sage.

Weick, K. E. (1979). *The Social Psychology of Organizing.* New York, McGraw Hill.

Wenger, E. (1998). *Communities of Practice: Learning, Meaning, and Identity.* Cambridge: Cambridge University Press.

Wenger, E. (1999). Communities of Practice: The Key to a Knowledge Strategy. *Knowledge Directions.* Vol. 1, Fall.

Wenger, E. (2000). Communities of Practice: The key to Knowledge Strategy. In Lesser, E. (Ed.), *Knowledge and communities.* Newton, MA: Butterworth-Heinemann.

Wenger, E., McDermott, R., & Snyder, B. (2002). *Cultivating Communities of Practice.* Harvard Business School: Boston.

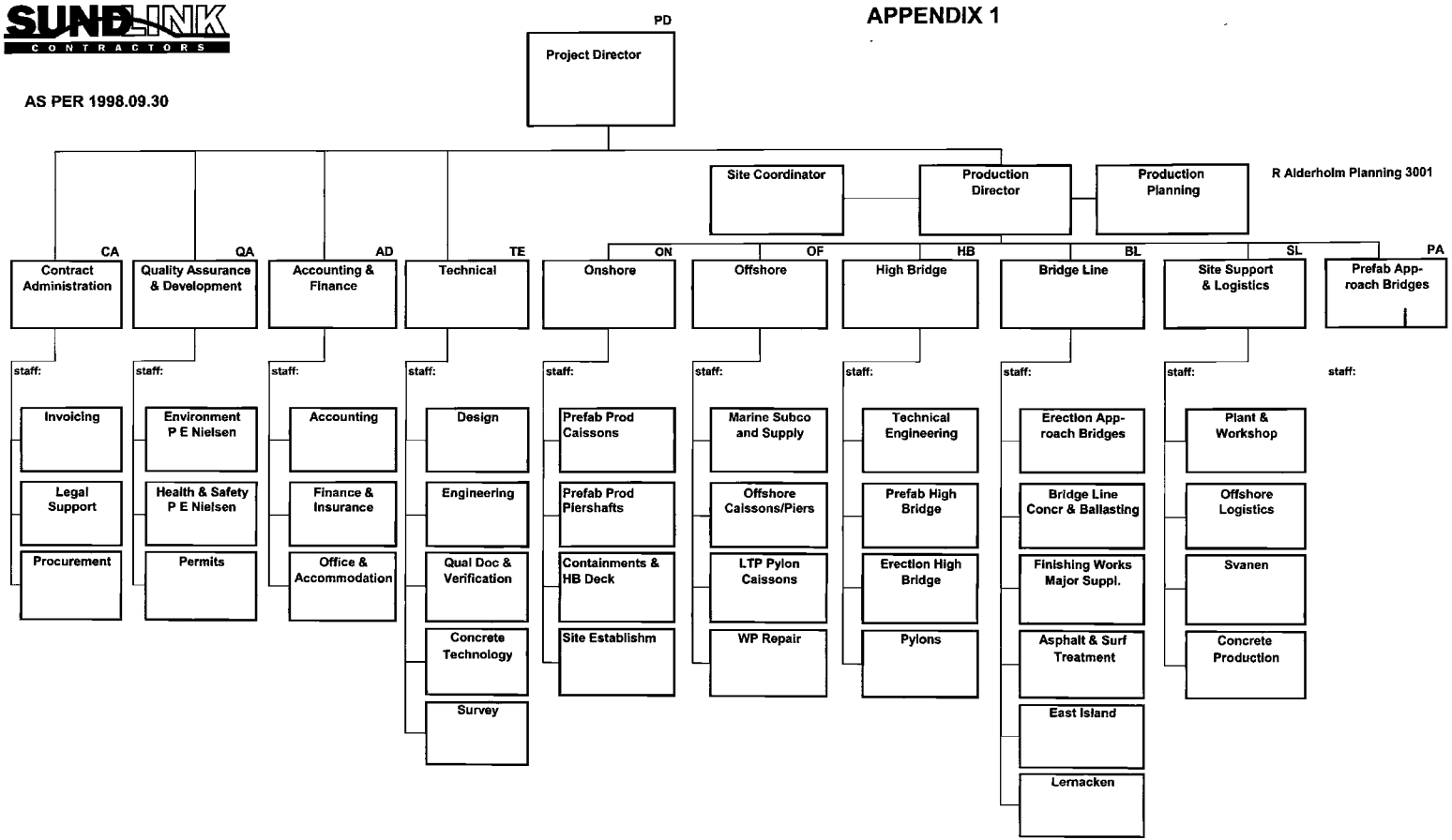
Yelle, L. E. 1979. The Learning Curve: Historical review and Comprehensive Survey. *Decision Science,* 10: 302-328.

Yin, R. (1993). *Case Study Research - design and Methods.* Newbury Park, Sage.

SUNDLINK CONTRACTORS

APPENDIX 1

AS PER 1998.09.30



PAPER I

Knowledge Based Theories of the Firm in Strategic Management: A Review and Extension

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Knowledge-Based Theories of the Firm in Strategic Management: A Review and Extension[*1]

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Knowledge-Based Theories of the Firm in Strategic Management: A Review and Extension

Knowledge has received increased attention as the basis to explain differences in firm performance. Yet, the knowledge-based view of the firm in strategic management is still a contested and unmapped terrain with no unified clear-cut theories. This paper critiques existing contributions to knowledge-based views and highlights tensions in the field. We introduce an integrated knowledge-based view of the firm that encompasses and extends previous contributions and acts as a foundation for a future research agenda.

The overall purpose of strategic management theory and research is to explain how and why there are differences in firms' performance. Strategy scholars, thus, have a collective interest in understanding the fundamental nature of the firm, and not surprisingly, theorizing about the firm's origin, structure, boundaries, and performance has assumed an increasingly important role in our field (e.g., Barney, 1999; Poppo & Zenger, 1998; Rumelt, Schendel, & Teece, 1991; Rumelt, 1997). The increasing sensitivity to theory is a natural step in the evolution of strategic management scholarship, from relying on case-by-case, inductively driven inquiry to a more coherent body of both theoretical understanding and empirical insights (Rumelt, et al, 1991). Recently, the field has produced significant unconventional theorizing and research breaking with one of the fundamental assumptions of orthodox economics, that the firm can be best be understood as a simple production function[i]. Contributions have gone in various directions. Some examples include a behavioral theory of the firm emphasizing information processing, organization structure and resource allocation processes (Cyert & March, 1963; Cyert & Williams, 1993), an attention-based view of the firm by which decision makers' focus on issues and decisions matter for performance outcomes (Ocasio, 1997), a transaction-cost based view of the firm with direct implications for strategy (Williamson, 1999), a resource-based view of the firm where performance differences are explained by the characteristics of firm assets and competencies (Wernerfelt, 1984; Barney, 1991), and lately, a knowledge-based view of the firm (KBV) (Kogut & Zander, 1992; Nonaka, 1994; Spender & Grant, 1996; von Krogh, Roos, & Slocum, 1994).

Of all these developments, the knowledge-based view of the firm has some features that are particularly appealing. First, it draws on and/or encompasses many of the insights developed in the behaviorally oriented firm theories, like the interplay between action, cognition, and a shared identity of organizational members (Kogut & Zander, 1996), as well as the resource-based view on the nature of competence and assets that enable sustainable competitive advantage (Barney, 1996; see also Mahoney, 1995; Christensen, 1995). In a mature form, it could also offer a complementary view to the transaction-cost economics explanation of firm boundaries (Poppo & Zenger, 1998). Second, it adds knowledge at the group and the firm levels of analysis to what had been a construct only at the individual

level of analysis. By so doing, it puts particular emphasis on the interactions among individuals and groups for knowledge sharing and creation (like the development of routines), and ultimately the implications of such interactions for competitive advantage (Grant, 1996; see also Szulanski, 1996). Third, it reflects an emergent understanding among managers and academics, that the new economy gives rise to firms that have knowledge as their most precious asset, and that these firms may behave very differently from their old-economy cousins that base their business on a balanced portfolio of material and immaterial assets. The knowledge-based view of the firm provides novel analytical tools and approaches for understanding such new economy firms (Teece, 1996; see also Evans and Wurster, 1999). Fourth, a knowledge-based view of the firm connects well to a parallel stream of knowledge management in practice. Over the last 5-7 years, managers have become increasingly aware of the importance of managing the information resources and the knowledge of their employees, and various techniques and instruments have been developed to this end (Tiwana, 1999). A knowledge-based theory of the firm might explain this movement, as well as the possible implications of knowledge management for firm performance (Burton-Jones, 1999).

Yet, the knowledge-based theory of the firm in strategic management is still a contested and unmapped terrain. In fact, as of this writing, no unified, clear-cut theory exists[ii]. There are many partial contributions each building on its own set of assumptions be it methodological individualism or social-psychological identity theory: the concepts and their relationships vary considerably, and no unified predictions can be made. We believe it is time to take stock of the knowledge-based views in strategic management, in order to provide a foundation for its further development into a coherent theory. In this paper, we shall *first* track the history of the debate on knowledge and the firm, and proceed to review the current contributions to the knowledge-based theories of the firm in strategic management, compare and contrast these, and highlight emerging tensions in the field. We have chosen our source literature by four criteria. Generativity: the contributions have demonstrated an ability to generate further theory building (e.g., Kogut & Zander, 1992) or debate about the nature of the firm (e.g., Tsoukas, 1996), evidenced by citations. Parsimony: the contributions selected have made "knowledge" the central construct to the theorizing about the firm (e.g.,

Grant, 1996). Multi-disciplinary: recognizing that strategic management is inherently multi-disciplinary (Rumelt et al, 1991), the review and extension includes contributions that shared the assumptions of either or both sociology (social psychology) and economics (e.g., Grant & Baden-Fuller, 2000; Spender, 1996). Sensitivity to basic construct: part of the progress in the knowledge-based theory of the firm can be attributed to a cluster of contributions studying the fundamental nature of knowledge in organizations (e.g., Nonaka, 1994; von Krogh et al, 1994).

Second, we shall provide an integrated model or knowledge-based view of the firm that encompasses and extends previous contributions, and that will be used to formulate a research agenda. The paper contributes to the strategic management field first and foremost by showing emerging tensions, and by reconciling these in an integrated model. Academics should be interested in this effort as an attempt to map, compare and contrast existing contributions. Moreover, the paper contributes to making the knowledge-based theory of the firm an accepted branch of the strategic management field by showing the strong progress achieved over a short time span. Practitioners, on the other hand, will obtain an overview of the theory building attempts so far, and normative implications for building a "knowledge-advantage" based on the integrated model.

KNOWLEDGE-BASED VIEW AS A THEORY OF THE FIRM

In this section, we review the antecedents of the current knowledge-based views of the firm, identify the criteria for a theory of the firm and examine current literature to determine to what extent these criteria have been met.

Antecedents and requisites of a KBV

Knowledge-based views have often positioned themselves as complements or reactions to the transaction cost economics of Coase (1937), which in grosso modo explain the existence of firms in terms of optimizing the costs of transactions, though each major theorist has a slightly different spin on the specific nature of the mechanism. Coase (1937) suggested that firms exist because they are more effective than markets in using price mechanisms to discover relevant information and to negotiate contracts. Furthermore, he argued that firms have lower costs because some authority (the entrepreneur) can more efficiently direct resources and control the terms

of trade. Alchian and Demsetz (1972) disagreed with Coase's conception of the entrepreneur and inherent authority relationships, and instead suggested that firms exist because they provide monitoring facilities, which prevent "shirking" or the non fulfillment of contractual conditions. Williamson (1975) explained that firms are more effective than markets because they control opportunism associated with the specificity of assets, and have lower costs that result from "haggling" associated with the negotiation of contracts. Despite significant inroads in the area of why firms exist, scholars from a more knowledge-based view have critiqued traditional transaction cost economics for its weakness in explaining heterogeneous firm performance (Liebeskind 1996) and how knowledge is treated (Holmstrom & Roberts, 1998). Contemporary KBV scholars such as Liebeskind (1996) and Grant (1996) have used transaction cost economics in order to explain a firm's knowledge activities. We suggest that the KBV can be viewed as both a complement and a response to these two weaknesses of transaction cost economics.

KBV theorists have also drawn directly from the resource-based theory of the firm, which argues that firms exist because they have unique, often historically dependent, abilities to accumulate specific resources that lead to differential levels of firm performance (e.g., Reed & DeFillippi, 1990). Penrose (1959), the starting point for resource-based view, conceptualized the firm as an entity endowed with a broad set of resources which are rendered into resource-based services that lead to a strategic advantage. Wernerfelt (1984) built upon Penrose's work by introducing resource specificity and context, suggesting that strategic action requires a specific set of physical, financial, human or organizational resources, and thus a firm's competitive advantage is determined by its ability to obtain and defend resources. While Wernerfelt did consider knowledge as a resource required to obtain and transform other resources, Barney (1991) included knowledge as a separate resource on equal footing with other resources. He argued that for firms to gain a competitive advantage they require the capability to transform resources. Capabilities and resources have three distinct features which make them difficult to imitate, according to Barney: they are historically determined, socially embedded in the organization, and tacit (Barney, 1991). Foss and Eriksen (1995) suggest that two features distinguish resources from capabilities: tradeability and the extent they are

tied to individual agents. Resources are always tradeable and often tied to the individual. While capabilities are not tradeable and do not necessarily belong to sole individuals. Although the resource-based view recognizes the importance and role of knowledge in firms achieving a competitive advantage, knowledge-based theorists argue that the RBV does not go far enough. Specifically, the RBV treats knowledge as a generic resource, rather than having special properties, and subsequently, does not make any distinction between different types of knowledge-based capabilities. In addition, the RBV does not precisely specify the distinctions between resources and capabilities, whether they are inherently internal to the firm or can be outsourced, and if resources by themselves enable capabilities or capabilities create resources.

The second stream of literature drawn upon by many KBV theorists is organizational theory. This stream offers insights into different types of behavior, inherent limitations of individuals, and the development of firms knowledge-based activities and routines. The point of departure for much of the organizational theory literature and its contribution to the KBV is the assumption that individuals are limited by their bounded rationality (March & Simon, 1958). As a consequence of bounded rationality, not all of the firm's knowledge can be found in any one person's head and, therefore, it is distributed across its members. Moreover, as Cyert and March (1963) argued in their seminal work, firms develop routines that act as repositories for knowledge and in this sense the firm becomes knowledgeable. Although organizational theory provides several contributions to the development of a KBV, the issue of the relationship between knowledge and firm performance is largely unaccounted for by this stream.

Using, therefore, transaction cost economics as a springboard, the knowledge-based view of the firm draws on two additional largely independent streams of research: resource-based theory and organization theory. Each stream of literature contributed to the KBV in terms of the role and conception of knowledge in firms. To determine the extent the KBV contributions actually form a theory of the firm, we argue that they must meet five tests. Firstly, any theory of the firm, not just a KBV, has to explain the existence of firms. This was pointed out and elucidated by Coase (1937), and remains as one of his seminal contributions to the theory of the firm literature. The second characteristic of a KBV, also pointed out

by Coase (1937) and elaborated on in a KBV context by Grant (1996), is the relationship between knowledge and a firm's boundaries or the scope of the firm. Third, a KBV must articulate the relationship between knowledge and the firm's structures (Grant, 1996). For example, building on the concept of bounded rationality and tacit knowledge, Grant suggested that there are two types of structures in firms that assist in integrating knowledge: designed (purposeful) or emergent (non-purposeful). Fourth, as highlighted by our review of resource-based view and organizational theory, knowledge has an impact on behavior, either, in the case of resource-based theory, on some type of social behavior (Barney, 1991), or in the case of organization theory, the exchange of knowledge between the individual and the organization as well as the development of firm routines (Cyert & March, 1963). While Holmstrom and Tirole (1989) consider the role of behavior from a theory of the firm perspective. Thus, a KBV has to elucidate the link between knowledge and behavior. Finally, for a theory of the firm to be strategic (to explain why certain firms obtain and maintain a competitive advantage over others), it must explain the relationship between knowledge and performance. This characteristic is a requisite by definition for any strategic theory of the firm.

In sum, we suggest that a strategic knowledge-based theory has five defining requirements: (1) why the firm exists, (2) effects of knowledge on the boundaries of the firm, (3) effects of knowledge on a firm's structure, (4) effects of knowledge on the behavior of the firm, and (5) effects of knowledge on the firm's performance.

A review of the knowledge-based view literature

Against these criteria, we propose to examine current knowledge-based theories of the firm in order to lay out a map and eventually point a way forward in this field. As a starting point, we also considered the respective theoretical perspective taken by the author as well as the concept of knowledge utilized.

Theoretical perspective. The KBV theories of the firm that we examined have emerged from different disciplines (broadly, economics, sociology and philosophy), and, as such, it is a mixed compote of ontological and epistemological underpinnings. Moreover, few KBVs are consistent, and even fewer are complete. Subsequently, in order to develop a theory, a minimum degree of congruence in underlying assumptions is

required in order to be consistent and additive. Our view of knowledge transcends the epistemological differences between the views. In attempting to be integrative across these varied views, we are taking the strategic management multidisciplinary perspective.

Concept of knowledge. One of the critical weaknesses of existing knowledge-based theories is the definitional ambiguity when it comes to the main construct, knowledge. First, there is disagreement about the level of analysis at which knowledge is a valid concept. Grant (1996), for example, postulates that knowledge exclusively resides in individuals. However, March and Simon (1958) as well as Levitt and March (1988) contend that organizations accumulate knowledge beyond that which is embodied in individuals through organizational learning. We argue that, in a strategic knowledge-based theory of the firm, knowledge should be included as a multi-level concept. Second, while all scholars seem to agree that there are two types of knowledge -- explicit and tacit – and, they have also developed their own typologies in conjunction with their specific theories (e.g., internal vs. external knowledge, know-how vs. know-what). What is often lacking is an underlying definition of knowledge that allows future scholars to generate operationalizable models of the firm and its performance. We develop a definition of knowledge in the context of an integrated knowledge-based view of the firm in the following section.

Firm existence. Despite this definition ambiguity, nearly every one of the scholars who have contributed in this domain offer some theory about how knowledge relates to the existence of firms. Some expand on the rationale offered by transaction cost economics, explaining in numerous variations that contracts help assure that you have reserves of capabilities when you need them (Loasby, 1998; Williamson, 1999), that firm knowledge can be substituted for employee bounded rationality through firm contracts (Conner & Prahalad, 1996), that firms are better able to manage motivation than markets (Osterloh & Frey, 2000), that employment contracts function specifically to protect knowledge inside the firm (Liebeskind, 1996) or that, because tacit knowledge has infinitely high measurement costs, it will not be transacted between firms (Hallwood, 1997). Contracts are also made less incomplete by higher order principles only possible in a firm setting (Foss, 1996).

Others argue that firms exist because they create special environments

where certain knowledge tasks can only take place. Firms exist to create absorptive capacity (Cohen & Levinthal, 1990) or to provide the conditions for individuals to integrate their specialist knowledge (Grant, 1996; Grant & Baden-Fuller, 2000). Firms outperform markets in their ability to organize the combination of knowledge (Kogut & Zander, 1992), often by lowering the cost of communication and coordination through the development of identity (Kogut & Zander, 1996). Many focus on the knowledge creation task in particular, positing that because organizations have more dense social capital[iii], they have an advantage over markets in creating and sharing intellectual capital (Nahapiet & Ghoshal, 1998), that organizations amplify new knowledge created by individuals (Nonaka, 1994), that firms are enduring alliances between independent knowledge creating individuals (Spender, 1996), and that firms protect the highly fragile knowledge creation process (von Krogh et al, 1994).

While there are many answers to the question of firm existence in the knowledge-based view of the firm, there is little consistency. For example, the knowledge protection imperative (Liebeskind, 1996) contradicts directly that of knowledge sharing (Grant, 1996) or knowledge combination (Kogut & Zander, 1992). Many of these scholars recognize that these kinds of conflicts have not yet been resolved and have called for theory with more coherent epistemological underpinnings (Minkler, 1993; Spender, 1996; Spender, 1998; von Krogh et al, 1994; Williamson, 1999) to make progress in defining a coherent knowledge-based theory to explain why firms exist.

Firm boundaries. The current theories have less to say about explaining firm boundaries or scope of operation. Many do not address boundaries at all. Others assume the presence of firm boundaries in order to discuss internal and external technologies (Cohen & Levinthal, 1990) or communities of interaction (Nonaka, 1994) but do not explain when and why these boundaries exist. Again, those with a transaction cost economics bent claim that boundaries depend on the bureaucratic costs associated with the decision to take a transaction out of the market and organize it internally (Osterloh & Frey, 2000; Williamson, 1999) and are determined by increasing moral hazard and capability differences such as the inability to communicate or higher information costs (Foss, 1996; Liebeskind, 1996). From the individual perspective, individuals choose between firms and market contracting depending on where their individual knowledge has the

highest value (Conner & Prahalad, 1996). Though, others would claim that boundaries are not determined by transaction costs alone, but by the replicability and imitability of tacit knowledge (Teece, 1998) or by the need to maximize the conversion rate of knowledge creation (Nonaka et al, 1999). Still others see boundary setting as a management tool for precipitating interpretive flexibility and defining the difference between data and knowledge/meaning (Spender, 1996, 1998).

These views of the firm boundary may be somewhat simplistic. A firm is generally portrayed as an entity within a boundary in which market forces do not predominate. Outside the firm's boundary there exists an infinite domain in which market forces dominate. Debates concerning the firm boundary generally concern themselves with which economic and social activities reside within the boundary and which do not. Here we concern ourselves only with boundaries separating the firm from the environment (those that should be explained by a theory of the firm) and do not consider other types of boundaries such as those between functions that could be critical in execution of knowledge processes (Carlile, 2000). In the next section, we will build on existing thinking to introduce the concept of the "double boundary" of the firm and show that while some things (such as resources and knowledge) can reside both inside and outside the firm, capabilities can only be located inside the firm. And, for knowledge to pass from outside to inside the firm, it must cross two boundaries, those of integration and absorption.

Firm structure. To the extent that scholars of the knowledge-based view of the firm discuss organization structure, it is mainly in the debate about the value and role of hierarchy. Hierarchies can control moral hazard (Foss, 1996), provide a coordination mechanism for specialized or localized knowledge (Conner & Prahalad, 1996; Loasby, 1998), facilitate knowledge integration through compliance with directives (Grant & Baden-Fuller, 2000) and disaggregate knowledge in order to protect it (Liebeskind, 1996). Hierarchies also have an intertwined relationship with higher order principles that can integrate individual and social knowledge (Kogut & Zander, 1992) and can make contracts less incomplete (Foss, 1996). But, hierarchies also appear to have some negative features when it comes to knowledge tasks. Tacit knowledge may be better coordinated in team-based settings (Alchian & Demsetz, 1972; Grant, 1996) and "egalitarian" or flatter

hierarchies may be more effective in the management of firms (Minkler, 1993; Spender 1998) in particular when managing dynamic capabilities (Teece, 1998). Nonaka proposes a resolution of this tension by suggesting that a dual structure of hierarchy (for socialization and internalization of knowledge) and heterarchy or project organization (for externalization and combination) is necessary (Nonaka, 1994; Nonaka, Nagata & Toyama, 1999).

Firm behavior. Firm behavior, the direct consequence of a firm exercising its capabilities, results in action that is observed externally as well as internally. Since different actions can be ascribed to different capabilities, the presence of a specific constellation of actions can provide convincing evidence for the existence of specific capabilities inside the firm. Subsequently, the presence of a specific body of knowledge that is required to exercise a defined set of specific capabilities can be inferred. Most of the theories developed by these scholars have implications for behavior inside the firm. While the views expressed are highly diverse, they appear to cluster around the development and application of several knowledge-based capabilities (which we will explore further in the next section): knowledge protection (Hallwood, 1997; Liebeskind, 1996), replication (Osterloh & Frey, 2000), integration (Grant, 1996; Grant & Baden-Fuller, 2000), absorption (Cohen & Levinthal, 1990), and creation (Nonaka, 1994; Nonaka et al, 1999). In the next section, we return to these capabilities: knowledge creation (plus its relatively unexamined pair, knowledge destruction), integration, absorption, protection, and replication in much greater depth as we build up an integrated model of the firm.

Firm performance. From a strategic management perspective, making the link between knowledge and performance should be one of the critical aspects of any knowledge-based theory of the firm. Yet, this is precisely the area where current scholarship leaves open the most questions (Williamson, 1999). While resource and knowledge-based views of the firm have opened up the "black box" of the firm so that we can look inside at behaviors, they have left their own black box, that of the link between behavior and performance. Most theories either do not address performance at all or simply state that a certain knowledge capability (variously, absorptive capacity, innovation, combinative capabilities, knowledge transfer, and protective capabilities) will give a firm competitive advantage

and thus lead to performance. Conner and Prahalad (1996) point out that any theory of firm performance requires that organizing an activity within the firm result in a competitive advantage, and some scholars have made more explicit statements in this vein: firms often lose to competitors when they replicate knowledge (Kogut & Zander, 1992), differences in firm performance may represent differences in the ability to create and exploit social capital (Nahapiet & Ghoshal, 1998) or competitive advantage emanates from the ownership of knowledge assets (Teece, 1998). These theories, however, have not drawn a strong causal link between knowledge or behaviors and performance, and they have not proposed reasonable metrics for knowledge or for the capabilities that knowledge creates. The mechanisms remain obscure.

THE INTEGRATED KNOWLEDGE-BASED VIEW (IKBV) OF THE FIRM

This review shows that while the emerging field of strategic knowledge-based theories of the firm has made significant strides in understanding critical components important in the development of a KBV, individually the theories are incomplete and collectively are often contradictory. They do not address all of the requirements of a theory of the firm and do not elucidate the mechanisms of the link between knowledge and performance. To integrate and clarify many of the issues debated in the literature into a coherent picture, the authors propose an integrated knowledge-based view (IKBV) of the firm as shown in Figure 1. In this representation, knowledge and resources are viewed as distinct from each other and can exist inside as well as outside of the firm. Capabilities serve as the link between knowledge and firm performance and reside within the firm. While capabilities can be viewed as the operators; knowledge is the operand. In our model, the firm has two boundaries, which reflects the notion that a firm can bring knowledge and resources into a firm (integration) without absorbing them. We will explore this model in the discussion below.

Insert Figure 1 about here

Defining knowledge

Because knowledge is not directly observable or measurable, then, it becomes a construct whose existence and properties can only be inferred through firm capabilities that are manifested in observable action (Stehr, 1992). Most of the knowledge-based views do not clearly articulate this relationship between task or behavior and knowledge. In an attempt to fill this gap, we propose the following definition of knowledge that integrates across the views of several different fields and scholars: ***knowledge*** is information whose certainty is given by a specific context (Arrow 1962a, 1969), which creates space for a justified true belief (Nonaka, 1994; von Krogh, Ichijo & Nonaka, 2000) and gives a firm the capacity to act (Stehr 1992). Thus knowledge is only identifiable through the observation of action. This differentiates knowledge from resources, which can be identified without observable action. By defining capabilities as the capacity to act, we deduce that knowledge, in conjunction with resources, gives the firm its capabilities, and that the existence of capabilities is the prerequisite for potential action of any kind. Conversely, the observation of action by the firm demonstrates the existence of capabilities, and the existence of capabilities inherently identifies the presence of knowledge, even if knowledge itself cannot be directly observed.

The distinct treatment of knowledge and resources differentiates the knowledge-based view of the firm from the resource-based view of the firm, which regards resources in a broad sense that tends to include many concepts traditionally associated with knowledge (Barney, 1996). In the knowledge-based view, a resource is treated as a finite traditional stock, which must be replenished after it is depleted and which contributes to achieving competitive advantage (primarily by depriving other firms of that resource) (Wernerfelt, 1984). Knowledge, by contrast, can be replicated or transferred from a transmitting entity to a receiving entity without loss to the transmitting entity, making a "knowledge position barrier" much harder to erect. The accumulation of knowledge in and of itself is not an inherent source of competitive advantage. Every firm must make an active effort at protecting its knowledge by selectively preventing it from being transferred to potential competitors outside the firm, but at the same time specifically transferring it to strategic partners and collaborators.

From Knowledge to Capabilities

While knowledge and resources are considered essential ingredients to firm survival, capabilities are its raison d'être -- they represent the firm's capacity to act. Therefore, the IKBV places capabilities exclusively inside the firm (outsourced activities are considered resources). As mentioned above, firm behavior, the direct consequence of a firm exercising its capabilities, results in action that is observed externally and internally. Since knowledge is not itself measurable, we only infer it through an organization's actions. Different actions can be ascribed to different capabilities. Thus a specific constellation of actions represents a specific set of capabilities inside the firm and implies the existence of specific knowledge that is required to exercise these capabilities.

Our synthesis of the past knowledge-based theories of the firm generates six critical capabilities: creation, destruction, integration, absorption, replication and protection. The six capabilities are not completely independent of each other: they appear to possess a dyadic organization structure. Specifically, creation is associated with destruction; integration is intimately tied to absorption; and replication is linked to protection. This also points to the existence of a meta-capability for the firm to enable and constrain the individual capabilities. The authors contend that this meta-capability constitutes the essence of strategic management.

In Table 1, we show how researchers have covered the territory of the key elements of the knowledge-based theory of the firm across the key capabilities. This analysis shows that while some capabilities have been discussed extensively (e.g., creation) others have barely been mentioned (e.g., destruction). In addition, no current knowledge-based theory of the firm has something to say about all of the six capabilities simultaneously, describing individual capabilities (possibly referring to them by a different name) and their effects on some, but not usually all, of the aspects of the theory of the firm: firm existence, boundaries, structure, behavior and performance. For each dyad, we first define the two capabilities and then show how they interact in a dyadic relationship.

Insert Table 1 about here

Creation and destruction

The ***creation capability*** is the capacity to combine knowledge with knowledge and knowledge with resources to produce output that exceeds the value of the sum of the inputs that are required to generate the output. Probably the strongest argument so far posited in the KBV is the firm's advantage in knowledge creation. Firms exist as alliances between knowledge creating entities (Spender 1996) or to protect the creative process (von Krogh et al, 1994). Loasby (1998) contends that firms outperform markets by building "reserves" of capabilities, which can be deployed to exploit new market opportunities. Nahapiet and Goshal (1998) claim that firms are conducive to higher levels of social capital than markets and are therefore better at creating and sharing intellectual capital. Kogut and Zander (1992) look at firms as a social community of voluntaristic action in which knowledge is learned, produced and commercially applied. Firms exist because they outperform markets in organizing the combination of knowledge. And, their boundaries are defined by the degree to which knowledge conversion takes place at a higher rate (Nonaka et al, 1999) or by the ability to resolve agency problems among individual knowledge creators (Spender, 1996). Perhaps only in relation to creation capabilities do researchers make an explicit theoretical link to performance. The combination of knowledge and resources allows the firm to develop new knowledge, which gives it the capacity to produce better products and services. Thus, competitive advantage emanates from ownership of knowledge assets and the ability to combine them with other assets to create value (Teece, 1998).

The ***destruction capability*** constitutes the capacity to eliminate elements of knowledge or disassemble the interconnectedness of knowledge. Knowledge destruction differs from knowledge loss mechanisms such as organizational forgetting because it constitutes a volitional act. Elements of knowledge that are targets for destruction include routines, behavior patterns or beliefs, which can become inertial forces that interfere with the innovation process (Nelson & Winter, 1982). Leonard-Barton (1992) extends this argument stating that core capabilities can become core rigidities, and firms need to know when to eliminate certain knowledge and associated capabilities. No scholars, of course, have argued that firms exist solely

based on superior knowledge destruction capabilities. Indeed, markets appear to be better at destruction (at least in the US, through easy bankruptcy laws) than firms are. But, others have shown that firm existence can be threatened by a failure to destroy old knowledge (Leonard Barton, 1992; Nelson & Winter, 1982). This link to performance has not been incorporated into existing KBV's. Furthermore, the relationship between knowledge destruction on one side and the firm boundary and firm structure on the other side remain largely unexplored. This relationship covers the consequences of merger and acquisition activity, where entities with intact routines and extensive tacit knowledge must change and possibly disaggregate to accommodate other entities within the firm. How knowledge is lost in the process, whether restructuring is inevitable, and how it proceeds are all topics that have yet to be explained.

Scholars have surmised a link between the creative and destructive capabilities of the firm ever since Schumpeter (1942) proposed that "creative destruction" was an essential component of the innovation process. Replication and protection of knowledge, as we will discuss below, may sustain a firm in a static environment, but innovation is required for a firm to remain on a prolonged growth trajectory. And innovation mandates both the creation and the destruction of knowledge. For a firm to enhance its performance through innovation, it must be able to create by combining knowledge with knowledge and knowledge with resources, as well as change internal processes and structures, an activity that generally involves the destruction of knowledge. Under such circumstances, the firm needs to disrupt routines possibly by disassembling organizational structures. Removing or disassembling structures that inhibit creation involve the destruction of knowledge. Thus, if a firm willfully destroys existing structures, it enables the creation of knowledge by removing barriers that inhibit creation. Conversely, surges in creative activity may induce the destruction of existing knowledge by transferring new knowledge into existing structures. As people learn about more effective methods, they may voluntarily begin to practice these methods and abandon existing methods. In that case, knowledge creation drives knowledge destruction.

Integration, absorption and the double boundary of the firm

The ***integration capability*** is the capacity to secure a supply of

knowledge and resources for the firm. Purchasing supplies is an example of integrating resources. Hiring people secures a supply of individual knowledge, be it tacit or explicit. Mergers and acquisitions integrate the knowledge and resources of whole firms. The main focus of research on integration has been on the boundary of the firm: for example, Williamson's (1999) demonstration that a firm may decide to take a transaction out of the market to reduce bureaucratic cost. Demsetz (1991) argues that the vertical boundaries of the firm are determined by the extent to which knowledge is transferred effectively, while Conner and Prahalad (1996) take the view from the other side, showing that an individual chooses between firm organization and market contracting depending on where the individual knowledge has the highest value. Researchers have argued that firms outperform markets as coordination mechanisms, implying that a firm's integrative capabilities are linked to the firm performance (Grant, 1996; Grant & Baden-Fuller, 2000), but this link has only been made implicitly.

The ***absorption capability***, the other half of the dyad, enables the use of knowledge and resources, and is intimately linked to integration. Moreover, bringing in some knowledge (by hiring individuals or making acquisitions) through integration is not enough; it must also be absorbed and made useful. Absorption of knowledge typically involves the externalization of tacit knowledge from employees and acquired entities, or the use of tacit knowledge within an enterprising context. The firm must also be willing and able to receive and use the knowledge, be it tacit or explicit in order for absorption to take place. The discussion about absorption of knowledge into a firm is most closely associated with Cohen and Levinthal (1990) who argue that firms exist because they can create absorptive capacity at an organizational level. A firm acquires absorptive capacity in a specific area by learning about related areas. R&D can enhance a firm's absorption capability by facilitating learning (Nonaka et al, 1999), lowering the cost of communication and coordination, providing a context of discourse and learning (Kogut & Zander, 1996), and generating innovation. Knowledge absorption is also linked to organization structure and behavior as well. The literature mentions that hierarchical relationships within firms serve to coordinate specialized knowledge resulting from division of labor (Loasby, 1998). Hierarchies also facilitate knowledge absorption is facilitated through sequencing and compliance with directives

(Grant & Baden-Fuller, 2000). While Cohen and Levinthal (1990) have proposed that the absorption of knowledge leads to improved performance.

Yet, the relationship between knowledge absorption and knowledge integration remains ill defined and unexplored. Adding knowledge to the firm without creating it inherently involves bringing knowledge or resources into the firm across the firm boundary. To do so, the firm must have capacity to procure the knowledge and resources from the outside. It must be able to integrate knowledge by hiring people that possess knowledge into the firm or by making acquisitions. Integration and absorption occur in tandem, because knowledge must be integrated before it can be absorbed. A firm can increase its acquisition rate either by increasing its rate of knowledge integration or by increasing its absorptive capacity (Cohen & Levinthal, 1990). This dual process of acquiring knowledge from outside the firm implies that the boundary of the firm has two layers. Knowledge that has not been integrated lies outside the firm's integration boundary; knowledge that has been both integrated and absorbed resides within the absorption boundary; and knowledge that has been integrated but not absorbed is located between the two boundaries.

Replication and protection

The ***replication capability*** represents the capacity to transfer knowledge from a transmitting entity (an individual, an organization or an industry) to a receiving entity with a minimal loss of information. While the literature makes no suggestions that the replication capability could serve as a justification for the existence of the firm, it does explore in depth the interaction between replication and the boundaries of the firm. Furthermore, the boundaries of the firm are also affected by the replicability and imitability of tacit knowledge, which can exist to a higher degree inside the firm (Nonaka et al, 1999); by capability differences, such as the inability to communicate or higher information costs (Foss, 1996); or by the extent to which knowledge is transferred effectively (Demsetz, 1991). Organizational form has also been linked to the ability to transfer tacit knowledge (Osterloh & Frey, 2000), to control moral hazard and to take advantage of higher order principles (Foss, 1996). Finally, Osterloh and Frey (2000) contend that the transfer of knowledge, especially tacit knowledge, enhances a firm's performance and is essential to its competitive advantage.

The ***protection capability***, the flip side of replication, is defined as the capacity to control the replication process or alternatively, the ability to protect knowledge. Theoretical work on replication to date has often placed this capability as the primary justification for firm existence. Firms provide the physical, social and resource allocation to shape knowledge into competence and have the ability to protect intellectual rights (Teece, 1998). They outperform markets in the protection of knowledge because they provide unified ownership and employment contracts instead of market and futurity of reward (Liebeskind, 1996). Foss (1996) argues that firms exist as contracts and higher order principles to control moral hazard and agency problems regarding knowledge protection. Mechanisms to protect knowledge may also determine the boundary of the firm by increasing the communication costs with the outside, and hierarchies serve to disaggregate knowledge for protection (Liebeskind, 1996). Firms establish formal mechanisms of knowledge protection (Liebeskind, 1996), such as patents, copyrights and trademarks, as well as informal mechanisms such as accumulating tacit knowledge (Kogut & Zander, 1992) or encoding private information in ways that raise measurement costs (Hallwood, 1997). Protective capabilities, such as privately held knowledge (Conner & Prahalad, 1996), give a firm competitive advantage, which subsequently influences the firm's performance in a positive way (Liebeskind 1996).

The replication/protection dyad is derived from the historical notions of explicit and tacit dimensions of knowledge. Explicit knowledge is well encoded and can be acquired and transferred directly and very easily. It is not "sticky" (Von Hippel, 1994): it is ready to use and easy to replicate. Tacit knowledge, on the other hand, can neither be expressed nor encoded very easily. It is extremely difficult to articulate an instruction set that would describe these activities to the point where other people could repeat them (Polanyi, 1966). It is "sticky", difficult to replicate, and can be transferred in one of two ways: indirectly through a time-consuming socialization process (Nonaka, 1994) or via the sequence of externalization, direct transfer, and internalization. The latter mechanism, which has not been discussed in the literature to date, is suited for organizations that want to grow rapidly and develop new capabilities (build up momentum). These organizations convert the tacit knowledge that resides in its employees into explicit knowledge through an externalization process such as writing a

book or developing a toolkit for users of technology (von Hippel 1994, 1999). Once externalized, large amounts of knowledge can be transferred directly, easily and at low cost. The explicit knowledge will be converted to tacit knowledge through internalization processes such as learning by doing (Arrow, 1962b), learning by using (Rosenberg, 1986), or other means of the developing routines (Nelson & Winter, 1982).

Replication and protection are countervailing capabilities that inhibit each other. Firms need to replicate their knowledge to mass produce and exploit economies of scale, yet easy replication of knowledge makes firms vulnerable to imitation (Kogut & Zander, 1992). The ability to replicate knowledge allows a firm to ramp up to production and take advantage of economies of scale. A firm's ability to replicate knowledge could prove to be a weakness because knowledge, especially if it is in explicit form, could leak outside the firm where others could pick it up and imitate the firm's products and services. Kogut and Zander (1992) would therefore recommend against running a firm in the manner that externalizes knowledge. By contrast, if the firm's knowledge remains primarily tacit, the firm would have the capability of constraining knowledge transfer to another company. An employee that leaves the firm would either transfer the knowledge through a time consuming socialization process or take a long time externalizing the knowledge, giving the firm that originated the knowledge a strong learning curve advantage. The greater the knowledge replication rate, the less knowledge is protected. Conversely, the more a firm focuses on protection, the less it can replicate knowledge. Firms must therefore find a balance between replication and protection, by knowing what knowledge to replicate and what knowledge to protect, a topic that the literature has not yet adequately discussed.

Metrics for capabilities

In order for the knowledge-based view of the firm to create models that can be operationalized, observable metrics for these capabilities must be developed. Table 2 lists some possible metrics for each of the six knowledge capabilities. Ultimately, research should be able to show that changes in these input measures would effect various measures of performance such as gross revenue, gross profit, net profit, return on assets, return on investment or, as posited more recently, IPO value (DeCarolis and

Deeds, 1999). For example, if research and development within a firm positively affects the firm's creation capability, then increasing the R&D budget should improve the firm's traditional performance metrics a few months or years after the increase in R&D spending was instituted. Conversely, an increase in the firm's budget for restructuring and reengineering should adversely affect the performance metrics of sections or divisions that are targeted for knowledge destruction, while improving the firm's global performance metrics. If a firm's integration capability directly affects firm performance, then changes in a firm's purchasing and hiring patterns should result in an observable change in the firm's traditional performance metrics. Changes in the training budget, selective elements of the IT budget, R&D budget should influence a firm's capability to absorb knowledge, which should also affect the firm's global performance metrics.

Insert Table 2 about here

Firm-to-firm comparisons are less complicated when capability-specific measures can be identified. For example, the cost of copying information, the cost of franchising, the cost of training, and a firm's willingness to invest resources (as measured by person-hours and dollars) into these activities should affect the firm's replication capability. Therefore, a firm that invests heavily in copying and training should be able to transfer a process from R&D to manufacturing and ramp it up to volume production in much less time than one who does not. Similarly, the costs of establishing and enforcing patents and trademarks affect a firm's ability to protect itself from imitation. A firm that invests heavily in patent and trademark protection should therefore be able to hold a product monopoly much longer than one who does not.

Strategic management: the meta-capability

The discussion above illustrates the critical intra- and inter-relationships and tensions for each of the dyads. Figure 2 shows that the nature of the relationships between the capabilities within each dyad varies from dyad to dyad. Replication and protection are mutually inhibitory; creation and destruction are mutually excitatory; and integration enables absorption. Dealing with these tensions becomes the linchpin of a meta-

capability that represents the essence of strategic management. Each firm must have the capacity to allocate resources in a manner that enables and constrains the exercise of these six capabilities, which give a firm some control in gaining a strategic advantage over its competitors. Of course, the decisions behind resource allocations require knowledge, which the firm can replicate, protect, create, destroy, integrate and absorb. It also appears, as Figure 2 shows, that the meta-capability is exercised on two levels: within the dyad, and between dyads.

Insert Figure 2 about here

For example, the firm can choose to increase its research and development budget and its budget for restructuring, a decision that is appropriate in an early stage of a project. These actions represent a stimulation of both components of the creation/destruction dyad, which would most likely induce a surge of creative activity. During product development a firm may discover it needs complementary knowledge that resides outside the firm. It may then decide to hire new people (integration), increase its funding of training programs (absorption), decrease the budget for R&D and restructuring, but invest more in IT. At that point, the firm has exercised the meta-capability at a higher level, by increasing the importance of the integration/absorption dyad at the expense of the creation/destruction dyad. The firm may also decide to invest in patents and trademarks to protect its intellectual property while a product is under development. However, once the product is ready, the firm is likely to enhance its replication capabilities and diminish its protection capabilities, by increasing its training budget and spending less on patent protection, which are decisions solely affecting the two components of the replication/protection dyad. As a consequence, employees in manufacturing facilities internalize the firm's recently created and acquired knowledge by learning by using or learning by doing. The knowledge becomes tacit, which protects the firm from imitation. Consequently, formal protection mechanisms become less important.

This kind of meta-capability has not been explored in depth either theoretically or empirically. Lei, Hitt and Bettis (1996) have postulated the existence of an organizational meta-learning capability that serves as the

basis for building a firm's dynamic core competencies. They define a firm's core competencies as set of problem-defining and problem-solving insights that foster the development of idiosyncratic growth alternatives. Our concept expands this view by identifying specific capabilities, suggesting metrics by which they can be observed, and describing the relationship between them. Once researchers characterize the interdependencies between these capabilities, practicing managers can utilize the meta-capability that we postulate to gain competitive advantage.

CONCLUSION

The purpose of this paper is to track and review developments leading to a knowledge-based theory of the firm in strategic management and to provide an integrated model of the firm that encompasses and extends previous contributions. We found many partial contributions, but none that provides a coherent view of knowledge related to a firm's existence, boundaries, behavior, structure, and competitive advantage. As a consequence, it should not come as a surprise to scholars that a knowledge-based view of the firm still has some way to go in order to assume an established role as a useful theory within strategic management (Burton-Jones, 1999; Williamson, 1999). Our model, an integrated knowledge-based view of the firm, links knowledge, capabilities, and competitive advantage to address some of these shortcomings. We identified six types of capabilities (*creation, destruction, integration, absorption, replication* and *protection*) that are organized in pairs, and should be understood as having a joint impact on competitive advantage. Strategic management is, in this view, considered a meta-capability that allocates resources to the building of these capabilities.

Scholars have been aware of the above capabilities, but to date have not integrated them into a comprehensive model. Instead, the literature has described individual capabilities and their effect on some aspects of firm existence, boundaries, structure, behavior and performance. To promote more empirical work on these capabilities, we have suggested some potential measures. We also tried to fill in where the literature has left significant gaps. For example, our survey found little work on how knowledge destruction has affected firm existence, boundaries, structure and performance. Yet the links between firm capabilities and these attributes

may exist, giving future scholars enormous opportunities for study.

Because our attempt with this model is to integrate and make additional move towards empirical research, purely discipline-based readers might find a limited attention to and discussion of fundamental theoretical assumptions. By bringing together of contributions from sociology, economics, and social-psychology, the model development is driven by a certain pragmatism characteristic for strategic management. In doing so, our predefined criteria for the literature search potentially leaves several blind spots that could impact on the field's understanding of capabilities as well as the overall organization of these. Also, this paper aimed to develop a mid-range model rather than building a new theory or conducting empirical research. We argue that more empirical work in this area is a critical next step.

A knowledge-based theory of the firm should hold great promise in strategic management, but it has to rise beyond the somewhat naive idea of "knowledge as a source of sustainable competitive advantage". Knowledge is also a double-edged sword: while the benefits are often immediate and easily recognizable, the costs related to rigidity, failure of appropriation, and change are more subtle, less transparent, and intimately tied to social processes. This, however, should embolden rather than discourage scholars in the field. Delving into the link between knowledge and capabilities and firm performance will keep us occupied for many years to come, and as empirical research gains ground using improved models, it has the potential to bring real a real value to the teaching and practice of management.

ENDNOTES

[i] Similar developments occur in contemporary economics. Many of the proponents here, some of which we will review in this paper, draw upon evolutionary economics in order to better explain the nature of the firm. See for example Nelson and Winter (1982), Winter (1991), and Nelson (1991). For a recent contribution see Dulbecco and Garrouste (2000).

[ii] This argument is very similar to that made by Oliver Williamson in his 1999 article in which he argues that no knowledge-based theories lend themselves to empirical verification or falsification. In fact, the knowledge-based theory of the firm seems more like a theoretical patchwork that a solid body of theoretical knowledge. In effect, empirical research is scant, and we should not expect a successful empirical project unless we are able top resolve some of the more fundamental theoretical controversies at the present time.

[iii] Social capital is variously defined but one more comprehensive view posits it as "the sum of actual and potential resources embedded within, available through, and derived from the network of relationships" (Nahapiet and Ghoshal 1998: 244)

REFERENCES

Alchian, A.A., & Demsetz, H. 1972. Production, information costs, and economic organization. ***American Economic Association***. 62(5): 777-795.

Arrow, K. 1962a Economic welfare and the allocation of resources for invention,. In NBER (ed.), ***The Direction and Rate of Inventive Activity***. Princeton, NJ: Princeton University Press.

Arrow, K. 1962b. The Economic Implications of Learning by Doing. ***Review of Economic Studies*** 29: 155-173.

Arrow, K. 1969. Classificatory Notes on the Production and Transmission of Technological Knowledge. ***American Economic Review Papers and Proceedings***,. 59: 29-35.

Barney, J. 1991. Firm resources and sustained competitive advantage. ***Journal of Management.*** 17: 99-120.

Barney, J.B. 1996. The resource-based theory of the firm. ***Organization Science***. 7: (5) 469-469.

Barney, J.B. 1999. How a firm's capabilities affect boundary decisions. ***Sloan Management Review***. 40: (3) 137

Burton-Jones, A. 1999 ***Knowledge-Capitalism: Business, Work, and Learning in the New Economy***. New York: Oxford University Press.

Carlile, P. 2000. A Pragmatic View of Knowledge and Boundaries:Boundary Objects in New Product Development. Cambridge, MA: ***Unpublished manuscript***, August 2000.

Chesbrough, H. & Teece, D. 1996. When is virtual virtuous, ***Harvard Business Review*** 74(1): 65-73

Christensen, J.F. 1995. Asset profiles for technological innovation. ***Research Policy.*** 24: (5) 727-745.

Coase, R.H. 1937 The nature of the firm. ***Economica***. 4: 386-485.

Cohen, W. & Levinthal, D. 1990. Absorptive Capacity: A New Perspective on Learning and Innovation. ***Administrative Science Quarterly***. 35(1): 128-152.

Conner, K. & Prahalad, C. 1996. A resource-based theory of the firm: Knowledge versus opportunism. ***Organization Science***. 7 (5): 477-501.

Cyert, R.M, & March, J. 1963. ***A Behavioral Theory of the Firm***. London: Blackwell.

Cyert, R.M. & Williams, J.R. 1993. Organizations, decision making, and strategy. ***Strategic Management Journal*** 14: 5-10.

DeCarolis, D. M., & Deeds, D. L. 1999. The impact of stocks and flows of organizational knowledge on firm performance: An empirical investigation of the biotechnology industry. ***Strategic Management Journal***, 20(10): 953-968.

Demsetz, H.. 1991. The Theory of the Firm Revisited. In Williamson, O.E. & Winter, S.G. ed. ***The nature of the firm: Origins, evolution, and development***. New York; Oxford: Oxford University Press.

Dulbecco, P. & Garrouste, P. 2000. Production structure and knowledge: Towards an Austrian theory of the firm. ***Revue Economique***. 51: (1) 75-101.

Evans, P., & Wurster, J.S., 1999. ***Blown to Bits: How the New Economics of Information Transforms Strategy.*** Cambridge, Mass.: Harvard Business School Press.

Foss, N.J. 1996. Knowledge-based approaches to the theory of the firm: Some critical comments. ***Organization Science.*** 7 (5): 470-476.

Foss, N.J. 1996. More critical comments on knowledge-based theories of the firm, ***Organization Science***. 7 (5): 519-523.

Foss, N. J., & Eriksen, B. 1995. Competitive Advantage and Industry Capabilities. In C. A. Montgomery (Ed.), ***Resource-based and evolutionary theories of the firm: Towards a synthesis***: 43-69. Dordrecht and Boston: Kluwer Academic.

Grant, R.M. & Baden-Fuller, C. 2000. Knowledge and economic organization: an application to the analysis of interfirm collaboration. In von Krogh, G., Nonaka, I. & Nishigushi, T. eds. ***Knowledge Creation: a new source of value:*** 89-111. London: MacMillan.

Grant, R. 1996. Toward a Knowledge Base Theory of the Firm. ***Strategic Management Journal.*** 17(Special Issue): 109-122.

Hallwood, C. P. 1997. Competencies as private information: An efficient capital asset pricing theory of the firm. ***J. Inst. Theor. Econ.-Z. Gesamte Staatswiss.*** 153(3): 532-44.

Holmstrom, B. & Roberts, J. 1998. The Boundaries of the Firm Revisited. ***Journal of Economic Perspectives.***12(4):73-94.

Holmstrom, B., & Tirole, J. 1989. The theory of the firm. In Schmalensee, R. & Willig, R.D. (Eds). ***Handbook of industrial organization***: volume 1: 61-133. Amsterdam: North Holland.

Klein, B., Crawford, R.G., & Alchian, A.A. 1978. Vertical integration, appropriable rents, and the competitive contracting process. ***Journal of Law and Economics***. 21: 297-326.

Kogut, B. & Zander, U. 1992, Knowledge of the firm, combinative capabilities, and the replication of technology. ***Organization Science***. 3 (3): 383-397.

Kogut, B., & Zander, U. 1996. What firms do? Coordination, identity, and learning. ***Organization Science***. 7 (5): 502-518.

Lei, D., Hitt, M.A. and Bettis, R. 1996. Dynamic core competences through meta-learning and strategic context. ***Journal of Management***. 22(4): 549-69.

Leonard-Barton, D. 1992. Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development. ***Strategic Management Journal***, 13(Special Issue): 111.

Levitt, B., & March, J. G. 1988. Organizational Learning. ***Annual Review of Sociology***, 14: 319-340.

Liebeskind, J.P. 1996. Knowledge, Strategy and Theories of the Firm. ***Strategic Management Journal.*** 17(Special Issue):93-107.

Loasby, J. 1998 The organization of capabilities. ***Economic Behavior and Organization.*** 35: 139-160.

Mahoney, J.T. 1995. The management of resources and the resource of management. ***Journal of Business Research.*** 33: (2) 91-101.

March J., & Simon, H. 1958. ***Organizations.*** New York: Wiley

Minkler, A. P. 1993. Knowledge and Internal Organization. ***Journal of Economic Behavior and Organization.*** 21(1):17-30.

Rosenberg, N. 1982. ***Inside the Black Box: Technology and economics.*** New York: Cambridge University Press.

Nahapiet, J. & Ghoshal, S. 1998. Social Capital, Intellectual Capital, and the Organizational Advantage. ***Academy of Management Review.*** 23(2): 242-266.

Nelson, R.R, 1991. Why do firms differ and how does it matter ? ***Strategic Management Journal.*** 12:61-74.

Nelson, R.R., & Winter, S. 1982. ***An evolutionary theory of economic change.*** Cambridge, MA: Harvard University Press.

Nonaka, I. 1994. A dynamic theory of organizational knowledge creation. ***Organization Science.*** 5(1): 14-37.

Nonaka, I., Nagata, A. & Toyama R. 1999. The Theory of Innovative Firm. ***Unpublished manuscript,*** July 1999.

Ocasio, W. 1997 Towards an attention-based view of the firm. ***Strategic Management Journal.*** 18: 187-206, Sp. Iss.

Osterloh, M. & Frey, B.S. 2000. Motivation, knowledge transfer, and organizational forms. ***Organization Science.*** 11(5): 538-50.

Penrose, E.T. 1959. ***The theory of the growth of the firm.*** New York: John Wiley & Sons Inc.

Polanyi, M. 1966. ***The Tacit Dimension.*** New York: Doubleday.

Poppo, L., & Zenger, T. 1998. Testing alternative theories of the firm: Transaction cost, knowledge-based, and measurement explanations for make-or-buy decisions in information services. ***Strategic Management Journal***. 19: (9) 853-877.

Reed, R., & DeFillippi, R. J. 1990. Casual Ambiguity, Barriers To Imitation, And Sustainable Competitive Advantage. ***The Academy of Management Review***, 15(1): 88.

Rumelt, R. P. 1997. Towards a Strategic Theory of the Firm. In N. J. Foss (Ed.), ***Resources, firms, and strategies: A reader in the resource-based perspective***: 131-145. Oxford and New York: Oxford Management Readers series. Oxford University Press.

Rumelt, R.P., Schendel, D., & Teece, D.J. 1991. Strategic management and economics, ***Strategic Management Journal*** 12: 5-29, Sp. Iss.

Schumpeter, J. 1942. ***Capitalism, Socialism and Democracy***, 2nd ed.. London: George Allen & Unwin, Ltd.

Spender, J.-C., & Grant, R. M. 1996. Knowledge and the firm: Overview. ***Strategic Management Journal***, 17: 5-9.

Spender, J. C. 1996. Making knowledge the basis of a dynamic theory of the firm. ***Strategic Management Journal***.17: 45-62.

Spender, J. C. 1998. Pluralist epistemology and the knowledge-based theory of the firm. ***Organization***. 5(2): 233-56.

Stehr, N. 1992. ***Practical Knowledge***. Sage Publications, Inc.

Szulanski G. 1996 Exploring internal stickiness: impediments to the transfer of best practice within the firm. ***Strategic Management Journal***. 17:27-43

Teece, D. J. 1996. Firm organization, industrial structure, and technological innovation. ***Journal of Economic Behavior & Organization***, 31(2): 193-224

Teece, D. J. 1998. Capturing value from knowledge assets: the new economy, markets for know-how, and intangible assets. ***California Management Review***. 40:55-79

Tiwana, A. 1999. ***Knowledge-Management Toolkit***. Englewood-Cliffs, NJ: Prentice-Hall.

Tsoukas H. 1996. The firm as a distributed knowledge system: A constructionist approach. ***Strategic Management Journal*** 17:11-25

Von Hippel, E., 1994. Sticky Information and the Locus of Problem Solving: Implications for Innovation. ***Management Science*** 40(4): 429-439.

Von Hippel, E. 1998. Economics of product development by users: the impact of sticky local information. ***Management Science***. 44(5): 629-643.

Von Hippel, E. 1999. Toolkits for User Innovation: The Design Side of Mass Customization. ***MIT Sloan School of Management*** Working paper # 4058, (February 1999).

Von Krogh, G., Ichijo, K.& Nonaka, I. 2000. ***Enabling knowledge creation : how to unlock the mystery of tacit knowledge and release the power of innovation***. Oxford ; New York: Oxford University Press.

Von Krogh, G., Roos, J. & Slocum, K. 1994. An Essay on Corporate Epistemology. ***Strategic Management Journal*** 15: 53-71.

Wernerfelt, B. 1984. A resource-based view of the firm. ***Strategic Management Journal***. 5(2): 171-180.

Williamson, O.E. 1975. ***Markets and hierarchies – analysis and antitrust implications***. New York: The Free Press.

Williamson, O. E. 1999. Strategy research: Governance and competence perspectives. ***Strategic Management Journal***, 20(12): 1087-1108.

Winter, S. 1991. On Coase, competence, and the corporation. In: Williamson, O.E. & Winter, S.G. (Eds). ***The nature of the firm - Origins, evolution, and development***. Oxford: Oxford University Press.

TABLE 1

Knowledge-based theories of the firm – by capability

Category	Effects of knowledge on firm existence	...on boundaries	...on structure	...on behavior	...on performance
Creation	Outperform markets in combining knowledge (Kogut & Zander 92) and protecting the creative process (Von Krogh, Roos, Slocum 94) Better at creating and sharing intellectual capital (Nahapiet & Goshal 98) and building reserves of capabilities (Loasby 98)	Knowledge creation internalized in firm if conversion rate higher than in market (Nonaka et al 99) Tacit knowledge can be higher inside firm boundaries (Nonaka et al 99) Firms resolve individual agency problems (Spender 96)	Redundant structures for knowledge creation (Spender 96) Higher order organizing principles integrate individual and social knowledge (Kogut & Zander 92) Dual structure of hierarchy and heterarchy assures knowledge creation and application (Nonaka et al 99)	R&D as a mechanism to facilitate learning and innovation (Cohen & Levinthal 90) Firms exchange and create intellectual capital through collective learning (Nahapiet & Goshal 98)	Knowledge creation leads to competitive advantage (Nonaka et al 99; Spender 96) Differences in firm performance due to ability to create/exploit social capital (Nahapiet & Goshal 98) Competitive advantage from ownership of knowledge assets and ability to combine with other assets (Teece 98)
Destruction				Core capabilities can become core rigidities. (Leonard-Barton 92)	Rigid routines lead to failure during discontinuities (Nelson & Winter, 82)
Integration	Coordination mechanisms (Grant 96, Grant & Baden-Fuller 00) Firms exist because tacit knowledge has infinitely high measurement costs and will not be transacted between firms (problems of efficient capital-asset pricing) (Hallwood 97)	Individual chooses between firm and market contracting based on highest value for knowledge (Conner and Prahalad 96) Boundaries depend on transaction costs (Williamson 99), effective-ness of knowledge transfer (Demsetz 91)	Hierarchy coordinates specialized knowledge resulting from division of labor (Loasby 98)	Firms seek to integrate individual knowledge which is often of a specialist character (Grant 96) Firms seek to integrate knowledge from partners through alliances (Grant & Baden-Fuller 00)	Integrative capabilities have impact on firm performance (Grant 96)

Category	Effects of knowledge on firm existence	...on boundaries	...on structure	...on behavior	...on performance
Absorption	Firms exist because they can create absorptive capacity at an organizational level (Cohen & Levinthal, 90; Nonaka et al 99) Firms lower cost of communication, coordination (Kogut & Zander 96)	Firms internalize knowledge creation if conversion rate is higher than in the market (Nonaka et al 99)	Hierarchical relationships in firms facilitate absorption by sequencing, compliance (Grant & Baden-Fuller 00) Higher order organizing principles integrate individual/social knowledge (Kogut & Zander 92)	R&D as mechanism to facilitate learning and generate innovation (Cohen & Levinthal 90)	Firm specific absorptive capacity can lead to innovation which leads to performance (Cohen & Levinthal 90)
Replication		Boundaries defined by inability to communicate or higher information costs (Foss 96) Boundaries determined by transaction costs and replicability of tacit knowledge (Teece 98); higher degree of tacit knowledge can exist inside a firm (Nonaka et al 99)	Type of organizational form linked with motivation and capabilities to generate and transfer tacit knowledge (Osterloh & Frey 00)	Intrinsic and extrinsic motivation matter in terms of transfer of tacit knowledge (Osterloh & Frey 00)	Knowledge generation and transfer are essential to a firm's competitive advantage. (Osterloh & Frey 00)
Protection	Firms are contracts, higher order principles to control moral hazard, agency problems (Foss 96), ability to protect intellectual rights (Teece 98) Employment contracts protect knowledge (Liebeskind 96)	Mechanisms to protection knowledge with outside increase communication costs (Liebeskind 96)	Hierarchies control moral hazard and lead to higher order principles (Foss 96) Hierarchies serve to disaggregate knowledge for protection (Liebeskind 96)	Firms establish mechanisms of knowledge protection (Liebeskind 96) Firms should see to encode private information in ways that raise measurement costs (Hallwood 97)	Privately held knowledge is a source of advantage (Conner & Prahalad 96) The protective capabilities create competitive advantage (Liebeskind 96)

TABLE 2

Definition of critical knowledge-based capabilities

Dyad	Capability	Description	Examples of metrics
Creation and destruction	**Creation**	Capacity to combine knowledge with knowledge or resources to produce output that exceeds the value of the sum of the inputs	R&D budget or R&D spending
	Destruction	Capacity to eliminate elements of knowledge or disassemble the interconnectedness of knowledge	Budgets for or spending on restructuring and reengineering
Integration and absorption	**Integration**	Capacity to secure a supply of knowledge and resources for the firm: hiring people (individual knowledge, tacit or explicit) or mergers and acquisitions (knowledge and resources of whole firms).	Purchasing records and salaries (labor costs)
	Absorption	Enables the use of knowledge and resources, and realizes their potential (typically involves the externalization of tacit knowledge from employees and acquired entities)	Training budget, selective elements of the IT budget, R&D budget
Replication and protection	**Replication**	Capacity to transfer knowledge from a transmitting entity -- an individual, an organization or an industry -- to a receiving entity without loss of information	Cost of copying information, cost of franchising, person-hours and resources invested in training
	Protection	Capacity to control the replication process including how many times knowledge can be replicated and whether it exits the firm	Legal costs, costs of establishing and enforcing patents, trademarks, etc.

FIGURE 1

The Integrated Knowledge-Based View of the Firm.

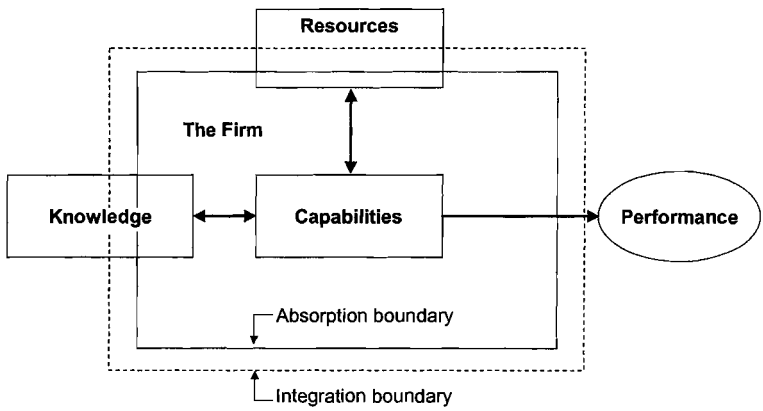
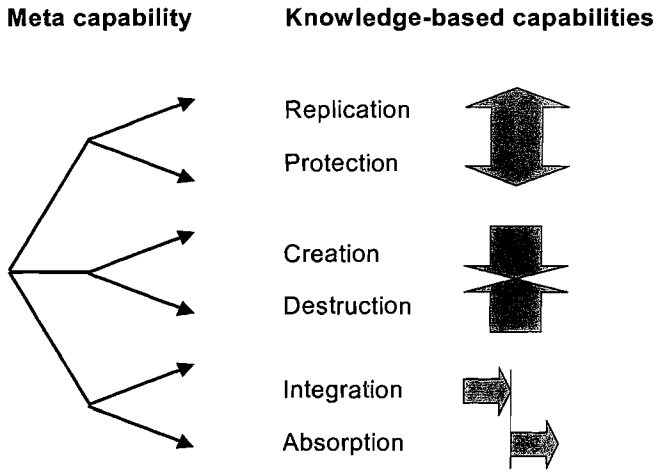


FIGURE 2

Organization of Capabilities



PAPER II

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

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Theorizing structural properties of communities of practice: A social network approach[1]

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Abstract

Management researchers are paying considerable attention to communities of practice 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 communities of practice. 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 communities of practice to organizational performance before concluding with a discussion.

Key words: Communities of practice; Social network; Knowledge; Performance; Construction

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1. 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, 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 communities of practice is related to several key knowledge activities and offers considerable promise for several reasons. First, community of practice 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 (Kanter, 1983, 1989; Kotter, 1982, 1985).

However, research on communities of practice is still at the earliest stages of development. The majority of the community of practice literature has concentrated on defining communities of practice, primarily focusing on the communication 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 communities of practice impact organizational performance and competitive advantage (Storck & Hill, 2000; Liedtka, 1999). These gaps in the research seem surprising because on the one hand, there is such a strong relationship between communication and structure, and on the other hand, the informal structure has been shown to play a strategic role in organizational outcomes (Kanter 1983, 1989; Kotter 1982, 1985; 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 structural properties of communities of practice and performance. Through identifying and specifying structural properties of communities of practice, we may open the door for additional theorizing on both the structural and communicative aspects of communities of practice 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 with 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 communities of practice and then synthesize these with existing concepts from community of practice literature to develop five structural properties of an "ideal" community 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.

2. Theoretical background

2.1 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 (Brown & Duguid, 1991; Lave & Wenger, 1991; Orr, 1990; Wenger, 1998). 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 communication based 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 communication map is developed (Brown & Duguid, 1991). The second aspect of communities of practice 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 (Boland & Tenkasi, 1995; Brown & Duguid, 1991; Wenger, 1998). In addition, through these three communication 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 communication aspects of communities of practice, researchers have also begun to look at various structural aspects of Communities of practice, 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 for 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 communities of practice: communication and structural. The communication 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 communities of practice.

3. Development of structural properties of a community of practice

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 pair-wise 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 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, 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 communities of practice: 1) connectedness, 2) graph-theoretic distance, 3) density, 4) core/periphery structure, and 5) coreness.

3.1 Connectedness

Perhaps the most fundamental aspect of a community of practice is mutual engagement (Wenger, 1998). Through engagement, individuals participate in each of the three communication based processes: narration, collaboration, and social construction that form the pillar of a community of practice. 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 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. 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.

3.2 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 (Burt, 1992; Friedkin, 1982; 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.

3.3 Density

Through mutual engagement and the associated communication 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.

3.4 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 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 consists of just one group, the core, to which all members are connected to a greater extent (core members) or lesser extent (periphery and marginal members). 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. Thus, we have our fourth structural property:

Structural property 4: Core/periphery - Communities of practice have core/periphery structures rather than clique structures.

3.5 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 communication 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.

4. Methods

This study uses data from Sundlink Contractors, an international contractor consortium that designed and constructed the Øresund 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 Communities of practice, 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.

TABLE 1.
Description of departments

Department	Activity	Size of structure	Location
Offshore Onshore (Operations)	Constructed prefabricated concrete structures called caissons and piershafts	800 to 4700 tons 10 to 51 meters tall	Malmö, Sweden
High Bridge (Operations)	Built concrete bridge pylons	Over 200 meters tall 4355 m3 of concrete 800 tons of reinforcement concrete	Malmö, Sweden
Bridge Line (Operations)	Constructed viaduct using steel and concrete	560 meters long	Malmö, Sweden
Prefab Approach Bridge (Operations)	Constructed steel and concrete girders	2000 to 6300 tons 120 meters long	Cadiz, Spain
Technical (Support)	Worked with design, survey, and other technical issues		Malmö, Sweden
Quality Assurance Department (QAD) (Support)	Drafted and implemented a quality system similar to ISO 9000		Malmö Sweden

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.

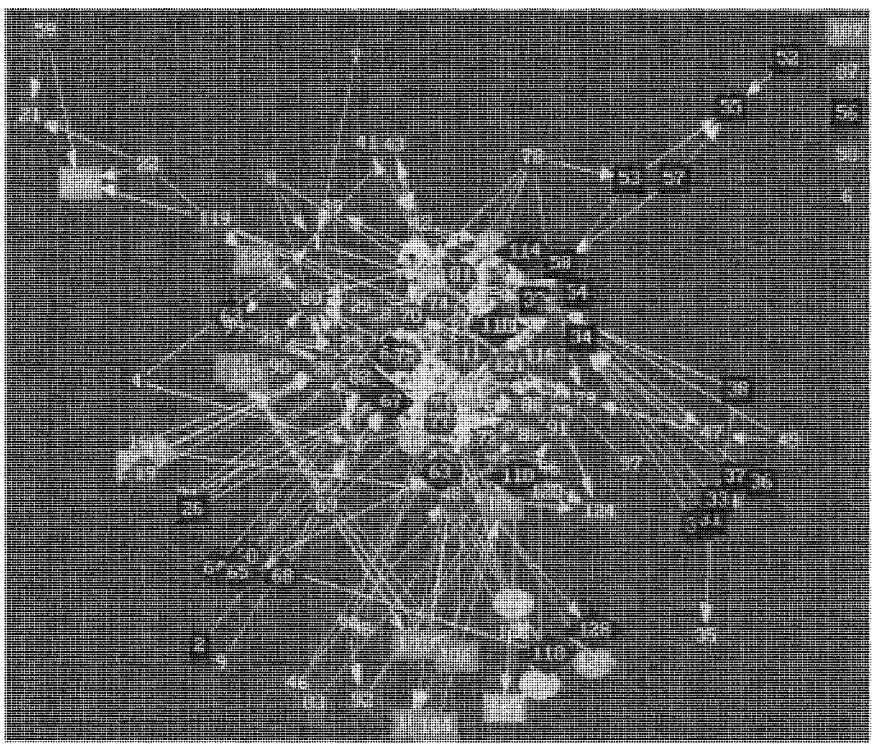
Sundlink Contractors utilized a formal quality system based upon ISO 9000, which articulated the work processes and procedures. It is within this quality system and the management of deviations that we have defined the joint enterprise for communities of practice in this study. In particular, we look 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).

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).

To illustrate the structural properties of "ideal" communities of practice, 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 et al., 1999) and imported into Krackplot (Krackhardt et al., 1994), a program used for the graphical analysis of networks, as well as SPSS. 5.

FIGURE 1.
Network of help-seeking among all project members (Node shape indicates section membership)



Analysis of network data

5.1 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.

5.1.1 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.

5.1.2 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.

5.1.3 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 community of practice structural property to a high degree.

5.1.4 Core/periphery structure

The crucial structural indicator of a community of practice 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.

5.1.5 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 community of practice 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***

[a]N ranges from 112-113

* $p < .05$

** $p < .01$

*** $p < .001$

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 mean that not all the people in the respective departments could interact on a face-to-face basis. This highlights the importance of facilitating conditions required for the development of communities of practice through face-to-face interactions.

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 community of practice 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 which corresponded to a university degree in engineering as opposed to a high school diploma which was the mean. 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 thought to be important facilitators of mutual engagement.

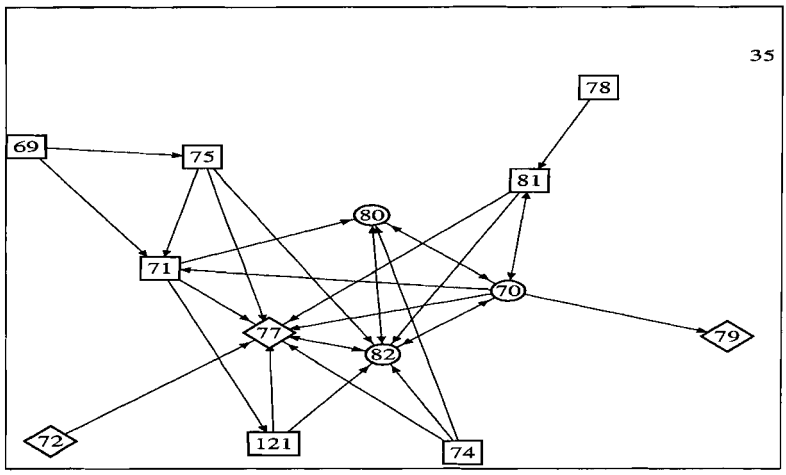
5.2 The Departments

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 community of practice 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.

5.2.1 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 property of communities of practice. 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.

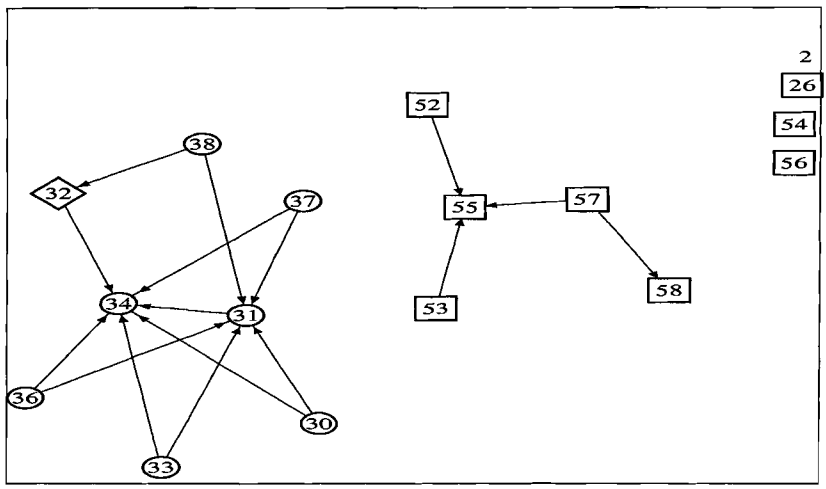
FIGURE 2.
Technical Department. Node Shapes Indicate Section Membership.



5.2.2 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 indications of two smaller communities of practice 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 sub-groups 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 communities of practice comes into question.

FIGURE 3.
Highbridge Department. Node Shapes Indicate Section Membership.

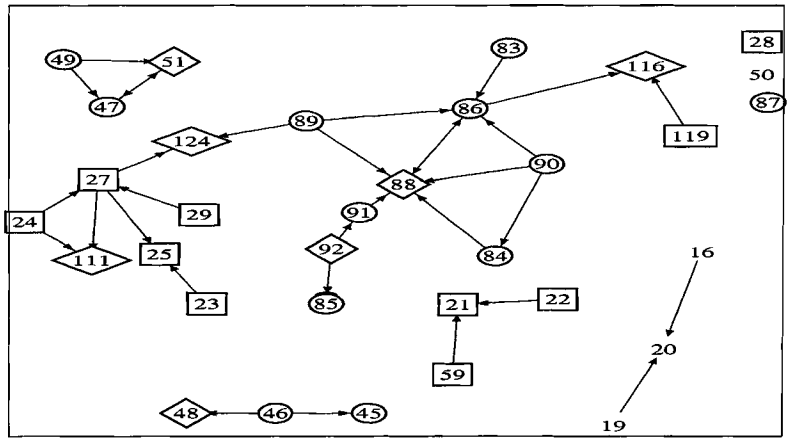


5.2.3 Bridge Line Department

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.

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 communities of practice within the High Bridge Department. Thus, we do see some support for the relationship between the development of communities of practice and the formal organization.

FIGURE 4.
Bridge Line Department. Node Shapes Indicate Section Membership.



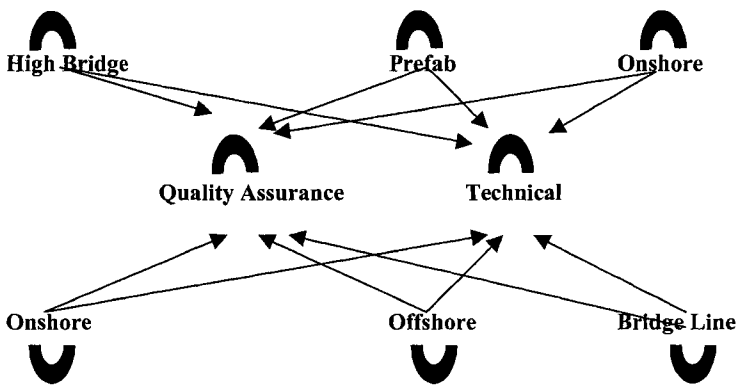
5.3 The overall inter-department project

An alternative way to analyze the project is to determine to what degree the project at the inter-department level, and not the inter-individual level, satisfies the structural properties of a community of practice. 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

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 Quality Assurance Department (QAD) and Technical Departments form the core, and the Prefab, High Bridge, Onshore, Offshore, and Bridge Line Departments form the periphery.

essentially responsible for the connectedness of the project network as a whole. Without these departments, the organization would be largely disconnected. Thus, this level of analysis provides an alternative method of understanding the extent to which how well an organization fulfills the structural properties of a community of practice extending it to include networks of practice.

Concluding our analysis and discussion, we find that the inter-department network displays structural characteristics of communities of practice 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 Communities of practice. 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.

6. Proposition development

In this section, we now turn to the relationship between communities of practice and organizational performance and develop a series of propositions that relate structural properties of communities of practice to performance.

6.1 Density and community performance

According to structural properties 1 and 3, a certain level of density is required to hold the community of practice together. If the community of practice dips below this, then it is likely that it would disintegrate and no longer fulfill the structural properties of a community of practice. But what is to be made of a community with a density just greater than the minimum that still satisfies the communication aspects of communities of practice (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 community of practice 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, 1999). 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 ($\leq$40 members), knowledge transfer increases linearly with density.

Proposition 1b: For larger communities of practice (>40 members, knowledge transfer increases curvilinearly with density.

6.2 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 do less centralized networks. 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.

6.3 Coreness and individual performance

Essential to the notion of communities of practice 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.

7. Implications, limitations, and conclusions

7.1 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 in a community of practice should be structured. Second, the community of practice 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 communities of practice. 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 (Quality Controllers) 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.

7.2 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 communication dimensions of communities of practice when conducting our analyses. However, further research should look at the interaction between the structural and communication dimensions of communities of practice and their relationship with organizational performance.

7.3 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 properties of a community of practice 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 community of practice, the better its performance.

However, as discussed above, the connection between performance and communities of practice is a largely neglected area. Thus, if the community of practice 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.

References

Allen, T.J. (1977). *Managing the flow of technology: Technology transfer and the dissemination of technological information within the R&D organization.* Cambridge, MA: MIT Press.

Bavelas, A. (1948). A mathematical model for group structure. *Human Organizations*, 7, 17-30.

Blau, P.M. (1977). *Inequality and heterogeneity.* New York: Free Press.

Bonacich, P. (1972). Factoring and weighting approaches to status scores and clique identification. *Journal of Mathematical Sociology*, 2, 113-120.

Borgatti, S.P., & Everett, M.G. (1999). Models of core/periphery structures. *Social Networks.* 21, 375-395.

Boland, R.J., & Tenkasi, R.V. (1995). Perspective making and perspective taking in communities of knowing. *Organization Science*, 6, 350-372.

Borgatti, S., Everett, M.G., & Freeman. L.C. (1999). *UCINET 5 for windows.* Natick, MA: Analytic Technologies.

Brown, J.S., & Duguid, P. (1991). Organizational learning and communities of practice. *Organization Science*, 2, 40-57.

Burt, R. (1992). *The Social Structure of Competition.* Cambridge: Harvard University Press.

Conner, K.R., & Prahalad, C.K. (1996). A resource-based theory of the firm: Knowledge versus opportunism. *Organization Science*, 7, 477-501.

Degenne, A., & Forsé, M. (1999). *Introducing social networks.* London: Sage.

Drucker, P. (1991). *Post-capitalist society.* Oxford: Butterworth-Heinemann.

Everett, M.G., & Borgatti, S.P. (1999). Peripheries of cohesive subsets. *Social Networks.* 21, 397-407.

Friedkin, N. (1982). Information flow through strong and weak ties in interorganizational social networks, *Social Networks*, 3, 273-285.

Galbraith, Jay R. (1973) Complex organizations, Addison-Wesley Pub. Co. (Reading, Mass).

Granovetter, M. (1973). The strength of weak ties. *American Journal of Sociology,* 81, 1287-1303.

Hansen, Morten T. (1999) The Search-Transfer Problem: The Role of Weak Ties in Sharing Knowledge Across Organization Subunits." *Administrative Science Quarterly* 44, no. 4: 82-111.

Harary, F. (1969). *Graph theory.* Reading, MA: Addison-Wesley.

Kanter, R.M. (1983). *The change masters.* New York: Simon & Schuster.

Kanter, R.M. (1989). The new managerial work. *Harvard Business Review*, 6, 85-92.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities and the replication of technology. *Organization Science*, 3, 383-397.

Kogut, B., & Zander, U. (1995). Knowledge of the firm and evolutionary theory of the multinational corporation. *Journal of International Business Studies*, 26, 625-644.

Kogut, B., & Zander, U. (1996). What firms do? Coordination, identity, and learning. *Organization Science*. 7 (5): 502-518.

Kotter, J.P. (1982). *The general managers*. New York: Free Press.

Kotter, J.P. (1985). *Power and influence: Beyond formal authority*. New York: Free Press.

Krackhardt, D., Blythe, J., & McGrath, C. (1994). Krackplot 3.0: An improved network drawing program. *Connections*, 17 (2), 53-55.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Lawrence, P.R., & Lorsch, J.W. (1967). *Organization and environment: Managing differentiation and integration*. Boston: HBS Press.

Leavitt, H.J. (1951). Some effects of communication patterns on group performance. *Journal of Abnormal and Social Psychology*, 46, 38-50.

Liebeskind, J.P. (1996). Knowledge, strategy and theories of the firm. *Strategic Management Journal*, 17, 45-62.

Liedtka, J. (1999). Linking competitive advantage with communities of practice. *Journal of Management Inquiry*, 8, 5-16.

Miles, R., & Snow, C. (1994). *Fit failure and the hall of fame*. NY: Free Press.

Mitchell, J. C. (1969). *Social networks in urban situations*. Manchester, England: Manchester University Press.

Orr, J. (1990). *Talking about machines: An ethnography of a modern job*. Ithaca, NY: Cornell University.

Poppo, L., & Zenger, T. (1998). Testing alternative theories of the firm: Transaction cost, knowledge-based, and measurement explanations for make-or-buy decisions in information services. *Strategic Management Journal*, 19, 853-877.

Prahalad, C.K., & Hamel, G. (1990). The core competence of the corporation. *Harvard Business Review*, 68, 79-91.

Ranson, S., Hinings B., & Greenwood, R. (1980). The structuring of organizational structures. *Administrative Science Quarterly*, 25, 1-17.

Rogers, E.M. (1995). *Diffusion of innovations*. New York, NY: The Free Press.

Schenkel, A. (2002) Managing Deviations: Communities of Practice or Communities of Discipline? In Jan Löwstedt and Bengt Stymne and Löwstedt, *Scener ur et Företag*. Lund: Studentlitteratur.

Schenkel, A., and Rognes, J., (1999). *Organisational Change, Learning and Communication: Learning in Building the Öresund Bridge*. Paper presented at the Academy of Management Meeting 1999, Chicago.

Simon, H.A. (1945). *Administrative behavior*. New York: The Free Press.

Spender, J.-C. (1989). *Industry recipes: The nature and sources of managerial judgement*. Oxford: Basil Blackwell.

Spender, J.-C. (1996a). Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal*, 17, 45-62.

Spender, J.-C., & Grant, R.M. (1996b). Knowledge and the firm: Overview. *Strategic Management Journal*, 17, 5-9.

Storck, J. & Hill, P.A. (2000). Knowledge and diffusion through "strategic communities". *Sloan Management Review*, Winter, 63-74.

Teigland, R. (2000). Communities of practice in an internet firm: Netovation vs. on-time performance. In Lesser, E. (Ed.), *Knowledge and communities*. Newton, MA: Butterworth-Heinemann.

Tushman, M. (1977). Communication across organizational boundaries: Special boundary roles in the innovation process. *Administrative Science Quarterly*, 22, 587-605.

Walker, M., Wasserman, S., & Wellman, B. (1994). Statistical models for social support networks. In Wasserman, S., & Galaskiewicz, J. (Eds.), *Advances in social network analysis*. London: Sage.

Wasserman, S., & Faust, K (1994). *Social network analysis: Methods and applications*. Cambridge: Cambridge University Press.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge: Cambridge University Press.

Williamson, O.E. (1975). *Markets and hierarchies: Analysis and antitrust implications*. New York: The Free Press.

PAPER III

Investigating the Relationship between Communities of Practice and Organizational Performance: A Case Study in the Construction Industry

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Investigating the Relationship Between Communities of Practice and Organizational Performance: A Case Study in the Construction Industry[1]

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ABSTRACT

Communities of practice are rapidly becoming part of management's everyday vocabulary as many firms are now actively creating the conditions to support communities of practice within company walls. In some cases, firms are even "organizing" them in the hope of increasing competitive advantage or improving the organizational learning process. However, empirical research on the relationship between communities of practice and organizational performance is extremely limited; thus, there is little empirical support for management's efforts to enhance organizational performance through communities of practice. This research is an exploratory effort to fill that research gap through the case study of several communities of practice consisting of construction managers, engineers and supervisors within the scope of a multibillion-dollar construction project. Using the concept of learning curves, we find that the communities of practice operating under stable conditions exhibited static or improved performance. However, at one community of practice where a physical move reduced the ability of its members to interact in informal and formal face-to-face exchanges, there was a period of declining performance associated with the move.

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Investigating the relationship between communities of practice and organizational performance: a case study in the construction industry

1. INTRODUCTION

In recent years scholars have turned their focus to the emerging theoretical concept of communities of practice in the hope of better understanding the dynamics underlying knowledge-based work (Brown & Duguid 1991, Wenger 1998). Many of these scholars have chosen to anchor their work in the knowledge-based view of the firm, which proposes that a firm's only "true" source of sustainable competitive advantage is the ability to continuously create, disseminate, and embed knowledge throughout the firm (Drucker 1991, Spender & Grant 1996). Communities of practice, or emergent groups that form through mutual engagement in a shared practice, hold considerable promise because they offer a means to understand the interrelated process of working, knowing, learning, and innovation in organizations (Brown & Duguid 1991, Lave & Wenger 1991). They provide insight into the manner in which stocks of knowledge are developed, transferred, and maintained (Brown & Duguid 1991, Wenger 1998, Wenger et al. 2002). They also shed light on the role of informal organizational structures as the nexus for sharing and transferring valuable tacit knowledge possessed by individuals and groups (Kogut & Zander 1992). In addition, communities of practice provide firms with a vital source of incremental innovation as community members improve their practice through the continuous creation of knowledge in the context of the work environment (Wenger 1998).

Current research on communities of practice is focused primarily on the emergence and operation of communities; recently, it has often relied on anecdotal accounts as the basis for development of theory (Wenger 1998, Wenger et al. 2002). However, the question of associating performance with the presence of communities of practice has received little attention. This can be due to difficulties involved in delineating communities of practice as a unit of analysis or in finding a measure of performance that would adequately capture community performance. It may also be due to the lack of basic theoretical concepts in this emerging area. Despite this paucity of empirical research, there is a growing assumption by managers of a positive relationship between communities of practice and

organizational performance (Liedtka 1999). As a result, management in many firms is now actively seeking to establish conditions that will support communities of practice. Their hope is to increase competitive advantage or to improve the organizational learning process (Boland & Tenkasi 1995, Brown & Duguid 1998, Davenport & Prusak 1998).

In particular, management is focusing on improving the ability of community of practice members to communicate with each other. The underlying rationale is that communication is considered fundamental to the development and sustainability of communities of practice (Wenger 1998). However, again there is little research on the relationship between communication and the dynamics of a community of practice.

Thus, the purpose of this research is to shed some light on the relationship between communities of practice, communication, and performance. The research setting is an exploratory case study of a multi-billion dollar construction project. We collected both qualitative and quantitative data on communities of practice consisting of construction managers, supervisors and engineers to examine the relationship between communities of practice, communication, and performance.

2. THEORETICAL BACKGROUND

Communities of practice

Communities of practice are in essence groups of individuals who "accumulate collective learning into social practices." As a phenomenon, such communities have existed since the beginning of history (Wenger 2000). However, only in recent years have they been identified and included in the vocabulary of management (Wenger 2000: p. 4). In an ethnographic study of Xerox service technicians in the late 1980s, a variance was observed between the organization's formal description of work and the way in which the work was actually performed (Orr 1990). When the technicians were faced with problems for which the formal structure did not provide solutions, as was often the case, they relied for help on the organization's informal systems, such as story-telling, conversation, mentoring, and experiential learning (Orr 1990, Brown & Duguid 1991, Lave & Wenger 1991, Wenger 1997). These emergent

structures were termed communities of practice and have been defined as groups of people contextually bound in a work situation applying a common competence in the pursuit of a common purpose (Brown & Duguid 1991, Lave & Wenger 1991, Wenger 1998).

The work situation can be seen as the context for members to develop a shared repertoire or the community's routines, gestures, artifacts, vocabulary and understandings that allow it to do its work and to solve problems (Wenger 1998, 1999). The shared repertoire is negotiated by members through three communication-based processes: narration, collaboration, and social construction (Brown & Duguid 1991). By narrating stories, employees help each other to make sense of ambiguous, problem-centered situations; in this context, they follow noncanonical practice. Problems are diagnosed through the rendition of a coherent account of a random sequence of events; at the same time, a causal cognitive map of the situation is developed (Brown & Duguid 1991). The second communicative process is the collaboration that occurs among community members. With knowledge-intensive tasks, often no one individual can solve the problem alone, the reason being the individual's bounded rationality. By relying on the community, individuals can perform their work without needing to know everything (Wenger 1998). Thus, through deliberations, community members reduce the equivocality of a problematic issue (Pava 1983, Purser et al. 1992). The third process, social construction, occurs during the course of comprehension. Members negotiate meanings, turning incoherent events into coherent accounts and gaining insights for the benefit of the community (Brown & Duguid 1991, Wenger 1998).

Community memory and communication

Through these three processes, narration, collaboration and social construction, community members create a shared repertoire that enables the community to develop and access the tacit, implicit, and explicit knowledge that forms the community's memory. While the community's memory is its store of relevant knowledge (Boland & Tenkasi 1995), the shared repertoire provides the ability to interpret that knowledge. There is a duality in the shared repertoire to the extent that it serves as the community's knowledge base as well as the means for interpreting and

developing it. The community memory is based on the history of stories narrated during informal collaboration as well as on the task norms developed during this collaboration. This cumulative knowledge base reflects the community's development, depicting the thread running through the intertwined actions of working, learning, and innovating of the community (Teigland & Timlon 1998). When diagnosing a problem encountered at work, members of the community can rely on the community memory. Consequently, the community of practice can successfully resolve each new challenge as its members activate its memory, accessing relevant knowledge regardless of time or space and effectively interpreting and applying it with the aid of their shared repertoire (Nonaka & Takeuchi 1995). Members also reciprocate by adding their experiences, both during and after problem solving, to the community memory.

In a considerable body of research on communities of practice, it has been found that the development and dissemination of a shared repertoire occurs primarily through informal face-to-face discussions in which members discuss practice-related issues (Lave & Wenger 1991, Wenger 1998, Brown and Duguid 1991). In this manner, valuable tacit knowledge may be disseminated implicitly – "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" (Reber 1993).

However, the shared repertoire and the community's memory are threatened when communication among community-of-practice members is hindered; in such cases, the community of practice may disintegrate into loose constellations (Wenger 1998). Thus, it is argued that the performance of a community of practice is dependent upon the ability of community members to continuously build and access its shared repertoire through frequent informal interactions. This in turn facilitates the effective creation and transfer of valuable tacit and implicit knowledge within the community (Lave & Wenger 1991).

Structural properties of communities of practice

Recent work has begun to focus on the structural properties of communities of practice. Drawing on the extensive field of social networks, Schenkel, Teigland, and Borgatti (2002) developed a series of structural properties of communities of practice at the group level. The authors argue that the logic of communities of practice exhibits strong parallels to the structural characteristics of embedded networks. According to a social-network approach, the individual is embedded in the overall network, which both constrains and enables his or her actions (Wasserman and Faust 1999) -- a view that also pervades the community-of-practice literature. Two structural properties worth examining here are connectedness and core/periphery structure. *Connectedness,* or the extent to which actors are directly or indirectly connected with each other (Harary 1969), is perhaps the most fundamental structural property of communities of practice. For the shared repertoire of a community to be developed and disseminated, all community members need to be directly or indirectly connected with each other, i.e., to have a high degree of connectedness. In addition, a community of practice should exhibit a *core/periphery structure* containing no significant subgroups, factions, or cliques except the core itself (Borgatti & Everett 1999, Everett & Borgatti 1999). Core/periphery structures facilitate the diffusion of information and innovation because they do not include significant clusters of nodes that are poorly connected to the rest of the network. Consequently, they can be expected to develop a relatively homogeneous shared repertoire in which most individuals are exposed to new practices and ideas soon after these emerge (Schenkel, Teigland and Borgatti 2002). Those structural properties are related to the ability of community-of-practice members to conduct the three communication processes discussed above.

Communities of practice and organizational performance

In the field of communities of practice, there is an inherent assumption that communities of practice have a positive impact on organizational performance (cf. Wenger 1998, Brown and Duguid 1991). However, there are few empirical studies that provide evidence of this positive relationship. At the individual level, Teigland (2000) found that the frequency and quality of the interaction between an individual and

specific communities of practice are related to his or her individual performance. Individuals who interacted to a higher degree with *both internal and external* firm communities exhibited a higher level of innovative performance than their colleagues, while those individuals who interacted to a high degree *only with external* communities exhibited a lower level of on-time performance.

Yet beyond the individual level, few empirical studies have been conducted. Rather, the general assumption is that as members of a community of practice work together, they improve their practice. Wenger (1998) argued that communities of practice produce incremental improvements in work practices but are not favorable to radical improvements. Similarly, Lave & Wenger (1991) held that communities are involved in simultaneously producing both practical outcomes for customers as well as learning for members (Liedtka 1999).

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. A single community of practice could include individuals crossing numerous organizational boundaries, varying from immediate workgroups to a set of Internet contacts on the other side of the world (Teigland 2000). In addition, there is no agreement on a performance measure that would capture the community of practice as a whole; again, the explanation is the fluid nature of communities of practice (Brown and Duguid 1991, Wenger 1998.). Moreover, the process of defining the membership of true communities of practice apparently takes away their very essence because they thrive on their informal nature. Thus, it is not surprising that the literature on communities of practice is populated with ethnographies and case studies rather than surveys or experiments.

However, attempts have been made to examine performance in "strategic" communities of practice since these groups display characteristics of traditional emergent communities of practice (Storck and Hill 2000). Strategic communities of practice are a result of efforts by management to artificially create and manage communities of practice. With strategic communities, management sets the focus, defines

membership, and provides resources for the communities. In emergent communities, by contrast, the community members determine both focus and membership. A feature shared by emergent and strategic communities of practice is that both are able to develop their own practice and shared repertoire independently of management. However, through defining focus and membership in strategic communities, it is possible to establish a unit of analysis and a performance measure. Storck and Hill's (2000) studies suggest that strategic communities of practice that have developed a shared repertoire provide long-term value to organizations through learning, innovation, and transfer of knowledge.

3. STUDY DESIGN AND DATA COLLECTION

This study is based on interviews, surveys, and performance data from Sundlink Contractors, an international contractor consortium that from 1996 to 2000 designed and built the Øresund Bridge, a 7.8 kilometer multi-level structure connecting Denmark and Sweden. Our study examines this immense, highly complex infrastructure project involving stringent quality requirements, well-defined completion times, and harsh environmental conditions. The primary reason for choosing this particular research site was that it was rich in emergent situations in a relatively controlled environment. This feature facilitated the study of communities of practice by offering well-defined units displaying attributes of communities of practice as well as providing a relevant measure of performance for these communities.

Organization structure

The Sundlink Contractor organization comprised ten departments, evenly divided between operations and support. The departments were functionally organized into sections, and in the case of the operative departments, the department sections corresponded to different physical sections of the bridge. The primary focus of this study was four sections -- Caisson, Piershaft, High Bridge Deck/Girder, and Pylon -- within the two operative departments of Onshore and High Bridge. A summary of the departments and sections included in this study is shown in Table 1. The Onshore Department was responsible for the production of large prefabricated concrete structures called piershafts, caissons, and high-

bridge deck/girders. The piershafts and caissons formed the columns upon which the concrete and steel and concrete decks of the high bridge rested. The High Bridge Department was responsible for building the pylons that created the 1,092-meter-long bridge with a span of 490 meters. The operative sections were staffed by professional craftsmen who reported to lower level managers: supervisors and superintendents. These lower-level managers in turn reported to the section head. Each section head then reported to the department manager. Construction managers, supervisors and engineers, who had not worked together previously in the majority of cases, were assigned to the various individual sections in 1996.

Table 1. Description of Sundlink Department

Department	Section	Activity	Size of structures
Onshore	- Caisson - Piershaft - High Bridge Deck/Girder	- Constructed prefabricated concrete structures	- 800 to 4700 tons - 10 to 51 meters tall
High Bridge	- Pylon	- Constructed concrete bridge pylons on land and at sea	- Over 200 meters tall - 4355 m3 of concrete - 800 tons of reinforcement concrete

Deviations

The construction of a bridge is characterized by a continuous stream of emergent problems, or equivocal situations. According to community-of-practice theory, this feature is the primary reason for the existence of communities of practice. One particular type of problem in the construction industry is a deviation, or a situation in which articulated procedures or processes are not followed or articulated objectives or targets are not achieved. Sundlink Contractors utilized a formal quality system based upon ISO 9000 standards that defined and facilitated the identification as well as the management of deviations. The management of deviations involved repairing the actual deviation and taking one of three corrective actions: 1) applying existing work methods, 2) changing existing work methods, or 3) changing targets. Work methods are the articulated processes to follow in order to attain targets. The successful management of deviations was of strategic importance to the departments

since these deviations affected the time, cost, and quality parameters of the overall bridge for Sundlink.

Communities of practice in this study

The communities of practice in this study were contained within formally defined department sections and thus resemble the claims-processor community described by Wenger (1998). The four observed sections were geographically separated from each other as well as from other Sundlink departments and other organizations.

It is suggested that formally defined communities of practice developed within these operative sections since they were physically isolated from individuals outside the sections and section members were all performing the same task. Festinger, Schacter & Back (1950) held that geographic proximity might be a predictor of communication between two people. One of the most frequently cited researchers, Allen (1977), identified a strong positive relationship between proximity and communication in his research on R&D labs. Further, Walsh & Baker (1972) found that task similarity, as opposed to distance, was a predictor of communication. In this study, individuals in these sections were conducting similar tasks and were also co-located. Around these sections, therefore, there arose a communication boundary that influenced the development of communities of practice. Consequently, these formal sections exhibited homophily, or the tendency to interact more with people within the same section than with people from other parts of the organization or from outside the organization (Homans 1950, Lazarfield and Merton 1954, Laumann 1966).

The continuous management of deviations provided the context for people to mutually engage in narration, collaboration, and social construction and in the process to develop and maintain a shared repertoire. The shared repertoire consisted of a common understanding of what defines a deviation as well as the routines for detecting and managing deviations. These routines involved a shared way of controlling work processes against defined processes as well as procedures to manage deviations. The procedure for managing deviations included completing a deviation report that stated the reason why the

deviation occurred and proposed actions both to remedy the deviation and to prevent it from recurring. Practice included contacting the department responsible for approving the deviation report as soon as the deviation occurred rather than when the department first received the deviation report. This type of informal practice helped to ensure speedy approval of recommended actions. The deviation reports constituted an artifact of the community, while the actions to prevent the deviation from recurring formed the basis for the further development of this community's shared repertoire through collaborative narratives. At the same time a distinct way of talking about deviations occurred with words like rat's hole and honeycombs used to describe them.

The context for developing these narratives through storytelling was that of informal meetings such as lunches or breaks, which were limited to onsite locations with other section members. Individuals collaborated on the same tasks, since the work concerned very specific activities within a physically defined area. The section members socially constructed their reality through discourse in the work context. Thus, through these three processes, the section members formed communities of practice, developing a shared repertoire for communicating and working. We were then able to observe communities of practice that emerged informally through mutually engaging in the management of deviations. These communities were wholly contained within each section as defined formally by the organization and as restricted by industry norms.

Sources of data

We drew on three sources of data to explore the relationship between communities of practice, performance, and communication. Firstly, to explore community of practice performance, we constructed a performance measure based on a particular type of deviation associated with concrete production -- repair deviations. These deviations were chosen since they were the most common ones among all the sections in this study; hence, cross group comparisons could be made. Secondly, repair deviations are among the more challenging and complex deviations; therefore, a single individual will generally have difficulty in formulating an action alone and will have to draw upon the community memory to resolve the deviation. Data on the 130 deviations that

occurred from June 30, 1996 to June 30, 1998 were gathered and classified by an engineer from Sundlink. Reliability was increased through internal quality audits as well as supervision by a Quality Controller whose responsibility was to ensure that all deviations were identified and reported.

To analyze these data, we used the concept of learning curves. The basic principle behind learning curves is that productivity is linked to volume of production and that learning enhances productivity as production increases. Following Li and Rajagopalan (1996), we measured productivity changes in terms of changes in the cumulative output of "defective" units. Since improvements are more difficult in absolute terms once a previous improvement is made, the learning curve normally follows a logarithmic decline (ceteris paribis). This function is depicted as a straight line in a linear-logarithmic diagram, and the use of this model is widely used to represent the learning curve (Yelle 1979). A period of constant learning in which the occurrence of the same type of situations is also constant is therefore shown as a straight line with a negative slope.

Deviations were analyzed using linear-logarithmic graphs of the accumulated relative number of Repair Deviations. The learning curves for the four observed sections were produced by calculating and plotting on a monthly basis the cumulative total of deviations divided by the cumulative total of concrete produced. This ratio then showed the relative number of cumulative deviations per 1000m3 of concrete produced. It should be noted that the goal of each section was to continuously improve concrete production through decreasing the number of deviations; thus, a negatively sloped learning curve represents improved performance.

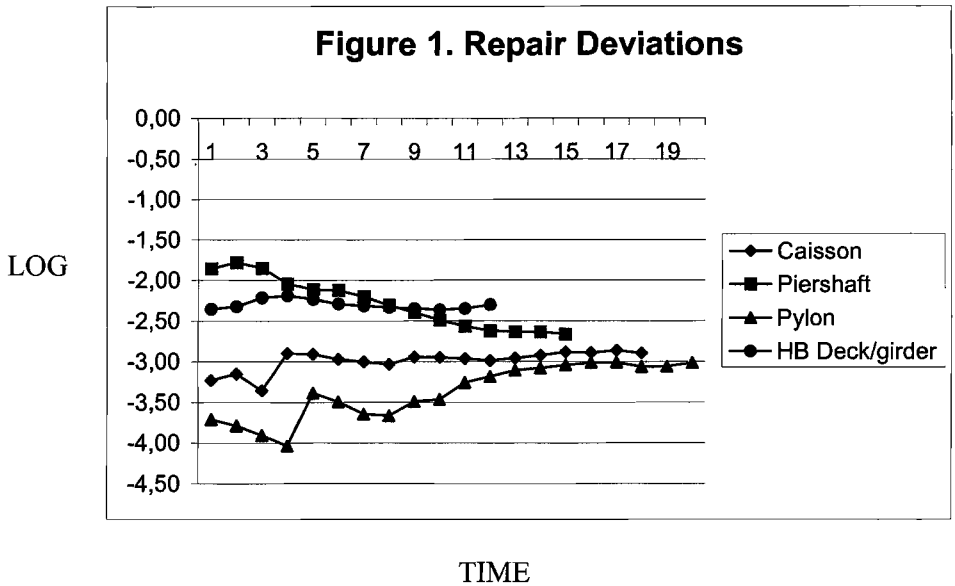
To gain a deeper understanding of the learning curves as well as the interaction and communication patterns in the context of managing deviations, both qualitative and quantitative data were gathered. Qualitative data took the form of twenty-eight interviews of 40-60 minutes each with managers and engineers involved in managing the deviations. The interview protocol was structured around open and semi-structured questions focusing on describing the deviation itself,

interaction patterns in the context of the deviation, and details concerning the management of the deviation. Quantitative data were gathered through a questionnaire that focused on communication patterns in managing deviations as well as on structural patterns. In total, 31 people out of the 34 people in four operational sections responded to the questionnaire, a response rate of 91%. As a result, the combined methods allowed us to concentrate on communities of practice emerging within formally defined structures, and on a performance measure directly associated with the specific community. We were therefore able to capture changes in performance in communities of practice.

4. LEARNING CURVES: UNDERSTANDING PERFORMANCE

We argue that the slope of the learning curves indicates the effectiveness of the communities of practice at this research site. A community of practice should exhibit improved performance when it is able to build and access the community's memory as manifested by its shared repertoire. Further, the processes that form a shared repertoire are dependent upon the ability to communicate. Through narration, collaboration and social construction, it is possible to disseminate and embed individual or selected experiences throughout the community. Thus, a negatively sloped curve would indicate that the community could both develop and access its shared repertoire – community memory. Conversely, a positively sloped learning curve would indicate a community that does not or cannot contribute to or access its memory.

To understand the relationship between performance and communication, we examined the slope of the learning curves for the four sections. In Figure 1, we find that the Piershaft Section displays a negatively sloped learning curve, the High Bridge Deck/girder and Caisson Sections have flat or static learning curves. However, the learning curve for the Pylon Section has a different pattern than the other three sections, exhibiting primarily a positive or flat slope. The positively sloped curve suggests that the incremental improvements or learning at the Pylon Section stopped as the cumulative number of improvements was no longer decreasing, and instead started to increase. Since this pattern was not found in any other section, we decided to focus on it.



Changes in communication at the pylon section

We suggest that a change in the slope of the Pylon Section's learning curve is indicative of changes in the section's ability to communicate, and by extension, the ability to contribute and access the community's memory. No such change was found at any other section included in this study.

The Pylon Section experienced a change in the spring of 1997 when the section was geographically divided into two operative subsections, both located 3.7 kilometers out at sea and separated by several hundred meters of water. The two subsections were also separated from the department's land based technical/support section. Each Pylon subsection was staffed by more or less equal teams of supervisors, quantity surveyors, and production personnel. The work of the two Pylon subsections was independent of one another. However, the problems that both subsections encountered remained similar since the design and execution of concrete production were identical at the two subsections. To this extent, the subsections could continue to share their practical experiences to the benefit of both even though they were physically separated.

We also focused our attention on the effects of this physical change on communication patterns. We propose that if changes negatively affect the ability of a community of practice to communicate, one would expect breaks followed by a horizontal or even a positively sloped curve. This would suggest that the community of practice is no longer functioning as well as it did prior to the change. In the context of this study, a positively sloped curve would indicate either that the individual learning of community-of-practice members during deviation management does not become a part of the community's memory, or that other members do not access the learning in the community's memory. As a result, these deviations continue to occur and performance does not improve. Such was seemingly the case at the Pylon Section.

The interview data revealed that communication between the two Pylon subsections was severely hampered by the move to sea. Travel between the two subsections became more difficult and irregular since a meeting between people from different subsections involved a two-hour ferry trip. Thus, one of the most important communication media, informal face-to-face interactions, was negatively affected to a considerable degree. One Pylon Section interviewee described how splitting the Pylon Section in the move to sea hampered informal communication: "*The department manager is not out (at the pylons) often, in fact, seldom. The section head is out (at the pylons) two times a week. The superintendent everyday and the quality control engineer two to three days a week.*" The frequency of interaction affected what information was exchanged and when it was exchanged. In the case of deviations, detection was hampered by the physical separation. One engineer stated, "*I don't see everything. I hope that I am informed about everything.*" In addition, the physical change led to reduced attendance at formal meetings. The Pylon Section as a whole had formal meetings once a week with the superintendent, section head, supervisors, and site engineer. However, it was more difficult for subsection personnel to attend the meetings, which were often held at the High Bridge Department's technical/management office on land. One supervisor expressed the challenge of formal meetings in the following way: "*There is a problem in that not all the superintendents and supervisors attend meetings. The problem is that because of conflicts the supervisors are not always there. For example,*

they have work that needs their attention. That is why all supervisors are not at the meetings."

We further examined the questionnaire data to gain a deeper understanding of the communication patterns. As Table 2 shows, the Pylon Section (as a whole after the move) had the lowest frequency of informal face-to-face interaction of all of the sections. Specifically, members of the Pylon Section reported that they had informal face-to-face interactions slightly less than once a week, while the other sections reported having such interactions one to two times a week. Furthermore, in contrast to the other sections, the Pylon Section used the telephone more frequently than any other communication channel.

Table 2. Comparison of communication channels

	Caisson	Piershaft	High Bridge Deck/Girder	Pylons	Total
Formal face-to-face a)	3,57	1,60	2,75	2,37	2,44
Paper based	1,86	2,20	3,00	2,62	2,71
Informal face-to-face	**4,00**	**3,60**	**3,25**	**2,71**	**3,78**
Telephone	2,86	1,40	3,00	3,75	3,36
E-mail	2,00	1,20	3,00	1,71	2,51
Fax	1,86	1,00	3,00	2,50	2,15

a) 1 = rarely or never, 2 = once a month, 3 = once a week, 4 = twice per week, 5 = once per day, 6 = five times per day, 7 = more than five times per day

Interview data also revealed that community-of-practice members in the other three sections spent considerable time building the community's memory through informal face-to-face interactions. Members of these three sections were continuously co-located throughout the project. Thus, each section operated as one integrated community. The difference between what was considered work and what was social became blurred in these sections. Individuals ate lunch and took breaks together, narrating for each other what they had experienced during the day as well as helping each other with ongoing tasks. As one operative employee remarked about the informal conversations, *"We sit and eat together, and talk with each other. It is an open dialogue the whole time."* Another

said, "*You meet a lot over a cup of coffee and in other ways like that. ...We meet all the time and then you talk, discuss your work.*"

In many cases, deviations had to be solved quickly. The fastest and easiest means of interacting, according to the interviewees, was informal: to track someone down with blueprints in hand. One interviewee described the nature and role of informal meetings in the following way, "*We only used informal meetings to solve this deviation...It is the normal procedure. You have informal talks to make things work... you don't set up a meeting. I knock on people's doors and they usually are there. You discuss matters when you meet.*"

On the basis of this evidence, it is argued that when the possibility for individuals in the Pylon Section to communicate informally and formally through face-to-face communication was limited, their ability to develop and access the community memory was negatively affected. It appears that the ability of the Pylon Section members to act as one connected component, the primary structural requirement for a community of practice, was impacted by the move. In addition, it became more difficult for the Pylon Section to maintain a core/periphery structure since it was divided into three geographically separate constellations: the two subsections and the land-based technical/management support office. Thus, when the possibilities of communication were curtailed for the Pylon Section, it was less able to engage in the three processes and to build and access the community's memory, thus lowering the section's performance as exhibited by the learning curves.

5. CONCLUSION

Research on communities of practice contributes significantly to our understanding of knowledge-based work. However, we are a long way from a thorough comprehension of their relationship to organizational performance. Progress toward this goal is hampered by the very nature of communities of practice – emergent, fluid, and informal – and by the consequent difficulty of finding an adequate measure of performance for them. To help overcome this obstacle to examining the relationship to organizational performance, our exploratory research was on communities of practice within a controlled environment. The observed

employees of the Sundlink organization developed communities of practice through narration, collaboration, and social construction in the pursuit of a joint enterprise, the production of concrete. A shared repertoire comprising a community's cumulative memory as well as a way of working was developed. It improved community-of-practice performance in one section, whereas the effect on performance was neutral in two other sections. Thus, our results provide some preliminary evidence of a positive relationship between communities of practice and incremental improvements in their performance.

The strength of this study lies in the examination of the learning curve of the Pylon Section. This examination indicates that the performance of this once co-located community of practice was affected by changes in means of communication that limited the community's ability to develop and access its shared repertoire and in turn its memory. Still, the question remains as to how long the Pylon section would continue to act as a community of practice given that it was geographically separated.

In terms of theoretical and practical implications, our results provide some support for the recent efforts by managers to sponsor and even "formally define" communities of practice within organizations. Further attention should be paid, however, to understanding the relationship between the development and performance of communities of practice and efforts made by management. In addition, this article illustrates how sensitive communities of practice are to changes in their ability to communicate. Therefore, managers should pay serious attention to organizational changes that affect the use of media; they should also supply the media that are essential if the community of practice is to develop. If suitable media as well as opportunities and resources to communicate are provided, the development and maintenance of communities of practice will be facilitated.

Within this research, we examined only communities of practice within one organization and one industry. Thus, we are limited in the degree to which we can generalize our results. Further research should focus, therefore, on examining the relationship between communities of practice and organizational performance in other organizational settings. Another research area is the role of communication in communities of practice.

One avenue for further study would be to examine the effects of using different media on the cognitive processes and performance of communities of practice. To date, research on communities of practice has made little distinction between the use of different communication media; in this regard, the concept of media richness in communities of practice would seem interesting to pursue.

References

Allen, T.J. (1977). *Managing the flow of technology: Technology transfer and the dissemination of technological information within the R&D organization.* Cambridge, MA: MIT Press.

Bavelas, A. (1948). A mathematical model for group structure. *Human Organizations*, 7, 17-30.

Blau, P.M. (1977). *Inequality and heterogeneity.* New York: Free Press.

Berger, P. and T. Luckmann (1966). *The Social construction of reality. London*, Penguin Books.

Bonacich, P. (1972). Factoring and weighting approaches to status scores and clique identification. *Journal of Mathematical Sociology.* 2, 113-120.

Borgatti, S.P., & Everett, M.G. (1999). Models of core/periphery structures. *Social Networks.* 21, 375-395.

Boland, R.J., & Tenkasi, R.V. (1995). Perspective making and perspective taking in communities of knowing. *Organization Science.* 6, 350-372.

Borgatti, S., Everett, M.G., & Freeman. L.C. (1999). *UCINET 5 for windows.* Natick, MA: Analytic Technologies.

Brown, J.S., & Duguid, P. (1991). Organizational learning and communities of practice. *Organization Science.* 2, 40-57.

Conner, K.R., & Prahalad, C.K. (1996). A resource-based theory of the firm: Knowledge versus opportunism. *Organization Science.* 7, 477-501.

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. *Management Science*, 32(5): 554-571.

Daft, R. L., Lengel, R. H., & Trevino, L. K. (1987). Message equivocality, media selection, and manager performance: implications for information systems. *MIS Quarterly*, 11(3): 355-366.

Davenport, T.H. and Prusak, L. (1998). *Working knowledge*, Boston: Harvard Business School Press.

Drucker, P. (1991). *Post-capitalist society.* Oxford: Butterworth-Heinemann.

Everett, M.G., & Borgatti, S.P. (1999). Peripheries of cohesive subsets. *Social Networks.* 21, 397-407.

Festinger, L., Schachter, S., & Back, K. (1950). *Social pressures in informal groups: A study of human factors in housing*. Palo Alto, CA: Stanford University Press.

Harary, F. (1969). *Graph theory*. Reading, MA: Addison-Wesley.

Homans, G.C. (1950). *The human group*. New York: Harcourt Brace.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities and the replication of technology. *Organization Science*, 3, 383-397.

Kogut, B., & Zander, U. (1995). Knowledge of the firm and evolutionary theory of the multinational corporation. *Journal of International Business Studies*, 26, 625-644.

Krackhardt, D., Blythe, J., & McGrath, C. (1994). Krackplot 3.0: An improved network drawing program. *Connections*, 17 (2), 53-55.

Laumann, E. O. (1966). *Prestige and association in an urban community*. Indianapolis: Bobbs-Merrill.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Lazarsfeld, P., & Merton. R. (1954). *Friendship as social Process*. in Freedom and Control in Modern Society, edited by Morroe Berger, Theodore Abel and Charles Page. New York: Octagon.

Li, G., and Rajagopalan, S. (1997). A learning curve model with knowledge depreciation. *European Journal of Operational Research*. 105, 1, 143-154.

Liebeskind, J.P. (1996). Knowledge, strategy and theories of the firm. *Strategic Management Journal*. 17, 45-62.

Liedtka, J. (1999). Linking competitive advantage with communities of practice. *Journal of Management Inquiry*, 8, 5-16.

Nonaka, I. and H. Takeuchi (1995). *The knowledge creating company*. New York: Oxford University Press.

Orr, J. (1990). *Talking about machines: An ethnography of a modern job*. Ithaca, NY: Cornell University.

Pava, C. (1983). *Managing new office technology*. New York: Free Press.

Purser, R.E., Pasmore, W.A. and Tenkasi, R.V. (1992). The influence of deliberations on learning in new product development teams. *Journal of Engineering and Technology Management*. 9 , 1-28.

Reber, A.S. (1993). *Implicit learning and tacit knowledge*. New York: Oxford University Press.

Schenkel, A. and Rognes, J. (1999). *Organisational change, learning and communication: Learning in building the Øresund Bridge.* Paper presented at the Academy of Management Meeting 1999, Chicago.

Snyder, W. (1996). Organizational learning and performance: An exploration of linkages between organizational learning, knowledge, and performance. University of Southern California. Ph.D.

Spender, J.-C., & Grant, R.M. (1996b). Knowledge and the firm: Overview. *Strategic Management Journal.* 17, 5-9.

Storck, J. & Hill, P.A. (2000). Knowledge and diffusion through "strategic communities". *Sloan Management Review*, Winter, 63-74.

Teigland, R. (2000). Communities of practice in an internet firm: Netovation vs. on-time performance. In Lesser, E. (Ed.), *Knowledge and communities.* Newton, MA: Butterworth-Heinemann.

Teigland, R & Timlon, J. (1998). The knowledge acquisition process of software programmers in an emerging digital communications company: From communities of practice to information technology. Working paper. Stockholm: Institute of International Business.

Walsh, V.M. and Baker, A.G. (1972) Project management and communication patterns in industrial research. *R & D Management* **2**, 103-109.

Wasserman, S., & Faust, K (1999). *Social network analysis: Methods and applications*. Cambridge: Cambridge University Press.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge: Cambridge University Press.

Wenger, E. (2000). Communities of practice: The key to knowledge strategy. In Lesser, E. (Ed.), *Knowledge and communities.* Newton, MA: Butterworth-Heinemann.

Wenger, E., McDermott, R., & Snyder, B. (2002). *Cultivating communities of practice.* Harvard Business School: Boston

Webster, J., & Trevino, L. K. 1995. Rational and social theories as complementary explanations of communication media choice: Two policy capturing studies. *Academy of Management Journal*, 38(6): 1544-1572.

Yelle, L. E. (1979). The learning curve: Historical review and comprehensive survey. *Decision Science.* 10: 302-328.

PAPER IV

Investigating the Influence of Media Richness on Learning in a Community of Practice: A Case Study at the Øresund Bridge

Andrew Schenkel

Investigating the Influence of Media Richness on Learning in a Community of Practice: A Case Study at the Øresund Bridge[1][2]

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INTRODUCTION

How organizations prevent and manage problems is critical to organizational performance and long-term competitiveness. Managing problems is recognized as one of the premier capabilities of the firm, and it has been argued that the firm should be considered a problem-solving institution (Loasby 1976, 1991) specialized in solving problems relative to local activities (Foss 1999). In solving problems, firms develop and draw on repositories of technological and organizational knowledge, which allows firms to grow (Dosi et al. 1992). Changes in the detection and correction of problems are considered as learning (Argyris and Schön 1995).

Not all problems that firms encounter are of the same quality and these differences can be understood in terms of equivocality (Daft and Lengel 1986, Daft and Weick 1984). The term equivocality refers to the existence of multiple and conflicting interpretations (Weick 1979). In a highly equivocal situation there are many possible meanings; people are not certain of what the relevant questions are to ask, or of the right answers to these questions (Weick 1995). Solving problems requires a low level of equivocality, since long term effective solutions to problems requires that the situation is well understood (Buchel and Raub 2001). This suggests that a low level of equivocality both precedes the development of effective solutions and is indicative of effective solutions that have already been found.

The concept of communities of practice offers a means to understand how problems in organizations are solved (Brown and Duguid, 1991, Lave and Wenger, 1991) and how equivocality is reduced during the problem-solving process. Communities of practice are groups of people contextually bound in a work situation and applying a common competence in the pursuit of a common enterprise (Brown and Duguid 1991, Lave and Wenger 1991, Wenger 1998, Teigland 2000). It has been suggested that through patterns of exchange and communication, communities are able to reduce equivocality (Pava 1983, Purser et al. 1992, Teigland 2000). Researchers (Lave and Wenger 1991, Wenger 1998, Brown and Duguid 1991) in the field of communities of practice

have recognized the importance of communication in problem solving; however, little distinction has been made between different types of communication media. The term communication in community-of-practice literature has referred in a broad sense to all types of communication media. However, there are differences in media "richness", or the ability of a specific medium to convey and change understanding or to reduce the degree of equivocality (Daft and Lengel 1986).

The goal of this exploratory research is to explore how media richness influences learning in communities of practice. The Øresund Bridge was chosen as the focus of this research. There is an increasing recognition that bridge building is a suitable context for studying learning as it offers a dynamic environment characterized by unique problems (Suchman 2000). Community-of-practice scholars (Lave and Wenger 1991, Brown and Duguid 1991) have argued that this particular type of environment provides the conditions for the development of communities of practice. The communities of practice observed in this study consisted of construction managers, supervisory personnel as well as engineers whose shared practice was the production of concrete and the management of deviations from customer requirements.

COMMUNICATING PRACTICE

Why do communities of practice arise?

Solving problems is of strategic importance to organizations. One useful concept in understanding how problems are solved in organizations is that of communities of practice. It has been suggested that communities of practice emerge because formal routines are inadequate for solving problems in dynamic environments (Brown and Duguid 1991). In such an environment it is difficult to anticipate all problems that can occur or to prescribe how they should be managed (Wenger 1998, Brown and Duguid 1991). The development of effective routines presupposes a high degree of rationality in the form of predicting all possible problems and identifying "optimal" solutions. However, as Simon (1947) pointed out, inherent cognitive limitations frustrate our striving to be rational and limit our predictive and interpretative skills. Therefore, it has been argued that

communities of practice arise to fill this gap (Teigland 2000). Further, the codification of routines involves transforming tacit knowledge, or knowledge embedded in the individual, into explicit knowledge. Because tacit knowledge is embedded in the individual, it is not easily accessible as people are not aware of the knowledge that they possess (Polanyi 1967). Moreover, even if routines can be formalized, organizations may not want to codify knowledge. It has been suggested that the codification of tacit knowledge is costly (Liebeskind 1996). Also, once knowledge is codified, it loses its strategic value since it can easily spread beyond the boundaries of the firm (ibid.).

A shared repertoire: a communication-based means of solving problems

The development and dissemination of the community's problem-solving ability are dependent upon a shared repertoire consisting of the community's routines, gestures, artifacts, vocabulary and understandings (Wenger 1998, 1999). Brown and Duguid (1991) in their seminal work on communities of practice noted that through collaborative narratives a shared repertoire is formed, developed, maintained and reproduced.

Narration describes how people create and tell stories in order to improve their understanding of events. The telling of stories tranforms incoherent accounts of events into coherent narratives. Stories have the advantage of flexibility and can therefore be adapted to each particular situation. The "richness" of stories can fill the gaps left by explicit manuals. According to Brown and Duguid (1991), story telling helps people to develop an understanding of the situation that encompasses cause and effect. The understanding gained from story telling acts as a type of memory that is used to interpret future events (Schank 1990).

Collaboration refers to the fact that the shared narratives developed by communities involve both storytellers and listeners. Given the collaborative nature of stories, an individual member need not know everything about how to solve problems, but can draw on the cumulative knowledge of the community (Wenger 1999). This possibility is particularly helpful with knowledge-intensive tasks, which are often

complex and require the cumulative knowledge of the group (Teigland 2000, Cross, Borgatti and Parker 2002).

Collaboration serves not only as a means of developing and disseminating knowledge, but also as a way of reducing equivocality (Weick 1979). Equivocality arises because meanings that people attach to situations are not objective and singular, but subjective, socially constructed and multiple (Weick 1979, Berger and Luckman 1966). The reduction of equivocality can be viewed as a series of iterative cycles in which "the community" discusses the problem at large, improving its understanding with each iteration (Weick 1979).

Communication media and problem solving in communities

Communication is fundamental to problem-solving in communities of practice, since communication reduces equivocality. In particular, it has been argued that reduction of equivocality is integrally linked with collaborative narratives (Teigland 2000), a communication-based process. These narratives are developed through different communication media; however, few researchers in the field of communities of practice have made a distinction between various communication media and their capacity for reducing equivocality.

According to a substantial body of literature in communication research, media vary in their ability to reduce equivocality (Daft and Lengel 1986, Trevino et al. 1987, Markus 1994)[1]. The theory of media richness holds that the effective reduction of equivocality requires matching the level of equivocality of the situation with the richness of the media. Communication may be conducted through a variety of media such as face-to-face communication, telephone, e-mail, telefax and paper-based messages, and video conferencing. Media differ in their level of richness, or the extent to which they possess the following qualities: inherent capacity for immediate feedback, number of cues and channels, personalization and language variety (Yates and Orlikowski 1992, Daft and Lengel 1986). A rich medium would have the following qualities: immediate feedback, the presence of multiple cues in the form of meanings conveyed through body language, voice, or tone, as well as

[1] This section is based on Schenkel and Rognes, 1999.

richly varied language through which understandings or feelings can be expressed. Conversely, a lean media would have little feedback, few cues and a limited variety of language. Daft and Lengel (1986) proposed that face-to-face communication is the richest communication, followed by telephone and written texts. Zmud et al. (1990) had similar findings, but included electronic mail and telefax in their study; these were considered leaner than paper-based communication.

Contrary to media-richness theorists, other communication researchers (Webster and Trevino 1995, Yates and Orlikowski, 1992) have argued that the richness of a communication medium is not predetermined, but is relative and socially influenced by governing norms and values (Fulk and Boyd 1991, Fulk 1993). Thus, richness is in the eye of the user rather than objectively determined. Consequently, the richness of media cannot be presupposed. For example, face-to-face conversation is not necessarily the richest medium; in some cases, e-mail or other normally lean media can be richer.

Whether richness is objective or socially determined is an empirical question. However, media-richness theory is nonetheless a means to understand how equivocality is reduced. Specifically, this theory prescribes the use of a rich media in situations high in equivocality since this will increase the overall clarity of the situation. It is argued that if a lean media is used instead, it will not be rich enough to improve the understanding of the situation, and a high level of equivocality will remain. Conversely, if a rich medium is used in a situation of low equivocality, it will not clarify the situation; it may even raise the level of equivocality. In sum, the effective reduction of equivocality, according to media-richness theory, requires matching the richness of the medium with the equivocality of the situation.

As indicated above, situations high in equivocality would seem to require rich media in order to reduce equivocality; otherwise, the level of equivocality cannot be reduced sufficiently for an effective solution. It is therefore suggested that in communities of practice, where equivocality is reduced through collaborative narratives, the effectiveness of these narratives in solving problems is highly dependent upon the availability of rich media. If rich media are not present, the community's ability to

learn is negatively affected. Thus, if rich media are exchanged for leaner media, there will be an increase in the number of deviations because it is no longer possible to reduce equivocality. Conversely, if lean media are exchanged, learning will be impaired.

STUDY DESIGN AND RESEARCH METHOD

The Organization: Sundlink Contractors

This study uses data from Sundlink Contractors, the international contractor consortium that designed and constructed the Øresund Bridge, a five-mile, multi-level bridge connecting Denmark and Sweden. The construction of the bridge took five years beginning in 1996 and ending in 2000. The context of this study is a highly complex infrastructure project of immense size, with stringent quality requirements and a well-defined completion time, and subject to harsh environmental conditions. With the complexity of the project, as well as the challenging external environment, there would likely be a continuous stream of emergent problem situations that were potentially high in equivocality. In this dynamic environment laden with potential problems, the conditions were present for the development of communities of practice.

Sundlink has a functional organization composed of support and operational departments. This study covers one support department, the Technical Department, and one operative department, the High Bridge Department. The Technical Department works with design matters, surveying, and other issues of a technical nature. The High Bridge Department is responsible for building the high bridge and the two large pylons that support it. Each of the departments had a small support staff that reported directly to the department manager. At the operational departments, the function of the departmental support staff was to provide administrative services on a small scale as well as limited technical and quality-focused services. The departments were divided into sections; the focus of this study is the Pylon Section.

The Pylon Section: a formal community of practice

The focus of this study is a community of practice that formed around a formal organizational unit, the Pylon Section. This unit was responsible constructing the 200-meter-high pylons that support the high bridge. The high bridge is 1,092 meters in length with a span of 490 meters. While the Pylon Section is a formal group, it arguably displays characteristics of a community of practice since it has a shared repertoire in the form of common vocabulary, routines, understandings and artifacts. At the Pylon Section the shared repertoire consisted of common means of detecting and managing deviations, a particular type of problem in the form of non-compliance with prescribed working processes. This study focuses on the management of one particular type of work-process deviation, repairs. These deviations took the form of honeycombs, blowholes and cracks. The terms "honeycombs" and "blowholes" represent a specific community vocabulary and describe different types of air pockets in concrete. This particular type of deviation was chosen as the focus of the study because it was the most common type of deviation in this community and moreover high in technical complexity.

The common routines of this shared repertoire are based on a shared understanding of what is meant by a deviation and procedures for detecting and managing deviations. There was a common procedure for controlling work processes against defined processes as well as procedures to manage deviations. The procedure for managing deviations included filling in a deviation report stating why the deviation occurred and proposing actions to repair the deviation and to prevent it from recurring. As an informal practice, departments would call the Technical Department before the deviation report was completed in order to inform them that it was on its way. This practice helped to ensure the approval of actions taken to remedy the situation. Further, the report constituted an artifact of the community and in conjunction with this report a vocabulary used to describe deviations emerged with words like rat's hole and honeycombs used to describe deviations. Collaborative narratives were developed in informal meetings such as lunches or breaks, which were limited to section members and on-site locations.

The boundaries of this community were defined by management, but strongly influenced by homophily and geographical separation (Schenkel, Teigland and Borgatti 2002). Homophily refers to the phenomenon that people find similar people attractive and develop relations with others like themselves (Homans 1950, Lazarfield and Merton 1954, Laumann 1966). Assuming this tendency for people to interact with those who have similar attributes, it is argued that people in this section/community interacted with each other rather than with employees of other departments or with persons outside the organization (Schenkel and Teigland 2002). In this case, homophily was amplified by the physical layout of the work site since formal groups were geographically separated from other. Interactions thus tended to have an internal focus (Schenkel, Teigland and Borgatti 2002), and as Allen (1977) has shown, physical proximity affects the frequency of communication. One consequence of the separation of groups was a tendency for groups to communicate internally as opposed to interacting with people outside the group. Thus, it is suggested this community was surrounded by a communication boundary which acted to delimit membership to the formal section.

Sources of data

Three sources of data were used to explore how media richness influenced learning in this community of practice. To explore learning at the Pylon Section, learning curves based upon the 31 repair (honeycomb, blowholes and crack) deviations that occurred from June 30, 1996 to June 30, 1998 were used. The data were gathered by an engineer at Sundlink rather than by the researcher, who lacked the competence to classify the different types of deviations, of which only one is included in this study. Reliability was increased through internal quality audits conducted in accordance with the ISO 9000 quality standard, and by an engineer whose responsibility was to ensure that procedures were followed.

Learning in this community of practice was measured by examining and analyzing the slope of the learning curve. The basic principle behind learning curves is that productivity is linked to the volume of production -- a higher volume of production results from productivity increases due to learning. Thus, learning is indicated by changes in the cumulative output of "defective" units (Li and Rajagopalan 1996). Since improvements are

more difficult in absolute terms (ceteris paribis), once a previous improvement is made, the learning curve normally follows a logarithmic decline in the form of a straight line with a negative slope (Yelle 1979). The learning curves were produced by calculating and plotting on a monthly basis the cumulative total of repair deviations, divided by the cumulative total of concrete produced. This ratio then shows the relative number of cumulative deviations per 1,000 cubic meters of concrete produced. In total, over 15,000 cubic meters of concrete were poured during the two-year period in which this study was conducted.

Qualitative data on media use were gathered. On a project-wide level, the data were collected through twenty-eight interviews lasting between 40-60 minutes each. Interviews were conducted with managers, supervisors, superintendents and engineers involved in the deviations. The interview was based on open and semi-structured questions focusing on describing the deviation as well as interaction and communication patterns associated with their management. The purpose of this approach was to gain a deeper understanding of the deviations and of the communication patterns underlying the learning curves.

Finally, data on media richness were gathered through a 39-question survey about communication patterns and attitudes. The questions focused on frequency of media use, perceived richness of media, and socio-demographic data. The survey was answered by eight people in the Pylon Section and two people in the department to which the Pylon Section belonged with only two people from the pylon section not answering the questionnairre (83 % response rate). The survey data were analyzed through SPSS, a program for statistical analysis.

MANAGING DEVIATIONS: SPECIFIC INSTANCES OF LEARNING AT THE PYLON SECTION

To understand the influence of media richness on learning in communities of practice, I chose an organization change affecting communication patterns as the point of departure for this study. This section begins by describing the organization change that occurred at the Pylon Section. Thereafter, the affect of this change on communication patterns is analyzed. Media richness is then examined at a point after the

change was established. The final part of this section seeks to determine whether changes in the richness of media had a corresponding affect on the learning curves of the Pylon Section.

The organizational change

In the spring of 1996, the production of the pylons was moved from the dry dock out to sea. Up until that juncture the Pylon Section consisted of one united production unit responsible for pouring the concrete that formed the base of the two pylons. This work was conducted on land in the dry dock. When the bases were completed, the dry docks were flooded, and these massive structures were shipped out to sea with the assistance of a giant floating crane. Thereafter, these were placed on the seabed through the use of a global satellite navigating system and deep-sea divers.

Once the structures were placed on the seabed, the overall production of the pylons continued out at sea. In conjunction with the move, there was an organization change as the once united land-based Pylon Section was divided into two geographically disconnected units located out at sea, mid-way between Sweden and Denmark. Further, not only did this move mean dividing the production section into two entities, the east and west pylon units, but it also entailed separating the production unit from the department's land based support office. Before the move, both the production and support office were located on land in close proximity to each other. Although the units conducted the pouring of concrete, the main task of the Pylon Section, independently of each other, they relied upon the department's support office for the overall management of deviations and limited technical advice. This advice took the form of writing and processing the report that documented deviations as well as formulated actions to prevent deviations from recurring. Moving production out to sea also meant that the production units were no longer both located on land with the main Technical Department. In this project, the Technical Department played a key role in the management of deviations: by providing advice on actions to be taken to prevent deviations from recurring, and by issuing formal approval for proposed solutions.

How the change affected communication media

The interview data revealed that the organization change affected three communication patterns: (1) within the Pylon Section, (2) between the Pylon Section and the department's support office, and (3) between the Pylon Section and the Technical Department. Firstly, the division of the Pylon Section into two production units meant that the formerly single unit was no longer co-located. For people in the east and west Pylon Sections to meet, they had to take a ferry. The ferries connecting the pylon units operated only a few times a day, and a round trip could take two or more hours. It is therefore suggested that the conditions for informal face-to-face interaction on a regular basis ceased to be present when members of the section were no longer co-located.

Secondly, the data revealed that communication between the Pylon Section and the department's support office changed in two ways. Firstly, attendance at the department's formal weekly meetings declined when people from the Pylon Section had to take a ferry to attend meetings. With slim resources and a tight production schedule, attending meetings was cumbersome and time-consuming. One supervisor expressed the reduced formal interaction in the following manner: "*There is a problem in that not all the superintendents and supervisors attend meetings. The problem is that because of conflicts the supervisors are not always there. For example, they have work that needs their attention.*" Further, the separation of the Pylon Section from the department's support staff meant that informal interaction between them was impeded since a meeting required that one of the parties take a ferry. Another member described the relatively low frequency of interaction between the Pylon Section and the department's support staff as follows: "*The superintendent is out a lot (away from the sub-section). The department manager is not out often, and the section head is out two times a week. The superintendent is out everyday and the quality control engineer is out two to three days a week.*" Informal interactions provide the context for the exchange and development of the collaborative narratives that constitute the shared repertoire. One person made the following comment about the role of informal communication at the project: "*I don't see everything. I hope that I am informed about everything. We are not*

against being forward. We sit and eat together, and talk with each other. It is an open dialogue the whole time."

Lastly, face-to-face interaction between the technical department and the production entities of the Pylon Section was impeded; the cause, it is suggested, was the organizational change. It is also suggested that problem-solving capability was adversely affected; interview data indicated that many people considered personnel from the technical department as the "experts" whose advice was essential in solving any problems that emerged.

The lack of face-to-face interaction could have been compensated for through the use of other media; however, the move out to sea restricted telephone usage since there were no fixed cables that connected the Pylon Section with the mainland. The lack of fixed telephone lines also curtailed the use of communication based on traditional telephone technology such as e-mail and telefax. Cellular telephones, an alternative that is not dependent upon fixed telephone lines, were an unreliable and limited form of communication, according to one interviewee. He explained that there was a lack of telephone coverage out, adding, "*The east and west surveyors have complained about communications. We have put up an additional antenna (for mobile telephones), but they still are not good. It is unfortunate that mobile telephones don't function there."* A member of the department's support staff described the difficulty in communicating with mobile telephones as follows: *"They have cellular telephones. But I must say that their connections are very bad."*

To compensate for the restrictions on communication, people used walkie-talkies, a media with limited access and poor voice quality. Firstly, access to walkie-talkies was confined to selected members of the east and west Pylon Section as well as some members of the department's administrative office. In particular, people in the technical department did not have access to walkie-talkies and thus could not be easily reached by people in other departments. Secondly, the quality of transmissions was lower in that only one person could speak at a time.

How the change affected media richness

The previous section highlighted how the organizational change affected communication with all types of media at the Pylon Section. As the focus of this study is on media richness, we now examine the extent to which "rich" media were affected by the organizational change. To explore this question, quantitative data on the perceived richness of three types of communication media at Sundlink: face-to-face, e-mail and telephone were studied.[2] These media were rated according to five different qualities which influence richness. A scale ranging from one to seven was used, with seven indicating that the medium possesses a particular quality to a high degree and a one, to a low degree. In other words, a seven would indicate a medium that was very rich in that quality and a one, a lean medium. The results in Tables 1, 2 and 3 indicate that face-to-face communication was the richest media overall and e-mail the leanest. In all qualities, the telephone was rated lower than face-to-face communication but somewhat higher than e-mail. The richest of all 15 different media qualities was that of exchanging sensitive information through face-to-face communication, and the leanest quality was that of e-mail as a means of expressing how one feels.

Table 1. Face to Face Richness

Variable	Mean	s.d.
Give and receive a quick answer	5.63	1.06
Express how you feel	5.50	1.31
Exchange and interpret different signals	5.75	1.04
Express nuances	5.88	1.36
Exchange sensitive information	6.00	1.19

[2] No distinction was been made between cellular telephones and "regular" telephones because interviewees suggested that the use of cellular telephones was often indistinguishable from using ordinary telephones. For example, people can connect their cellular telephone to their regular telephone, so that when a person calls their ordinary telephone he or she is connected to their cellular phone. A further complication is the use of the cordless telephone, a hybrid of cellular and traditional telephone technology.

Table 2. E-mail Richness

Variable	Mean	s.d.
Give and receive a quick answer	3.25	1.67
Express how you feel	2.50	1.51
Exchange and interpret different signals	2.75	1.58
Express nuances	2.63	1.77
Exchange sensitive information	3.13	1.81

Table 3. Telephone Richness

Variable	Mean	s.d.
Give and receive a quick answer	5.25	.89
Express how you feel	5.50	.93
Exchange and interpret different signals	4.63	1.30
Express nuances	4.50	.93
Exchange sensitive information	5.00	1.20

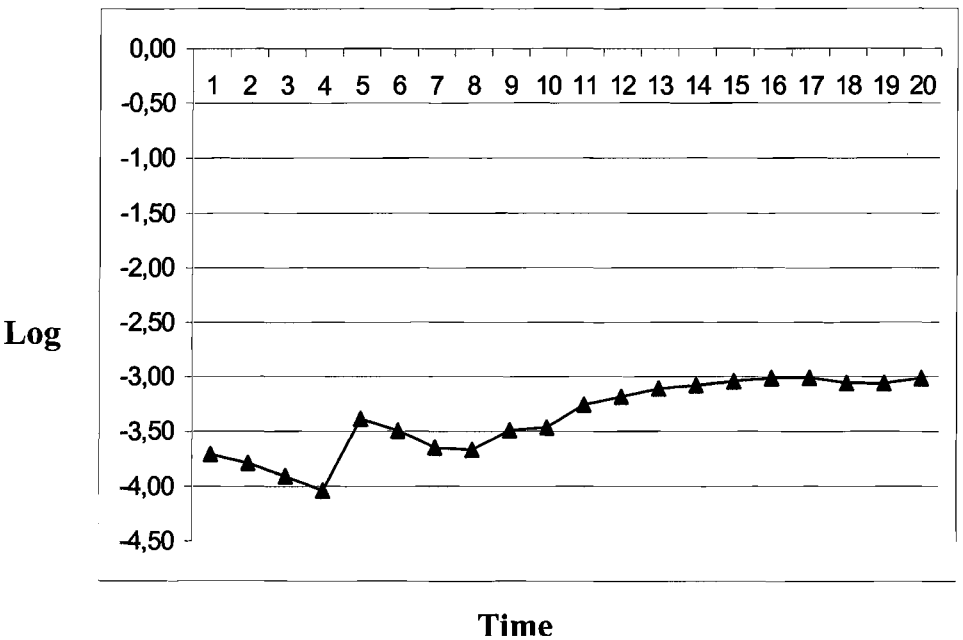
Media richness and learning

Thus far it has been suggested that that the organization change -- the Pylon Section's move out to sea -- influenced overall communication patterns. It is suggested further that the effect was to impede the use of rich media in the form of formal and informal face-to-face communication as well as the use of fixed and cellular telephones. In a problem-laden environment, the absence of rich media should be accompanied by a change in the learning curve since the community is less able to use collaborative narratives to reduce equivocality, with consequent effects on the level of learning in the community. In terms of learning curves, an increase in equivocality would be associated with a learning curve that has a positive slope and a decrease in equivocality associated with a learning curve that has a negative slope (ceteris paribus).

To explore this question the learning curve of the Pylon Section was examined. As can be seen in Figure 1, the learning curve of the Pylon Section has a negative slope followed by a positive slope. Specifically, the cumulative number of repair deviations was decreasing until period four, where the slope of the curve is broken and turns positive for one period. Thereafter, the curve has a slight negative slope for three periods

followed by a positive slope for the following 13 periods. The negative slope for the Pylon Section corresponds to the period when there was a united Pylon Section located on land, while the positive slope is for the period when the two section units were located out at sea.

Figure 1. Repair deviations: honeycombs, blowholes and cracks



In sum, media-richness theory suggests that when equivocality is high, rich media are required to reduce equivocality. In the case of the Pylon Section, the organizational change curtailed access to the rich media of informal and formal face-to-face communication and the telephone. The next best alternative to face-to-face communication in this case was the walkie-talkie, which was not rich enough to reduce equivocality. As a consequence, successive improvements could not be made. Media-richness theory suggests further that the richest medium available to the people of the Pylon Section was not rich enough for them to develop and disseminate a shared repertoire that could reduce the level of equivocality – an explanation evidenced by the positive slope of the learning curve.

DISCUSSION AND CONCLUSIONS

Solving problems is considered one of the fundamental activities of firms. The concept of communities of practice offers a means for understanding how problems are solved and knowledge is developed in dynamic environments. This study found that an organizational change affected communication possibilities in terms of the richness of available media, and that in turn the occurrence of deviations increased. Specifically, the organizational change impeded face-to-face communication and telephone communication, both rich media. In view of the change in learning curves and changes in communication media, it is suggested that when communities of practice do not have access to rich media in equivocal situations, learning is impeded. It is proposed that communication plays a key role in the development and exchange of collaborative narratives, and that this process is sensitive to the context of the situation, the degree of equivocality, and the richness of the media used. When rich media are not available, equivocality cannot be reduced sufficiently to permit formulating effective actions to prevent deviations from reoccurring. This suggests that if there is a mismatch between the level of equivocality of the situation and the richness of the media used for communication, organizational learning in communities of practice will be impeded. When deprived of rich media, communities of practice facing highly equivocal situations will fail to solve their problems.

This study has several implications for practice. Firstly, it highlights the impact of an organizational change on communication patterns and consequently on learning in communities of practice. This suggests that managers need to consider carefully how changes can impact on communication media as well as on the overall level of equivocality. In this connection, the question of the availability of media before and after the change must be addressed. In addition, the social, physical and technical factors that influence media usage must be determined. Once this evaluation is made, it becomes possible to formulate actions to facilitate learning. Moreover, this chapter has illustrated the pivotal role of communication in learning, particularly the role of rich media. This suggests that the ability to communicate through rich media is fundamental to learning in communities of practice. Therefore, managers should determine whether this capability is present to a sufficient degree

in the groups under their charge; if not, this deficiency should be rectified.

References

Allen, T.J. (1977). *Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information within the Rand Organization.* Cambridge, MA: MIT Press.

Argyris, C., and Schön. D. (1995). *Organizational Learning II.* Ma: Addison-Wesley.

Berger, P. and T. Luckmann (1966). *The Social Construction of Reality. London*, Penguin Books.

Brown, J.S., and Duguid, P. (1991). Organizational Learning and Communities of Practice. *Organization Science*, 2, 40-57.

Buchel, B., and Raub, S. (2001). Media Choice and Organizational learning. in Handbook of Organizational Learning and Knowledge. Edited by Meinolf Dierkes. Oxford: Oxford University Press.

Cross, R., Borgatti, S. and Parker, A. (2002). Making Invisible Work Visible: Using Social Network Analysis to Support Human Networks. *California Management Review.* 44(2). pp 25-46.

Daft, R. L., and Lengel, R. H. (1986). Organizational Information Requirements, Media Richness and Structural Design. *Management Science.* 32(5): 554-571.

Daft, R. L., Lengel, R. H., and Trevino, L. K. (1987). Message Equivocality, Media Selction, and Manager Performance: Implications for Information Systems. *MIS Quarterly.* 11(3): 355-366.

Daft, R.H., and Weick, K.E. (1984). Toward a Model of Organizations as Interpretative Systems. *Academy of Management Review.* 9, 284-295.

Dosi, G., Winter, S., and D.J. Teece (1992). Towards a Theory of Corporate Coherence, in G. Dosi, R. Giannetti, and P.A. Toninelli, (Eds), Oxford: Clarendon Press.

Foss, N, (1999). Networks, Capabilities and Competitive Advantage. *Scandinavian Journal of Management.* 15 1-15.

Fulk, J. (1993). Social Construction of Communication Technology. *Academy of Managament Journal.* 36, 921-950

Fulk. J., and Boyd. B., (1991) Emerging Theories of Communication in Organization. *Journal of Management.* 17, 407-446.

Homans, G.C. (1950). *The Human Group.* New York: Harcourt Brace.

Laumann, E. O. (1966). *Prestige and Association in an Urban Community.* Indianapolis: Bobbs-Merrill.

Lazarsfeld, P., and Merton. R. (1954). *Friendship as Social Process*. in Freedom and Control in Modern Society, edited by Morroe Berger, Theodore Abel and Charles Page. New York: Octagon.

Lave, J., and Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation*. Cambridge: Cambridge University Press.

Li, G., and Rajagopalan. S. (1997). A Learning Curve Model with Knowledge Depreciation. *European Journal of Operational Research*, 105, 1, 143-154.

Loasby, B.J. (1991). *Equilibrium and Evloution; An Exploration of Connecting Principles in Economics*, Manchester; Manchester University Press.

Loasby, B.J. (1976). *Choice, Complexity and Ignorance*, Cambridge: Cambridge University Press.

Orr, J. (1990). *Talking about machines: An Ethnography of a Modern Job*. Ithaca, NY: Cornell University.

Pava, C. (1983). *Managing New Office Technology*. New York: Free Press.

Polanyi, M. (1967). *The Tacit Dimension*. London, Routledge and Kegan Paul Ltd.

Purser, R.E., Pasmore, W.A. and Tenkasi, R.V. (1992). The Influence of Deliberations on Learning in New Product Development Teams. *Journal of Engineering and Technology Management* **9** , 1-28.

Schank, R. (1990). *Tell Me a Story: Narrative and Intelligence*. Evanston: Northwestern University Press.

Schenkel, A. and Teigland, R. (2002). Investigating the Relationship between Communities of Practice and Organizational Performance: A Case-study in the Construction Industry. Unpublished paper.

Schenkel, A., Teigland R., and Borgatti, S. (2002). *Theorizing Structural Dimensions of communties of Practice: A Social Network Approach*. Unpublished paper.

Schenkel, A. and Rognes, J. (1999). *Organisational Change, Learning and Communication: Learning in Building the Öresund Bridge*. Paper presented at the Academy of Management Meeting 1999, Chicago.

Simon, H. (1947). *Administrative Behavior*. New York

Snyder, W. (1996). Organizational Learning and Performance: An Exploration of Linkages Between Organizational Learning,

Knowledge, and Performance. University of Southern California. Ph.D.

Storck, J. and Hill, P.A. (2000). Knowledge and diffusion through "strategic communities". *Sloan Management Review*, Winter, 63-74.

Suchman, L. (2000). Organizing Alignment: A Case of Bridge Building. *Organization*. 2, 311-328.

Teigland, R. (2000). Communities of Practice in an Internet Firm: Netovation vs. On-time Performance. In Lesser, E. (Ed.), *Knowledge and Communities.* Newton, MA: Butterworth-Heinemann.

Trevino, L.K., Daft. R.H., and Lengel W. (1987). Media Symbolism, Media Richness and Media Choice in Organizations. *Communication Research*, 1, 553-57

Wenger, E. (1998). *Communities of Practice: Learning, Meaning, and Identity*. Cambridge: Cambridge University Press.

Wenger, E. (2000). Communities of Practice: The Key to Knowledge Strategy. In Lesser, E. (Ed.), *Knowledge and Communities.* Newton, MA: Butterworth-Heinemann.

Wenger, E. (1998). Communities of Practice: The Key to a Knowledge Strategy, *Knowledge Directions*, Vol. 1.

Wenger, E., McDermott, R., and Snyder, B. (2002). *Cultivating Communities of Practice.* Harvard Business School: Boston

Webster, J., and Trevino, L. K. 1995. Rational and Social Theories as Complementary Explanations of Communication Media Choice: Two Policy Capturing Studies. *Academy of Management Journal*, 38(6): 1544-1572.00

Weick, K. E. (1995). *Sensemaking in Organizations*. Thousand Oaks, Sage.

Weick, K. E. (1979). *The Social Psychology of Organizing*. New York, McGraw Hill.

Wenger, E. (1999). Communities of practice: The Key to a Knowledge Strategy. *Knowledge Directions.* Vol. 1, Fall.

Yates, J. and Orlikowski, W. J. (1992). Genres of Organizational Communication: A Structurational Approach to Studying Communications and Media. *Academy of Management Review*, 17(2), 299-326.

Yelle, L. E. 1979. The Learning Curve: Historical Review and Comprehensive Survey. *Decision Science*. 10: 302-328.

Zmud, R., Lind, M., and Young, F. (1990). An Attribute Space for Organizational Communication Channels. *Information Systems Research*. 1(4), pp. 440-457.

PAPER V

Exploring the Influence that ISO 9000 has on the Devlopment of Communities of Practice

Andrew Schenkel

Exploring the Influence that ISO 9000 has on the Development of Communities of Practice[1]

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INTRODUCTION

During the construction of the multi-billion dollar bridge between Sweden and Denmark, Tom, a 28-year-old civil engineer, conducted a routine control of a concrete support beam called a girder. The control procedure was conducted in accordance with the ISO 9000 quality standard, which was used to check that articulated requirements were met and working processes followed. To his surprise, during the checklist-based inspection Tom found a deviation from requirements in the form of a "rat-hole," or area where there was no concrete. Tom knew that this deviation was not desirable; it meant that customer requirements were not met, it could delay the overall project, and it could have cost implications. Management had made it clear on numerous occasions that the success of the project depended upon meeting the prescribed schedule.

As the Quality Controller for the girder section, one of Tom's formal duties in managing this deviation was to complete a one-page "Non-Conformity Report". This report described the deviation, identified its causes, and suggested actions to prevent it from recurring. However, in filling out the report, Tom could not establish what should be changed in the current working methods in order to prevent the deviation from recurring. Tom therefore consulted his colleague, Jan, a supervisor with over 30 years of experience in the construction industry. But Jan could not assist him. Tom then turned to his formal manager for advice. The manager's recommendation was that Tom follow the prescribed procedure and consult the Technical Department. Soon after being contacted, the head of the Concrete Section at the Technical Department went to the girder-production area to inspect the deviation – the "rat-hole". Tom described the inspection and ensuing interaction as follows: "The members of the technical department go down and look at the deviation and make a decision. They are the concrete experts, the ones who know a lot about it." After the inspection, working methods were modified by the "expert". Tom continued with a new working method in mind.

The above description of Tom's management of a deviation is illustrative; it shows how a quality standard can function in a large complex project. ISO 9000 is not only a quality standard but also an example of formalized routines, roles, relations and rules (Scott 1992) in the form of manuals (Hall 1977). The purpose of formalization is to obtain uniform and homogeneous outcomes through generation of predictable behavior. Formalization in the context of ISO 9000 means that customer requirements are formulated and explicit procedures to control and evaluate that targets are met are articulated in manuals. Further, when deviations from targets are identified there are explicit procedures for how these should be managed with the purpose of fulfilling customer requirements.

When Tom discovered the "rat-hole," he followed formal procedure and turned to the technical department for advice. Clearly, in the case of the "rat-hole", one would have expected more extensive informal contacts with other parts of the organization since many groups in this project were conducting similar work and therefore encountering the same type of problems. In other words, people could have gained by informally sharing their knowledge. However, this was not the case in the management of the "rat-hole," where only formally prescribed rules, relations and roles were used under the guise of following ISO 9000.

An alternative means of managing deviations, including the solving of problems, is through informal organizations. One type of informal organization currently championed by management scholars and practitioners alike is communities of practice. These are defined as groups of people informally and contextually bound in a work situation who are applying a common competence in the pursuit of a common enterprise (Brown and Duguid 1991, Lave and Wenger 1991, Wenger 1998, Teigland 2000). The concept of communities of practice received attention in the early 1990's, when it was noticed that in problem situations formal routines are not followed (Orr 1990) and that learning takes place through informal social interaction anchored in problem solving (Brown and Duguid 1991). It has been proposed that the inflexibility of formal routines leads to the development of informal groups to solve problems (Lave and Wenger 1991 and Brown and Duguid 1991). As individuals in these communities work together over time,

they develop shared mental models, a common language, and common behaviors (Kogut and Zander 1992, Hellgren and Löwstedt 1997). In turn, these facilitate the efficient creation and transfer of tacit knowledge (Kogut and Zander, 1992) as well as providing a vital source of incremental innovation (Lave and Wenger 1991, Brown and Duguid 1991). Subsequently, numerous scholars (Kanter 1983; 1989, Kotter 1982, 1985; Ibarra 1992) have noted that informal organizations are more effective than formal organizations in the achievement of regular organizational outcomes. Thus, the question arises as to why communities of practice were not developed further at Sundlink. Why did Tom not seek advice from colleagues in another group who were dealing with similar problems? Is ISO 9000, with its extreme formalization, the reason why communities of practices were seemingly not developed further at this project?

The purpose of this chapter is twofold: firstly, to explain the influence of ISO 9000 on informal organizations as exemplified by communities of practice; secondly, to explain how ISO 9000 affects the development of communities of practice. The Foucauldian concepts of discipline and surveillance are proposed as the underlying factors that influence the formation of communities of practice. These concepts were chosen in view of the suggestion by Sewell and Wilkinson (1992) that divergences from expected behavior are mitigated through peer discipline and IT (information technology). When combined, these disciplinary forces form a comprehensive surveillance system that controls and modifies behavior such that desired results are obtained. Since it is argued that ISO 9000 is a quality standard whose articulated purpose is to ensure homogeneity, I chose to examine the effects of the standard in light of the concepts of discipline and surveillance.

COMMUNITIES OF PRACTICE

A *community of practice* is a particular type of informal group in which practice is founded on and manifested in everyday work. The basis for any community of practice, according Wenger (1998), consists of **a *joint enterprise, a shared repertoire*** and ***mutual engagement. Joint enterprise*** is the common purpose that binds the group (Wenger 1998) and guides the development of the community's common means of

conducting work. A ***shared repertoire*** consists of the community's common way of doing things, gestures, artifacts, vocabulary and causal maps (Wenger 1998); to this extent it represents the accumulated tacit and explicit knowledge of the community (Teigland 2000, Schenkel and Teigland 2002). The shared repertoire can be viewed as the glue that binds communities of practice and distinguishes them from other types of groups (Boland and Tenkasi 1995, Brown and Duguid 1991, Wenger 1998, Teigland 2000). Brown and Duguid (1991) noted that primarily through three communication-based processes – *narration, collaboration* and *social construction* – a shared repertoire is formed, maintained and reproduced.

Narration describes how people create and tell stories in order to improve their understanding of problem situations. In contrast to formal manuals, which are inflexible, stories are flexible as well as rich and can therefore be customized to each particular situation. Brown and Duguid (ibid.) point out that through story telling people interactively develop an understanding of the situation that encompasses cause and effect. As these interpretations become part of the community's shared repertoire, they are used to interpret future situations. *Collaboration* refers to the involvement of both storytellers and listeners in the stories that are told. As a consequence, insights gained belong not only to the individual, but also to the community. Through collaboration it becomes unnecessary for individuals to know all that is required to solve a problem since they can rely on the cumulative knowledge of the community (Wenger 1999). Collaboration is of particular importance in knowledge-intensive tasks, which are often complex and thus require the cumulative knowledge of the group (Teigland 2000, Cross, Borgatti and Parker 2002). *Social construction* describes how people in a dialogue negotiate meanings that become accepted as knowledge (Berger and Luckman 1966). Thus, what is considered knowledge is not an objective phenomenon, but is subjectively negotiated (ibid.) within and by the community.

The development of a community's joint enterprise and shared repertoire are dependent upon ***mutual engagement*** in terms of the ability of community members to interact. The amount and pattern of interactions is commonly referred to as the structure, which can be examined on two levels: individual and network. Wenger (1998) provides a cursory

examination of the structure of community of practices on an *individual* level and defines four categories of individual participation: 1) full participation (insider), 2) full non-participation (outsider), 3) peripherality, and 4) marginality. It is important to note that levels of participation are not absolutes, but are determined by community in relation to the individual members. At one end of the continuum, full participation denotes a full member of the community who has gained both legitimacy and the formal and informal ability to behave as a community member (Lave and Wenger 1991). The opposite of full participation is full non-participation, or total exclusion. In between full participation and full non-participation are peripherality and marginality. Peripherality denotes a level of partial participation in the community, while marginality refers to participation that is not sanctioned by the community – an uninvited bystander or observer would be an example of marginal participation.

Building upon the idea of different types of community membership, Schenkel, Teigland and Borgatti (2002)[1] drew on concepts and measures from social-network analysis to further develop the notion of different levels of community membership. Individual membership in communities of practice can be viewed in terms of "coreness," or the extent to which a person is located in the center, at the core, of the group or on the outside, at the periphery. They suggest that people with high coreness are well connected to both core and peripheral members and that people with low coreness are connected mostly to core members. The basis for calculating coreness is the number of people that refer to the person for advice or what is called in-degrees. A person that has more in-degrees relative to other actors in the network is more "core".

Structure in the context of communities of practice applies to the *network* level as well as the individual. In a network perspective, the individual cannot be divorced from other people in his or her network, and the broader network acts to constrain or enable individuals (Wasserman and Faust 1999). Schenkel, Teigland and Borgatti (2002) using concepts and measures from social network analysis proposed four structural properties

[1] This section as well as the analysis of the network data builds upon Schenkel, Teigland and Borgatti (2002) as well as summarizing some of their key findings.

of "well functioning" community of practice: connectedness, density, graph-theoretic distance and core/periphery structure.

Of these four interrelated properties, the most fundamental structural property of a community of practice is *connectedness*, or the degree to which individuals mutually engage with each other. Connectedness is of importance since the extent to which a network is connected affects the degree to which the community's shared repertoire, one of the defining characteristics of a community of practice, is developed, disseminated and reproduced (ibid.). Through mutually engaging with other community members, individuals learn the community's shared repertoire and can thus be identified as members of the community (Lave and Wenger 1991, Schenkel, Teigland and Borgatti 2002). Conversely, if individuals are impeded from interacting with each other or do not interact with community members, they cannot learn the shared repertoire and be identified as members.

Closely related to connectedness is *density*, or the proportion of pairs of individuals who are interact with each other. A dense network consists of people who in large part are directly connected to each other, rather than connected through intermediaries. Direct connections are powerful in terms of influence and transmitting tacit knowledge. Through a dense network a shared repertoire is more evenly disseminated and can potentially be more developed (Schenkel, Teigland and Borgatti 2002).

The *graph-theoretic* distance between two nodes in a network is defined as the shortest path connecting them. Granovetter (1973) suggested that the distance between actors is of interest since the greater the distances between members of a community, the greater the likelihood that transmitted communications arrive distorted or too late to be of practical value. Further, individuals separated by wide distances tend to develop variations; in this case, the existence of a shared repertoire can be questioned (Schenkel, Teigland and Borgatti 2002). Thus, it is argued that relative to organizational networks in general, communities of practice have shorter paths linking all pairs of members (ibid.).

The last structural property of a community of practice is the presence of a *core/periphery* structure, or a network in which there are no significant

subgroups, factions, or cliques except the core itself (Borgatti and Everett 1999, Everett and Borgatti, 1999). Networks with a core/periphery structure can be expected to generate a relatively homogeneous shared repertoire in which most individuals are exposed to new practices and ideas soon after they emerge (Schenkel, Teigland and Borgatti 2002). By comparison, networks lacking a core/periphery structure are divided into cliques or factions that develop their own practices. The presence of multiple practices can be considered inconsistent with a shared repertoire, a defining element of communities of practice (ibid.).

DISCIPLINE AND SURVEILLANCE

The discussion so far has focused on communities of practice; however, informal organizations do not exist in isolation, but are affected by formal organizations. For example, it has been suggested that a person's formal position influences the informal network to which he/she belongs (Salancick 1995, Podolny and Baron 1997).

One of the ways in which the formal organization affects the informal organization is through the peer discipline that results from surveillance (Sewell and Wilkinson 1992). The concepts of discipline and surveillance emanate from Foucault's (1977) book *Discipline and Punish*. This book describes how a penal system went from inflicting physical punishment on the body to breaking down and rearranging both body and mind in order to bring about desired behavior. This change meant that behavior and thinking were perceived as independent of the individual and appropriate for manipulation. Disciplining thus took on a strategic dimension since it could be used to achieve a particular end. Normality was judged in terms of this end, and all other ways of thinking and behavior were viewed as deviant.

The principal techniques on which disciplining is based are *active* and *passive* surveillance. Foucault discusses in some detail Bentham's Panopticon, a type of *passive* surveillance system. The panopticon, the basis of a model prison, is an architectural structure comprising a central watchtower surrounded by a ring of cells. From the watchtower, an unseen observer can view prisoner's cells, positions, rooms and beds. Whether prisoners are actually monitored or not is unimportant. Unable

to see into the tower and thus to know whether they are being watched, they assume that they are constantly monitored. In this respect surveillance becomes omnipresent. The effect of the panopticon according to Foucault (1977) is "to induce in the inmate a state of conscious and permanent visibility that assures the automatic functioning of power. So to arrange things that the surveillance is permanent in its effects, even if it is discontinuous in its action."

While the panopticon is the basis for passive surveillance, *active* surveillance requires a "disciplinary gaze" in the form of constant physical monitoring. Passive surveillance can be discontinuous because prisoners do not know whether they are being monitored, but active surveillance needs visible agents to exercise control in order to be credible. To be effective, active surveillance is conducted through hierarchical relationships in which selected group members watch over others. Thus, active surveillance is based on physical presence with the potential threat of punishment to normalize behavior.

Whether surveillance takes place passively through the panopticon or actively in the hierarchy, the disciplining effect of surveillance in producing normalized behavior can lead to *self-regulation* by individuals, who start to correct their own actions. As this process advances, the robustness and credibility of the surveillance systems become less important since disciplining is increasingly passive and independent of the individual. Therefore, once self-regulation has been established, the threat of punishment is no longer necessary.

Disciplining requires not only active and passive surveillance, but *individualization* as well, since individualization permits identification of deviant behavior. In other words, an effective surveillance system requires that groups or individuals be "visible" because visibility makes it possible to detect and normalize deviant behavior -- reports and files are one means of rendering people visible. Individuals and groups that are visible become "unique" objects, which can be disciplined (Foucault 1977). In Sewell and Wilkinsson's (1992) study, IT played an essential role in making deviations from the norm visible. Once made visible, it then becomes possible to apply discipline.

In sum, this section has laid the groundwork for examining informal organizations as conceived by communities of practice. It has also reviewed the Foucauldian concepts of discipline and surveillance which are proposed as the mechanisms through which the formal organization influences the informal.

RESEARCH METHODS

The international contracting consortium, Sundlink Contractors, which designed and constructed the 7.8-kilometer Øresund Bridge connecting Denmark and Sweden, provides the research site of this study. Sundlink Contractors utilized a formal quality system standard based upon ISO 9000. Organizationally, Sundlink is functional and divided functionally into two main groups: operational and support departments. The operational groups consisted of five departments responsible for the actual construction of the bridge. The support departments included in this study were limited to those involved with technical and quality issues. A description of the respective departments is shown in Table 1.

TABLE 1
Description of Operations and Support Departments

Department	Function	Activity	Size of structure	Location
Offshore, Onshore	Operative	Constructed prefabricated concrete structures called caissons and piershafts	800 to 4700 tons 10 to 51 meters high	Malmö, Sweden
High Bridge	Operative	Built concrete bridge pylons	Over 200 meters tall 4355 m3 of concrete 800 tons of reinforcement concrete	Malmö, Sweden
Bridge Line	Operative	Constructed viaduct using steel and concrete	560 meters long	Malmö, Sweden
Prefab Approach Bridge	Operative	Constructed steel and concrete girders	2000 to 6300 tons 120 meters long	Cadiz, Spain
Technical department	Support	Provide technical support and advice		Malmö, Sweden
Quality Assurance and Development	Support	Provide support and advice on quality issues, as well as monitoring and enforcing quality system		Malmö, Sweden

The empirical data for this study consist of both primary and secondary data. The primary data take the form of nine small case studies based on

interviews and a questionnaire. The case studies focused on understanding how reported deviations from prescribed procedures or products were managed – there were over 2,000 such deviations during the five-year period in which the bridge was constructed. The criteria for selecting the case studies were (1) that reported deviations could not be over two weeks old and (2) that diversity was sought in terms of a variety of individuals and formal organizational groups involved in the deviation. In total, twenty-eight interviews of 40-60 minutes each were conducted with a list of interviewees generated through a "snowball" sampling. The interviews were structured around open and semi-structured questions, with particular attention paid to describing the deviation, interaction patterns in the context of the deviation, and details concerning the management of the deviation.

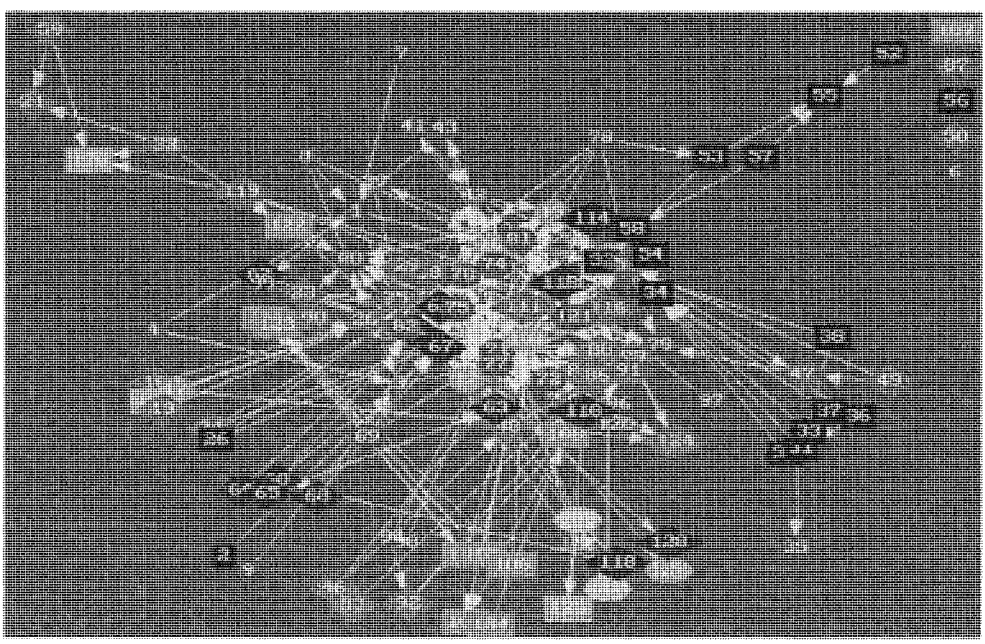
The questionnaire was distributed to 137 people who formed the population of this study. In total 120 people responded to the questionnaire, for a response rate of 87.6%. The population consisted of all managers, engineers, supervisors and superintendents involved in the management of deviations. This paper utilized one network-based question from the survey. Specifically, in this question respondents were asked to list the people from whom they sought advice in the context of a deviation. Data from this question were analyzed using the UCINET software package for network analysis (Borgatti et al., 1999) and were imported into Krackplot (Krackhardt et al., 1994), a program for graphical analysis of networks.

The secondary data consist of *Sundlink's General Procedure for the Control of Non-Conformities* and the two-part *Operations Manual* that cumulatively describe the ISO 9000 based standard. The *Operations Manual* defined working methods as well as control procedures to check whether targets were attained and proper working methods followed. When deviations from targets and procedures were found, these were managed according to the *General Procedure for the Control of Non-conformities*. The purpose of this procedure was to ensure either that underlying processes were improved or that targets were changed.

ANALYZING THE ADVICE NETWORK

The initial example in the beginning of the chapter is one limited indication that informal organizations as conceptualized by communities of practice were not widespread at Sundlink. This section takes a broader perspective and explores the extent to which the structure of the project's emergent advice network as shown in Figure 1, fulfills the structural requirements of a "well functioning" community of practice.

FIGURE 1
Informal Network of Help-Seeking Among All Project Members
(Node Shape Indicates Section Membership)



1 Connectedness

Of the 120 project members, there were only five isolates, or individuals that were not connected to any other member in the network. All other members were connected with at least one other person in the network. Although this network is connected, one of the defining properties of a well functioning community of practice, it is not sufficiently well

connected to be considered a community of practice -- there are too many one-way, unilateral connections. In a community of practice, one would expect many more multi-directional connections between pairs of individuals.

2 Density

The density of the network was calculated at 3.9%, or less than 300 pairs connected out of the 7,000 possible pair-wise contacts. Unfortunately, there is no standard database of published organizational networks that we can use to compare our result. However, based on the author's and his collaborators' experience, the observed density of this network is quite low given its size and scope. 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 exhibit the second structural property to a high degree.

3 Graph-theoretic distance

The average graph-theoretic distance among all pairs of persons in the network (excluding the five isolates) was 3.6 (s.d. = 1.5). This means that advice from one person has to travel via two intermediaries before reaching the other. This relatively long distance is not consistent with the concept of communities of practice, where distances between members should be short.

4 Core/periphery structure

The crucial structural indicator of a community of practice is the presence of a core/periphery structure, or the absence of factions. For this network, we obtained a fit to the core/periphery model of 0.33, which is quite far from what we would expect in a well-functioning community of practice. Generally, interconnectedness between individuals does not seem strong enough for efficient transfer and development of practice. Thus, we suggest that this project does not possess the fourth structural property to a high degree, either.

In terms of the four structural properties of a community of practice, it can be concluded that the informal advice network on a project level did not qualify as a well functioning community of practice.

WHAT NETWORK CHARACTERISTICS DID THE EMERGENT NETWORK EXHIBIT?

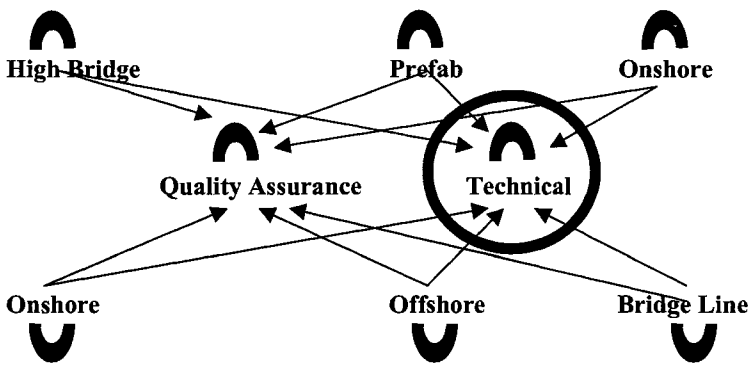
As noted, the informal advice network did not display structural properties of a well functioning community of practice. What, then, were its characteristics? This question was investigated through comparing the informal advice network with the formal advice network as prescribed by Sundlink's *General Procedure for the Control of Non-Conformities.*

What was this procedure? It began with the initial reporting of the deviation to the Quality Controller, a specific actor responsible for quality issues, and specifically for completing a Non-Conformity Report (NCR) that documented the deviation. This report consisted of four parts: (1) a description of the deviation, (2) an explanation for its occurrence (3) proposed remedial action, or action focused on remedying the situation on hand, and (4) proposed corrective action, or action to prevent the deviation from recurring. If unable to complete the report for lack of relevant knowledge, the Quality Controller was to contact the Technical department on technical matters and the Quality Assurance department for advice on contractual issues. For example, the Quality Controller might not know what remedial or corrective actions should be taken and would turn to the Technical Department for assistance. Once completed, the report was to be signed by the department manager and sent to the Quality Assurance Department for approval and further processing. Thus, in terms of interactions, the formal procedure prescribes that the Quality Controller should be contact with the Technical and Quality Assurance departments in deviation situations.

Through a statistical technique called the Quadratic Assignment Procedure (Hubert and Schultz 1976; Huber and Coledge 1981 and Baker and Hubert 1981), we can establish the degree to which the emergent advice network as ascertained by questionnaire data is correlated with the formal advice network as prescribed by the *General Procedure for the Control of Non-Conformities.* In other words, it is possible to determine

the extent to which the formal procedure for the management of deviations was followed in practice. The analysis showed that the two networks overlapped and were significantly correlated at 71.4% ($p < .0001$), suggesting that interactions as prescribed by the formal procedures were followed. In turn, this finding can be taken to indicate that the formal procedures influenced the informal advice network to the extent that well functioning communities of practice did not form at a project level. One consequence of the formal procedures was that the Technical Department became core in the inter-organizational advice network as shown by Figure 2.

FIGURE 2
Network of Inter-Department Relations



The qualitative data also indicate that people at this project felt compelled to contact the Technical Department for assistance. The alternative to seeking advice from this department would have been contacting members of other operative departments or even people outside of this project. However, this was seemingly not the case. One Quality Controller described his contact with the in the following manner: "When a deviation occurs, the Technical Department's expert must be quickly informed. I call the Technical Department and describe what type of problem we have. We then go around, look, and come up with a solution."

A similar view was expressed by another Quality Controller, who said, "I contacted Technical Department's expert. But, it was because of the

discussion that I had with my section head and my predecessor. They recommended that we ask the Technical Department's expert whether we could repair the deviation on the spot or wait."

Finally, an operative supervisor commented about the key role of the Technical Department as follows: "When we have damages that we have to discuss we usually contact the Technical Department's expert. He usually comes down and then we discuss corrective action."

A closer examination of the network data reveals that the Quality Controller played a central role in the management of deviations according to the prescribed procedure. As Table 2 illustrates, the Quality Controller has the highest mean number of in-degrees and therefore a high degree of coreness.

TABLE 2
In-degrees

Years of similar experience	Position	In-degrees
12	Section head	5.0
17.5	Other managers	3.5
1	Quality Controller	6.0

Interestingly, the person most often contacted in deviation situations, the Quality Controller, also had the least experience. In a deviation situation, one would expect that more experienced personnel, rather than a relative newcomer to the industry, would be consulted. When asked why the relatively young and inexperienced Quality Controller was contacted in this particular situation, the section manager referred to the role of the formal organization, commenting, "(He) is the person responsible for the girder handling."

The Quality Controller confirmed the influence of the formal organization on the informal advice network when he said, "As soon as there is a non-conformity (deviation) at the work site, it is reported. If I do not see it myself, then the workers or supervisors report it to me. Then it is my responsibility to take care of it. Partly to inspect it with the supervisors and section head, and then we develop a decision as to what we should do. As soon as there is a non-conformity (deviation), I should

immediately make a report." Thus, it is suggested that formal procedures as prescribed by ISO 9000 affect the structure of the informal advice network to the extent that communities of practice are not more pronounced.

IS THE ADVICE NETWORK A COMMUNITY OF DISCIPLINE?

In the previous section it was suggested that there was a strong relationship between the informal and formal advice networks, indicating that prescribed procedures were followed. This indicates that the Technical Department and the Quality Controller played central roles. It may also be interpreted to mean that the formal procedures for managing deviations influenced the development of communities of practice. To explain how a formalized system like ISO 9000 can influence the development of a community of practice, the concepts of discipline and surveillance are used.

To ensure normality -- that is, adherence to prescribed procedures -- surveillance is required. It is suggested that surveillance was conducted by an extensive system of actors and systems embedded in control procedures based on ISO 9000. As actors conducting surveillance through their formal position, Quality Controllers were officially responsible for ensuring that working methods and procedures were followed and for conducting spot checks on a regular basis. The operations manual describes the responsibilities of the Quality Controller as follows: "Quality Controllers have the responsibility for the compilation of Quality Records and Inspection Reports. The Quality Controller shall also perform spot checks on inspection routines to ensure the correct preparation of inspection records."

It is proposed that this type of surveillance comprised an active surveillance system embedded in the hierarchy. The Quality Controller was immediately subordinate to the Department Manager and also reported directly to the Technical Manager and the Quality Assurance managers. One department manager commented about the reporting obligations of the Quality Controller as follows: "We have a Quality Controller that reports to me. His duty is see that the system is working and that the papers are flowing."

However, the Quality Controller was not the only actor charged with surveillance; formal audits were conducted by the Quality Assurance Manager and a person representing the Øresund Consortium. In the context of ISO 9000, these audits consisted of examining the procedures and accompanying paperwork by examining whether Non-Conformity Reports (deviation reports), checklists and inspection lists were in order. These audits were normally conducted on a quarterly basis.

An effective surveillance system requires that deviations be visibly segregated. For this purpose, checklists/inspection reports were used to judge whether work was normal or deviant and this had the effect of segregating deviations and making them visible. As one operative supervisor commented, "I am responsible for this caisson and all the concrete in it. So when we take off the forms, we do a visual check of it and discover any damage. I perform this check and fill out what type of damage it is. Then I leave it to the Quality Controller."

Through this type of detailed record keeping, the Quality Controller discovered the deviation described in the beginning of this chapter. Record keeping specifically involves checking that prescribed working methods are followed and confirming that the final product meets prescribed targets. In making deviations visible, a system of classifying deviations emerged. One operative supervisor exemplified as follows, "There are two areas of damage on the eastern wall up there along the long wall. Honeycombs Type 1 because it is not a visible wall. If you had seen the reinforcement, it would have been Type 2 damage. "

Once deviations are identified, they are further segregated and made through the *General Procedure for Control of Non-Conformities.* This procedure stipulated that in conjunction with each identified deviation that a report called a "Non-conformity Report" is filled out. In this standardized report information such as the section where the deviation occurred as well as its causes and proposed actions to prevent it from reoccurring are filled in. Once the report was completed it was sent to the Quality Assurance Department where it received a unique identification number. Initially, reports were classified according to operative section as well as deviation type. This allowed for trends within and between

sections to be made. Thus, through a comprehensive set of checklists and procedures for the management of deviations, a comprehensive surveillance system was constituted to ensure normalization in the form of following work methods and attaining targets.

CONCLUSION

ISO 9000 is used in organizations for the purpose of ensuring quality. However, as this chapter has shown, quality standards are not neutral. From a learning and knowledge perspective, a number of important issues are raised. It appears from the analyses that ISO 9000 influenced the structures of the informal advice network to the extent that on a project level they strongly resembled the formalized network.

It is suggested that the specific disciplining and surveillance techniques embedded in ISO 9000 limited the formation of communities of practice on a project level at Sundlink. The surveillance system was based on reinforcing dominant formal procedures at the expense of developing informal practice. By the disciplinary nature of ISO 9000, the Technical Department and Quality Controllers were to be contacted when help was required in deviation situations. That requirement was based on the assumption that these actors were knowledgeable. However, this assumption was not questioned. While the Technical Department was contacted because it was assumed to be knowledgeable, it became increasingly knowledgeable in fact as a consequence of continually being contacted. It gained valuable experience about working methods in the field and useful skills in diagnosing and solving problems. Because similar types of technology were used throughout the project, the proposed "experts" quickly built up their expertise, enhancing the central role of the Technical Department. Thus, in the application of ISO 9000, the role of the expert becomes an aspect of knowledge development and transfer.

Conformity to procedure influenced the pattern of interactions and had widespread implications since practice is learned through observing and acting like a member of the group. There was imitation of the more or less formal practice prescribed by procedures. Deviations from this practice were not permitted and were limited through the use of ISO

9000. If informal practice is subjected to disciplining, the practice that is imitated displays strong characteristics of formal practice. However, it can be argued that whether practice is formal or informal, it becomes a function of domination and subjugation as well as production and reproduction. Thus the concept of discipline and surveillance is not limited to formal practice, but can be applied to informal practice as well. Practice involves being disciplined, and to be disciplined is to learn practice.

ISO 9000 could have been used as an opportunity to develop and disseminate knowledge as well as a focal point for learning. However, this was not the case, as ISO 9000 was a rigid closed system from a knowledge and learning perspective. The conditions for the development of communities of practice were not present, but were simply "crowded out". The role of knowledge in the modern economy and the advantages of informal organizations suggest that organizations should pay more attention to the implementation and use of quality standards such as ISO 9000. In other words, opening up ISO 9000 and drawing on a broader base of knowledge would facilitate the development as well as the transfer of knowledge. To truly leverage knowledge, it is necessary to consider the questions what is knowledge and who is knowledgeable. The challenges of using a quality standard are many, but so are the opportunities for learning and gaining new knowledge presented by its use.

References

Allen, T.J. (1977). *Managing the Flow of Technology: Technology Transfer and the Dissemination of Technological Information within the R&D Organization.* Cambridge, MA: MIT Press.

Baker, F., and Hubert, L., (1981). The Analysis of Social Interaction. *Sociological Methods and Research.* 9, 339-361.

Bavelas, A. (1948). A Mathematical Model for Group Structure. *Human Organizations*, 7, 17-30.

Barley, S. (1986). Technology as an Occasion for Structuring: Evidence from Observations of CT scanners and the Social Order of Radiology Departments. *Administrative Science Quarterly.* 31, 1, 78-109.

Barley, S.R. (1988). Technology, Power, and the Social Organization of Work. *Research in the Sociology of Organizations*, **6**, 1988: 33-80.

Berger, P. and Luckman, T. (1966). *The Social Construction of Reality: A Treatise in the Sociology of Knowledge.* London: Penguin Publishers.

Blau, P.M. (1977). *Inequality and Heterogeneity.* New York: Free Press.

Blau, P.M., Falbe, C.M., McKinley, W. and Tracy, P.K. (1976). Technology and Organization in Manufacturing. *Administrative Science Quarterly.* 21, 20-40.

Boland, R.J., & Tenkasi, R.V. (1995). Perspective Making and Perspective Taking in Communities of Knowing. *Organization Science*, 6, 350-372.

Bonacich, P. (1972). Factoring and Weighting Approaches to Status Scores and Cique Ientification. *Journal of Mathematical Sociology*, 2, 113-120.

Borgatti, S., Everett, M.G., & Freeman. L.C. (1999). *UCINET 5 for Windows.* Natick, MA: Analytic Technologies.

Borgatti, S.P., & Everett, M.G. (1999). Models of Core/periphery Structures. *Social Networks.* 21, 375-395.

Borgatti, S.P. & Everett, M.G. (2000). Models of Core/Periphery Structures. *Social Networks.*

Brown, J.S., & Duguid, P. (1991). Organizational Learning and Communities of Oractice. *Organization Science*, 2, 40-57.

Cross, R., Borgatti, S. & Parker, A. (2002). Making Invisible Work Visible: Using Social Network Analysis to Support Human Networks. *California Management Review,* 44(2), pp 25-46.

Everett, M.G., & Borgatti, S.P. (1999). Peripheries of Cohesive Subsets. *Social Networks.* 21, 397-407.

Hubert, L., and Golledge, G., (1981). A Heuristic Method for the Comparison of Related Structures. *Journal of Mathematical Sociology,* 23: 214-226.

Hubert, L., and Schultz, J., (1976). Quadratic Assignment as a General Data Analysis Strategy. *British Journal of Mathematical and Statistical Psychology,* 29: 190-241.

Foucault, M. (1977). *Madness and Civilization: A History of Insanity in the Age of Reason.* London: Tavistock.

Foucault, M. (1973). *The Order of Things: An Archeology of the Human Sciences.* NY: Vintage Books.

Foucault, M. (1977) *Discipline and Punish: The Birth of the Prison.* London: Penguin Press.

Granovetter, M. (1973). The Strength of Weak Ties. *American Journal of Sociology.* 81, 1287-1303.

Hall, R.H. (1992). *Organizations: Structures, Processes, and Outcomes* (5th edn). Englewoods Cliffs, NJ: Prentice Hall.

Harary, F. (1969). *Graph Theory.* Reading, MA: Addison-Wesley.

Hellgren, Bo & Jan Löwstedt (eds.): *Management in the Thought-Full Enterprise.* European Ideas on Organizing. Fagbokforlaget: Bergen.

Hunt, A. and Wickham. G, (1994). *Foucault and Law: Towards a Sociolgy of Law as Governance.* London: Pluto Press.

Ibarra, H. (1992). Structural Alignments, Individual Strategies, and Managerial Action. In Nohria and Eccles (Eds), *Networks and Organizations.* Boston: Harvard Business School Press.

Kanter, R. (1983). *The Change Masters.* NY: Simon & Schuster.

Kanter, R. (1989). The New Managerial work." *Harvard Business Review.* 6, 85-92.

Kogut, B., & Zander, U. (1992). Knowledge of the Firm, Combinative Capabilities and the Replication of Technology. *Organization Science.* 3, 383-397.

Kogut, B., & Zander, U. (1995). Knowledge of the Firm and evolutionary Theory of the Multinational Corporation. *Journal of International Business Studies*, 26, 625-644.

Kotter, J.P. (1985). *Power and Influence: Beyond Formal Authority.* New York: Free Press.

Kotter, J.P. (1982). *The General Managers.* New York: Free Press.

Krackhardt, D. and Blythe, J. and McGrath, C (1994). Krackplot 3.0: an Improved Network Drawing Program. *Connections.* 17(2):53-55.

Lave, J., & Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation.* Cambridge: Cambridge University Press.

McHoul, A and Grace, W. (1993). *A Foucault Primer.* Victoria: Melbourne University Press.

Orr, J. (1990). *Talking About Machines: An Ethnography of a Modern Job*. Ithaca, NY: Cornell University.

Podolny, J. M., & Baron, J., N. (1997) Resources and Relationships: Social Networks and Mobility in the Work place. American Sociological Review, *62, 673-693.*

Salancick, G. R. (1995). Wanted: A Good Network Theory of Organization. *Administrative Science Quarterly,* 40(2), 345-349.

Schenkel, A., Teigland R., and Borgatti, S. (2001). Theorizing Structural Dimensions of Communties of Practice: A Social Network Approach. Working Paper.

Schenkel, A. (2002) Conceptualizing and Exploring the Second Level Effects of ISO 9000. Paper presented at Third European Conference on Organization Knowledge, Learning and Capabilities, Athens.

Scott, W. R. (1991). *Organizations: Rational, Natural, and Open Systems* (3rd edition). Engelwood Cliffs, NJ: Prentice Hall.

Sewell, G. and Wilkinson, G. (1992). Someone to Watch Over Me: Surveillance in a Total Quality Organization. *Sociology*, 26, 271-289.

Simon, H.A. (1945). *Administrative Behavior*. New York: The Free Press.

Smart, B. (1985). *Michel Foucault*. Tavistock: London.

Wasserman, S., and Faust, K (1999). *Social Network Analysis*, Cambridge: Cambridge University Press.

Wenger, E. (1998). *Communities of Practice: Learning, Meaning, and Identity*, Cambridge: Cambridge University Press.

PAPER VI

Conceptualizing and Exploring the Second-Level Effects of ISO 9000 in the Construction of the Øresund Bridge

Andrew Schenkel

Conceptualizing and Exploring the Second-Level Effects of ISO 9000 in the Construction of the Øresund Bridge[1]

Andrew Schenkel

[1] An earlier version of this paper was published as part of the proceedings of the Third European Conference on Organization Knowledge, Learning and Capabilities, Athens, Greece

Conceptualizing and Exploring the Second-Level Effects of ISO 9000 in the Construction of the Øresund Bridge[2]

ABSTRACT

This paper conceptualizes and analyzes the second-level, or indirect, social effects of the ISO 9000 standard. From the framework developed in this paper, it appears that indirect effects of technology are not limited to social practice as previous research has suggested, but include discourse and thought figures. This framework is applied to the contractor organisation that constructed the 7.8 kilometer Øresund Bridge connecting Sweden and Denmark. From multiple sources of data, it was found that ISO 9000 affects the way that people communicate, think and work in a large, complex project. Additionally, the codification of procedures that ISO 9000 requires represents an expression of power as well as a change in knowledge bases: from knowledge practically anchored in the performance of work to theoretically based professional knowledge.

[2] An earlier version of this paper was published as part of the proceedings of the Third European Conference on Organization Knowledge, Learning and Capabilities, Athens, Greece

INTRODUCTION

Scholars have shown that the implementation and use of new technology has both first- and second-level effects on organizations. First-level effects refer to efficiency or productivity gains associated with the adoption and use of new technology. This type of effect is functional and is often expressed in terms of increased output, some measure of time, or financially, in terms of a return on investment (Blau et al. 1976, Kraut et al. 1988). Second-level effects are considered the indirect effects of technology on social systems and consist of interdependent events, behaviors, and other effects on people (Sproul and Kiesler, 1991). First-level and second-level effects are related to each other to the extent that investments made with the purpose of obtaining first-level effects have offsetting second-level effects.

The relationship between technology and second-level effects of technology has long been of interest to organizational researchers. Through the years studies have focused primarily on the effects of technology in two areas: structure (Chandler 1977, Barley 1986, Orlikowski 1992; 2000) and routines (Sproul and Kiesler 1991, Edmondson et al. 2001). The findings in these studies all broadly reflect that technology affects social practice, or the community-recognized and governed procedures, methods, or techniques used in a given situation (Cuff, Sharrock & Francis 1979, Giddens 1984, Wenger 1998). Moreover, it has been suggested that the effect of technology on social practice is so pervasive and encompassing that second-level effects of technology are more important to organizations than first-level effects (Sproul and Kiesler 1991, Chandler 1977, Barley 1986).

However, I argue that the current conceptualization of second-level effects of technology is both narrow and limited since the primary focus is on the effects

of technology on social practice. To expand the conceptualization of second-level effects of technology, I draw on insights from a study of idea-critical history. In particular, the concept that changes in social practice do not occur in isolation, but in conjunction with discourse as well as thought figures (Asplund 1979), is used as the theoretical basis for expanding the conceptualization of second-level effects.

ISO 9000, a quality standard, is a particular type of technology which by its very design has direct effects on social practice. I argue that ISO 9000 is a special type of technology in that it represents the systematic application of knowledge to practical tasks (Oxford English Dictionary, 1983). **The overall purpose of this study is to describe and explain the second-level effects of ISO 9000.** To this end, an expanded framework for understanding the second-level effects of technology is developed. Thereafter, this framework is applied to the contractor organization that built the multibillion-dollar Øresund Bridge connecting Sweden and Denmark. The study of the second-level effects of ISO 9000 in a large complex project may, in turn, produce useful insights about the second-level effects of technology in general.

SECOND-LEVEL EFFECTS: DISCOURSE, THOUGHT FIGURES AND SOCIAL PRACTICE

Social Practice

Over the last several years, studies on the second-level effects of technology have focused on the effects of IT. Sproul and Kiesler (1991) examined the implementation of new communication technology; they found second-level effects of this technology in the form of changes in social interaction patterns, in addition to the impact on norms, roles, procedures, jobs, and departments.

Orlikowski (1999) concluded that the use of IT is influenced by social practice and described how the adoption and use of new technology reflect explicit and implicit structuring (2000). Cumulatively, these studies suggest a two-way relationship between IT, on the one hand, and the nature of the work and manner of conducting it, on the other.

Outside the area of IT, several studies have directly or indirectly considered the second-level effects of other types of technology. Through ethnographic and sociometric methods, Barley (1986) established that new medical technology in the form of computer-imaging devices affected work roles and thereby skills, tasks, and activities. Further, he noted that work roles affected the role-holder's relations, with a consequent impact on the organizational and occupational structure. Chandler (1977), in his seminal work on modern capitalism, observed that high-volume assembly-line production required new organizational structures. These took the form of further development of the hierarchy and accompanying changes in the distribution of work, lines of authority, and communication. It is argued that all of these studies represent a variation on a single theme: how the implementation of new technology influences social practice.

Thought Figures

The view that second-level effects of technology are manifested only in social practice is limited and one-dimensional since changes in social practice do not occur in isolation. In his study of idea-critical history, Asplund (1979) suggested that social practice directly and indirectly affects thought figures and discourse. *Thought figures* are defined as ways in which individuals categorize, understand, and recall things (Johnson-Laird 1983, Foucault 1973). The

importance of thought figures cannot be underestimated, since what is considered a valid or invalid interpretation of a particular situation is developed through them (Foucault 1977). Although at any particular time there are a plethora of possible interpretations, some thought figures become dominant. Thus, some interpretations are enabled, and others are constrained (ibid.). Not that one interpretation is necessarily correct and the other wrong; rather, some are considered more appropriate than others. The role of a thought figure is not limited to present interpretations, but also affects how future situations are viewed (Mezirow 1991). If assumptions underlying thought figures are left unquestioned, previous understandings can be reinforced (Schein 1985, Mezirow 1991, Argyris and Schön 1996) and consequently reproduced.

Discourse

Asplund (1979) argues that there is an indirect relationship between *discourse* and social practice as well as a direct relationship between *discourse* and thought figures. Discourse refers to rule-governed ways of communicating, which reflect socio-historical arrangements and circumstances (Cuff, Sharrock and Francis 1979), and it governs many aspects of our communication. In particular, discourse regulates who may speak or write, under what circumstances they may speak or write, what they may speak or write about, how they do it, and why they do it (Jackson and Carter 2000). Discourse refers as much to rules regulating non-communication as to rules on communication. The capacity to communicate or not to communicate in a specific situation also impacts who or what is considered knowledgeable. For example, formal or informal rules that allow a person to communicate in a certain situation convey the impression that he or she is knowledgeable. Conversely, non-communication may imply that a person is not knowledgeable.

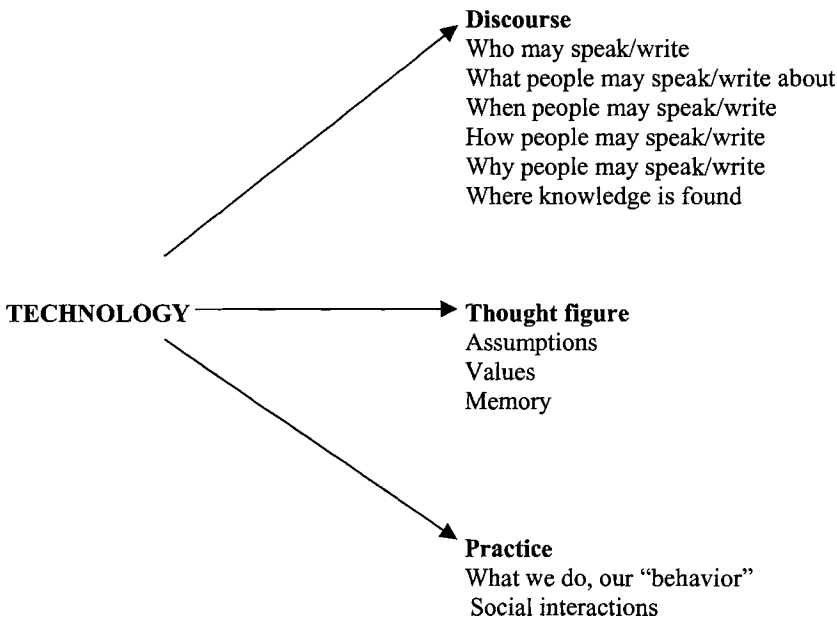
The notion of discourse used in this study is different from Foucault's (1977) conceptualization of discourse, which includes social practice and thought figures in addition to rules governing communication. The Foucauldian view of discourse has not been chosen. Since this conceptualization is extremely broad in regard to what constitutes discourse, the analytical power of the term is so diminished that it is difficult to identify different second-level effects.

Relationship between social practice, thought figures and discourse

According to Asplund (1979), the relationship between discourse, thought figures and social practice is such that thought figures act as the lynchpin between discourse and social practice. Consequently, he argues, social practice affects, and reflects, the underlying thought figures and, indirectly, discourse. Similarly, discourse affects, and reflects, underlying thought figures and, indirectly, social practice. To this extent thought figures develop dialectically and are a reflection of both social practice and discourse. While the interrelationship of discourse, thought figures and social practice has already been noted, by extension this relationship implies that technology affects discourse and thought figures as well as social practice. As shown in Figure 1, the focus of this research is how technology in the form of ISO 9000 affects discourse, thought figures and social practice separately as opposed to their interrelationship.

FIGURE 1

Conceptual Model for Understanding Second-level Effects of Technology



WHAT IS ISO 9000?

Second-level effects of technology are studied in the context of ISO 9000, a quality-system standard applicable to the processes which create products and services (Johnson 1993). The numerous reasons why organizations adopt ISO 9000 include: ensuring that customer expectations and requirements are met (ibid.), providing a way for organizations to gain a competitive advantage by achieving cost advantages (Hansen 1993), institutional reasons (Brunsson and Jakobson 2002), and as a prerequisite for firms to compete in Europe (Bodinson 1991). As an open standard, ISO 9000 consists of a set of principles, goals and objectives as opposed to specific techniques and methods. Therefore, all types of organizations throughout a broad spectrum of industries can use ISO 9000. Currently, over 350,000 (International Standards Organization, 2002)

organizations are doing so. The leading principle behind ISO 9000 is that through a continuous cycle of formally defining customer requirements, planning activities to attain them, thereafter controlling to see that they are met, and when instances of deviations from requirements are detected articulating procedures to correct these deviations (Johnson 1993), it becomes possible to fulfill them. Thus, ISO 9000 involves aspects of both quality assurance and quality control (ibid.). Quality control consists of techniques focused on monitoring and elimination of variation (ibid.), while quality assurance refers to formalized activities to ensure that quality control is enforced and that when deviations are identified the underlying processes or procedures are improved.

RESEARCH SITE AND METHODS

Research site

I studied the second-level effects of ISO 9000 at the international contractor consortium, Sundlink Contractors, which designed and constructed the 7.8-kilometer Øresund Bridge connecting Denmark and Sweden. Construction of the multi-billion dollar bridge began in 1996 and ended in 2000. This research site was selected as an example of ISO 9000 technology in a recently formed organization that had not used it previously. The reason for this choice was that I did not want the second-level effects to be distorted by prior organizational experience with quality standards. It is important to remark that the focus of this study was a highly complex infrastructure project of immense size, with stringent quality requirements and a well-defined completion time, and subject to harsh environmental conditions.

Organizationally, Sundlink was divided into ten departments, equally divided between support and operation departments. The support departments

examined in this study were limited to those involved with technical and quality issues. A description of the respective departments is provided in Table 1. Each of the departments was divided into three to seven sections, with each section responsible for a particular activity.

TABLE 1
Description of Operations and Support Departments

Department	Activity	Size of structure	Location
OPERATIONS			
Offshore, Onshore	Constructed prefabricated concrete structures called caissons and pier shafts	800 to 4700 tons 10 to 51 meters high	Malmö, Sweden
High Bridge	Built concrete bridge pylons	Over 200 meters tall 4355 m^3 of concrete 800 tons of reinforcement concrete	Malmö, Sweden
Bridge Line	Constructed viaduct using steel and concrete	560 meters long	Malmö, Sweden
Prefab Approach Bridge	Constructed steel and concrete girders	2000 to 6300 tons 120 meters long	Cadiz, Spain
SUPPORT			
Technical	Provided technical support and advice		Malmö, Sweden
Quality Assurance and Development	Provided support and advice around quality issues as well as monitoring and enforcing quality system		Malmö, Sweden

Research methods

Multiple methods, in the form of secondary data, case studies, and a questionnaire, were used to prepare a description of ISO 9000 as implemented and applied at Sundlink. Secondary data on ISO 9000 as implemented at Sundlink were taken from two documents: *General Procedure for the Control of Non-Conformities* and the *Operations Manual*. The *Operations Manual* focused on describing working methods to attain targets as well as control procedures used to check whether customer targets were met and working

methods followed. When deviations from targets and procedures were detected, they were to be managed according to procedures set forth in the *General Procedure for the Control of Non-conformities*.

I conducted a series of nine case studies of ISO 9000 deviations during the period from March 1998 to May 1999 in order to develop an in-depth understanding of the second-level effects of ISO 9000. Over 2,000 ISO deviations were reported in the five-year period during which the bridge was constructed. The cases studied were selected on the following criteria: (1) to enhance accuracy, reported deviations could not be over two weeks old, and (2) there had to be diversity in the variety of individuals and formal organizational groups involved in the deviation. For the case studies, I conducted 28 interviews of 40-60 minutes each. I generated the list of interviewees through "snowball" sampling. The interviews were structured around open and semi-structured questions, with particular attention paid to describing the deviation as well as patterns of communication and interaction.

The third source of data was a questionnaire administered to 137 people (87.6% response rate) during a nine-month period ending in May 1999. The survey was distributed to all managers, engineers as well as operational supervisors and superintendents involved in the management of deviations. Questionnaire data focused on communication and interaction patterns as well as sociometric data. This paper used the response to the survey question that asked respondents to list the people from whom they sought advice in a deviation situation, since patterns of interactions are an indicator of social practice (Barley 1986). Data from this question were analyzed using the UCINET software package for network analysis (Borgatti et al., 1999) and were imported into Krackplot (Krackhardt et al., 1994), a program for graphical analysis of networks.

ISO 9000 AT SUNDLINK

To conduct analyses of the second-level effects of ISO 9000, secondary and primary data were repackaged to form a comprehensive description of the ISO 9000 standard as implemented and used at Sundlink. This section describes the implementation and use of the ISO 9000 quality standard at Sundlink. It begins with the targets of this system and thereafter moves on to processes to achieve targets (Working Methods – *Operations Manual*), followed by procedures for quality control (Control Procedures – *Operations Manual*) and quality assurance (*General Procedure for the Control of Non-conformities*). The overall purpose of this section is to lay the groundwork for analyzing the second-level effects of ISO 9000.

Customer requirements

On the most basic level, the customer's target was the construction of the Øresund Bridge. This target was broken down into sub-targets for the different land- and sea-based components that formed the bridge. In the construction of the bridge, certain components were prefabricated on land and thereafter shipped out to sea, while other components were constructed *in situ*, out at sea. It is interesting to note that many of the components corresponded to formal organizational sections at Sundlink. For example, the pylon, piershaft, and caissons were all functional parts of the bridge; for each, there was a formal organizational section.

Processes to achieve requirements

After the targets were developed, processes to achieve them were planned. These processes prescribed working methods. According to the *Operations*

Manual, working methods are the detailed plans that describe how work should be carried out, the division and co-ordination of labor, the number of people involved in activities, the time required to complete each activity, and the resources required in the form of equipment and materials. The most important working methods were those involving concrete since the bridge was a composite structure consisting of concrete and steel. In total, over 310,000 m^3 of concrete were used in the construction of this bridge. In contrast to many other construction projects, in which craftsmen defined working methods, at Sundlink members of the Technical Department established these methods. An operative employee described this difference as follows: "Previously we were told what to do, but not how to do it." There were unintended consequences associated with this change, which had the effect of invalidating previous work experience. An operative supervisor expressed his displeasure as follows: "Imagine someone telling you to cool concrete for 30 weeks because that is what the written guide says. I feel ignored and insulted. They are telling us that what we have done in previous projects is not good enough. Our hands are tied."

Procedures to control processes

To confirm that working methods were followed and targets attained, control procedures were formulated. Through the use of control procedures, it is possible to identify both deviant processes and deviant products. The process-oriented control procedures took the form of checklists to ensure that prescribed working methods were followed. The product-based control also relied on checklists, but in this instance for product conformity, specifically to ensure that the end product met customer requirements. Over time these checklists seemingly became a natural part of work. One operative supervisor commented as follows: "I am responsible for this caisson (a concrete structure) and all the

concrete in it. So when we take off the forms, we do a visual check to see whether there is any damage. I perform the check and fill in what type of damage there is, and then I leave it to the Quality Controller. He sends in the NCR [a specific type of deviation report]."

The detection of product-based deviations brought about the development of a classification system, with words like "rat-holes" and "honeycombs" to describe and classify deviations. A "rat-hole," for instance, refers to a situation in which the concrete has not filled all parts of the concrete form, while a "honeycomb" results when air gets into the concrete and produces a structure like the inside of a beehive. Further sub-classification of deviations developed. As one operative supervisor commented, "There are two damaged areas in the eastern wall up there along the long wall. They are Type 1 honeycombs because they are not a visible in the wall. If you had seen the reinforcement, it would have been Type 2. "

As with working methods, the conduct of formal control procedures represented a change from the traditional working practices at a large complex project. In previous projects, product- and process-based control was often performed by an official external controller, who inspected the actual work to confirm that prescribed processes had been followed and targets attained. In this project, however, both the operative personnel carrying out the work and the Quality Controller, a person whose work was with quality-related issues, were responsible for checking that procedures were followed and requirements met. As one operative department manager commented about the change, "This project is quite special, but I think that having us inspect our own work will be the wave of the future. Our quality system is based on our controlling our own work, so that the client does not need to have any inspector."

Procedures for managing deviations

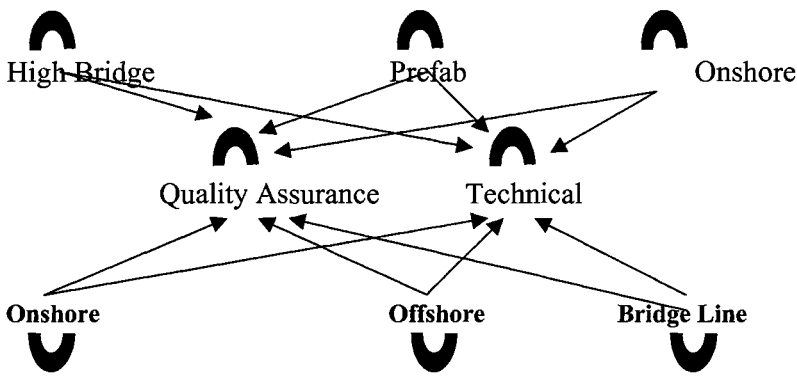
The quality-control procedures made it possible to identify deviations. Once these are detected, the *General Procedure for the Control of Non-conformities,* prescribed how they should be managed. The first step in this procedure was for the person who detected the deviation to immediately notify his/her superior or the Quality Controller. The Quality Controller was responsible for completing a one-page report on each deviation. This four-part standardized report consisted of a description of the deviation, an explanation as to why it occurred, and proposed remedial and corrective actions. A remedial action refers to an action to remedy the situation at hand, while the purpose of a corrective action is to prevent the deviation from recurring.

At times the Quality Controller would need assistance in completing this report; in these cases, formal procedure required that the Quality Controller seek advice from the Technical Department. Such situations would exist when the Quality Controller did not know why the deviation occurred, what actions should be taken to remedy the situation or how to prevent it from recurring. Contacting the Technical Department for assistance became a seemingly regular event influenced by formal procedures. A newly appointed Quality Controller described how his discussions with his line manager influenced his interaction with the Technical Department: "I contacted the Technical Department's expert. But I did so because of the discussion that I had with my section head and my predecessor. They recommended that we ask the Technical Department's expert whether we could repair the deviation on the spot or wait." Another Quality Controller described his almost automatic contact with the Technical Department in the following way: "If it is something you think is a deviation, then you get help from the Technical Department. They are the company experts."

These quotations are illustrative of a more comprehensive pattern. As can be seen in Figure 2, the emergent advice network clearly shows that operational groups followed the prescribed procedures by seeking advice directly from the Technical Department as well as within the department as indicated by the "halo" above the name of the respective deparmtent.

FIGURE 2

Emergent Advice Network for Managing Deviations

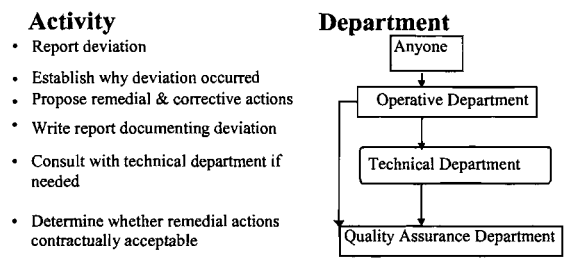


Once the deviation report was completed by the Quality Controller and approved by the department manager, a paper copy was to be sent to the Quality Assurance Department for registration. This department was responsible for the overall implementation and auditing of ISO 9000. Interestingly, the procedures specified that only a paper-based version of the deviation report could be used; all other forms of communication were prohibited. A Quality Controller commented about how the prescribed procedure stipulated the use of a particular medium: "It tells you all about how to do it. I have to use paper and I have to deliver it personally because the quality procedure for the control of non-conformities tells me to do so. There is no room for e-mail or things like that. I cannot process a NCR (deviation report) with e-mail. I have to hand

over the paper." After the Quality Assurance Department registered the report, it was to be sent to the Technical Department, whose responsibility according to the *General Procedure for the Control of Non-conformities Procedure* was to "verify that the proposed remedial action is acceptable from a technical and contractual point of view." Once the Technical Department approved the report, it was to be sent back to the Quality Assurance Department to confirm that contractual conditions were fulfilled. When all relevant approvals had been received, the operative departments were to be notified that they could begin their respective remedial and corrective actions. Figure 3 summarizes the main activities of the *General Control of Non-conformities Procedure* as well as the department responsible for each activity.

FIGURE 3

Summary of the General Control of Non-conformities Procedure



ANALYZING ISO 9000 FOR SECOND-LEVEL EFFECTS

The previous section described the three parts of ISO 9000 as implemented at Sundlink. The categories of second-level effects per activity that were found at Sundlink are summarized in Table 2. As can be seen, ISO 9000 has second-level effects on discourse, thought figures and social practice. The remainder of this section discusses these second-level effects in more detail beginning with the second-level effects of working methods. Although working methods are

not considered a direct part of ISO 9000, they are the focus of quality-control and -assurance procedures; therefore their second-level effects are considered.

TABLE 2
Summary of Second-level Effects of ISO

Activity	Discourse	Thought figure	Practice
Working methods	Who can formulate working methods (technical personnel) & who cannot (operative personnel) What people can discuss: technical people can discuss concrete methods How methods are expressed: written Why: technical people can discuss because they are knowledgeable When: can discuss in the formulating of methods.	Definition of what is normal and what is deviant Who is able to define working methods – technical as opposed to operative Influences who or what is knowledgeable (Technical Department as well as explicit knowledge in methods) Expresses values in the form of preferences Assumption about how work is carried out and who it is done by Values the knowledge of the Technical Department	Methods affect practice in terms of what work is carried out, who carries it out
Control procedure	What medium people use to check work Who can define this media	A way for people to start to think about how to do their job	Checking work is a type of action taken Specified actors for checking work
Non-conformity procedure	Who can report deviations Who can discuss them Who can present suggestions and grant approval Media used to express deviation	Reinforced concept of normality and deviation Sub-classification system developed Organizational memory of contacting Technical Department and of valuing their advice	Filling in reports Contacting the Technical Department for assistance

Analyzing working methods

Working methods not only served as the basis for conducting work, but also formed a traceable and documented means of working that influenced *discourse.* The Technical Department established the all-important concrete working methods; this represented a change in terms of who could formulate working methods. Previously, the operative personnel, rather than engineers from the Technical Department, generally defined how they should work. Operative personnel in this case were seemingly relegated to following the working methods articulated by the Technical Department rather than defining these methods themselves. It is suggested that the change in who could express working methods is integrally connected with ISO 9000's reliance on codification as opposed to untraceable routines embedded in the actual work. Further, the use of codified procedures, as opposed to determination of the working methods by operative personnel, represented a change from knowledge anchored in doing to knowledge embodied in procedures explicitly expressed in manuals.

Working methods, which reflect *thought figures* of how work should be conducted, represent one of the more pronounced second-level effects of ISO 9000. The reason is that while there are numerous methods by which targets can be achieved, the articulation of a specific means serves to define a standard against which work processes are judged. The articulation of a standard introduces a way of thinking about work in terms of what is normal and what is deviant as well as how targets should be achieved.

The working methods chosen directly affected *practice,* since they explicitly stated what and how work was to be done as well as specifying the division of labor and prescribing the manner of coordination in conjunction with the

conduct of work. It does not matter that the new working method might not necessarily represent a change from the old one; the essential point is that working methods are expressed through ISO 9000 and that this in turn influences social practice.

Analyzing control procedures

The comprehensive control procedures at Sundlink had second-level effects in terms of influencing a *discourse* about control. The discourse consisted of written checklists and procedures for conducting control, a fundamental part of ISO 9000. This suggests that knowledge about control can be found in the written documentation. Further, the control procedures influenced who could communicate about control, with the focus not on external controllers but within Sundlink itself. Specifically, control was the responsibility of the Quality Controller, of the operatives doing the work and of staff from the Quality Assurance Department.

Most of the control procedures were based on checklists. These reinforced *thought figures* about what constituted normal work as well as customer requirements. In this case normality was equated with following working methods and attaining articulated targets, while deviations denoted situations in which either targets were not achieved or methods not followed. To this extent, normality came to represent a dominant set of values concerning what work should be conducted and how it should be done. The control procedures served to reinforce the one "right" way. Further, when deviations were identified, a classification system developed as words such as "rat-hole" and "honeycombs" entered the vernacular to describe and classify different types of deviations.

In terms of *practice*, the use of formalized checklists influenced roles and tasks. For example, the Quality Controller and operative personnel both filled in checklists when conducting and inspecting their work. Control at Sundlink was for the most part conducted internally; this was a direct effect of technology. In other words, control procedures led to new roles, with new actors performing different tasks.

Analyzing evaluation procedures

The *General Procedure for Non-conformities* affected the *discourse* of quality assurance in terms of who could communicate about deviations, what they could communicate about, and how they could communicate. For example, in deviation situations, the Quality Controller was authorized to write the deviation report and comment on the causes of the deviation as well as determine what actions were required. The Technical Department was empowered to approve the deviation report and to provide advice in deviation situations. Conversely, discourse strongly influenced who could not comment on non-conformity reports; in this case, other operative departments were not formally encouraged to comment about the deviations of another department. Further, the actual choice of communication media was influenced by the prescribed procedures, which in this case required that only paper-based reports documenting the deviations could be used. Other types of media, such as e-mail, were prohibited. Through the formal layout of the one-page paper report documenting the deviation, information deemed relevant was defined and categorized.

The procedure for managing deviations also influenced *thought figures* in terms of where advice should be sought when a deviation occurs. In other words, it is suggested that the procedure influenced who was considered knowledgeable,

and by extension, where advice should be sought. Subsequently, the Technical Department became the locus of knowledge, and it is argued that operative departments seemingly refrained from contacting each other for advice because they were not considered knowledgeable. Instead, they sought advice directly from the Technical Department.

Procedures for managing deviations influenced *practice* in terms of interactions. The emergent advice network in the context of deviation situations was formalized; as a consequence, there was little direct contact between the operative departments. Specifically, the High Bridge, Onshore, Offshore and Prefabrication departments were not interacting directly. Instead, the Technical and Quality Assurance Departments brokered the contacts between operative departments. The absence of contacts between operative departments is surprising because, according to one interviewee, these departments were encountering similar problems and could have gained from sharing experiences directly with each other.

DISCUSSION AND CONCLUSIONS

The analysis of ISO 9000 as implemented and used at Sundlink contributes to our overall understanding of the second-level effects of technology through showing that second-level effects encompass more than social practice. As a technology, the implementation and use of ISO 9000 at Sundlink, had a profound effect on who, what, how, and why people communicated (discourse), on thinking (thought figures), and on working (social practice) in a large complex project. In this sense ISO 9000 is not just a tool for ensuring that customer requirements were met, but a comprehensive technology that influences the very way in which people think and speak about quality. As this

study has shown, the second-level effects of ISO 9000 are wide-ranging and affect many aspects of organizations.

The concept that second-level effects extend to discourse, thought figures and social practice provides the basis for several related conclusions centered on the Foucauldian concept of power and knowledge (1977). Firstly, the second-level effects highlighted in this paper can be interpreted as expressions of power as opposed to products of technology. It has been argued that at any one time there are competing forms of discourse, thought figures, and practice, and that the ones which become dominant are expressions and manifestations of power (Foucault 1977). Thus, practice, thought figures, and discourse are not only second-level effects, but also – in effect – manifestations of power over what is done and experienced (practice), interpretations of situations and meanings attached to them (thought figures), and communication (discourse).

Given the limitations of a single project, the ideas presented in this paper about the second-level effects of ISO 9000 remain speculative. The specialized context of this study, ISO 9000 in a large complex project, raises concerns about the generalizability of this study. One should be wary of drawing overly sweeping conclusions from the results. Furthermore, the data were collected at one particular point -- about midway through the project. Had the data been collected earlier in the course of project, the results might have been different.

References

Argyris, C. and Schön, D. (1996). *Organizational learning II.* Mass: Addison Wesley.

Asplund, J. (1979). *Teorier om framtiden.* Stockholm: Liber.

Barley, S. (1986). Technology as an occasion for structuring: Evidence from observations of CT scanners and the social order of radiology departments. *Administrative Science Quarterly.* 31, 1, 78-109.

Barley, S.R. (1988). Technology, power, and the social organization of work. *Research in the Sociology of Organizations*, 6, 1988: 33-80.

Blau, P.M., Falbe, C.M., McKinley, W. and Tracy, P.K. (1976). Technology and organization in manufacturing. *Administrative Science Quarterly.* 21, 20-40.

Bodinson, G.W, (1991). Warning: Ignoring ISO standards may be harmful to your company's future. *Industrial Management.* March/April, p. 11-12.

Borgatti, S., Everett, M.G., & Freeman. L.C. 1999. *UCINET 5 for Windows.* Natick, MA: Analytic Technologies.

Borgatti, S.P., & Everett, M.G. (1999). Models of core/periphery structures. *Social Networks.* 21, 375-395.

Brunsson, N., and Jakobsson, B. (2000). *A world of standards.* Oxford : Oxford University Press.

Chandler, A. (1977). *The visible hand: The managerial revolution in American business.* Boston: Harvard University Press.

Cuff, E., Sharrock, W., and Francis, D. (1979). *Perspectives in sociology.* London: Routledge.

Edmondson, A., Bohmer, R., and Pisano, G. (2001). Disrupted routines: team learning and new technology implementation in Hospitals. *Administrative Science Quarterly.* 46, 685-717.

Foucault, M. (1973). *The Order of Things: An archeology of the human sciences.* NY: Vintage Books.

Foucault, M. (1977) *Discipline and punish: The birth of the prison.* London: Penguin Press.

Ibarra, H. (1992). Structural alignments, individual strategies, and managerial action. In Nohria and Eccles (Eds), *Networks and Organizations.* Boston: Harvard Business School Press.

Jackson, N., & Carter, P. (2000). *Rethinking organisational behaviour.* London: Prentice Hall.

Johnson, P. (1993). *ISO 9000: Meeting the new international standard.* New York: McGraw Hill.

Kanter, R. (1983). *The Change Masters.* NY: Simon & Schuster.

Kanter, R. (1989). The new managerial work. *Harvard Business Review,* 6, 85-92.

Kotter, J. (1982). *The general managers.* NY: Free Press.

Kotter, J. (1985). *Power and influence: Beyond formal authority.* NY: Free Press.

Krackhardt, D. and Blythe, J. and McGrath, C (1994). Krackplot 3.0: An Improved Network Drawing Program. *Connections.* 17(2):53-55.

Kraut, R., Koch, S. and Dumais, S. (1988). Computerization, productivity and quality of employment. *Communications of the ACM.* 32, 2, 220-238.

Mezirow, J. (1991). *Transformative dimensions of adult learning.* Oxford: Jossey-Bass.

Orlikowski, W.J. (1992). The duality of technology: Rethinking the concept of technology in organizations. *Organization Science,* 3, 3, 398-427.

Pinch, T.J. and Bijker, W.E. (1987). The social construction of facts and artifacts. In W. Bijker, T. Hughes and T. Pinch (Eds.), *The Social construction of technological systems.* Cambridge, MA: The MIT Press.

Schein, E. (1985), *Organizational culture and leadership: A dynamic view.* San Franciso: Jossey-Bass.

Schön, D. (1983). *The reflective practioner.* NY: Basic Books.

Sproul, L. & Kiesler, S. (1991). *Connections: New ways of working in the networked organization.* Boston: MIT Press.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity.* Cambridge: Cambridge University Press.

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2000

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I huvudet på kunden. Söderlund, M., (red).
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1999
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Osynlig Företagsledning. Sjöstrand, S-E., Sandberg, J., Tyrstrup, M., (red).
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1998

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Berg-Suurwee, U., Styrning av kultur- och fritidsförvaltning innan stadsdelsnämnds-reformen.

Berg-Suurwee, U., Nyckeltal avseende kultur- och fritidsförvaltning innan stadsdels-nämndsreformen.

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