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Social Networks and Adaptability to IT-Enabled Change: The Case of Healthcare Information Technologies

By

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Doctor of Philosophy

Business

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An Abstract of
A Dissertation submitted to the Faculty of the Graduate
School of Emory University in partial fulfillment
of the Requirements for the degree of
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ABSTRACT

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Text of Abstract

Long-term assimilation of information technology (IT) is a persistent challenge for organizations, limiting the business value of these information technologies. Failure to adapt to IT-enabled changes in work processes is one factor limiting long-term assimilation of the technology. In an empirical study, a large hospital faced such long-term assimilation challenges, such that different units within the same organization differed in the extent to which they were able to adapt to IT-enabled changes in work processes. This was the case even though all units were using the same technology features, had access to the same resources, and were subject to the same concurrent implementation effort. In this study, I seek to understand why. Using social network analysis as the methodological lens, I examine the association between intra-unit social structures of knowledge demand and knowledge supply and unit-level variations in adaptability. Results show that structural variations in the knowledge demand and knowledge supply networks across units explain more of the variance in the adaptability of these units, than do other non-relational attributes of the units that have been explored in prior literature. Furthermore, my study also shows that the two arms of knowledge sharing- knowledge demand versus knowledge supply- have distinct social structural characteristics, and do not have the same impact on adaptability to IT-enabled change. In the knowledge demand network, the network structural characteristics of low average incloseness centrality and high network density had a positive effect on adaptability.

Network cohesion had a negative effect on adaptability in partial models, when network density was not included in the analysis. In the knowledge supply network, high average eigenvector centrality and high network density had a positive effect on adaptability. The cohesiveness of the knowledge supply network was not found to have any significant effect on adaptability. This supports recent work on knowledge sourcing in the knowledge management literature that calls for taking a more nuanced, directional approach in the study of knowledge sharing. My research also contributes to the social networks literature, where such a directional approach to the study of knowledge networks has largely remained under-explored.

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TABLE OF CONTENTS

TABLE OF CONTENTS- LIST OF FIGURES

TABLE OF CONTENTS- LIST OF TABLES

CHAPTER 1: Problem Statement, Research Question, and Significance of the Study

Model hospital, a large urban hospital, is currently implementing a clinical information system (CIS) comprising electronic medical records and associated decision support technologies. This is a major implementation effort that has been unfolding over the course of three to four years. The CIS is replacing the existing paper-based system, which, for decades, has been the standard technology for documentation and data management at Model Hospital. This implementation marks the transition of the entire hospital from a paper-based to a paperless system for managing patient care information and documenting patient care activities throughout the hospital. An interesting phenomenon at Model Hospital is that although the entire hospital has access to the same system, with identical functionalities, as well as the same resources, and the same implementation effort is concurrently unfolding throughout the organization, yet, different patient care units at the hospital are able to adapt only to different extents to all the changes that the technology is introducing in their work processes. While some units are assimilating the technology well, as evidenced by their ability to meet technology-related work goals, other units are struggling. Moreover, these differences across patient-care units are persistent over time and cannot be completely explained by commonly understood factors, such as unit size, patient-load, etc. These differences in IT assimilation present an intriguing problem for Model: despite being successful in the initial implementation period, performative discrepancies and inefficiencies arise and linger as the system continues to be used over time within the organization, leading to sub-optimal assimilation of the technology over the longer term.

The scenario described above is not an isolated incident. Transforming work processes through the use of information technology is commonplace in contemporary organizations, where work processes are defined as interdependent sequences of activities involving multiple people that work together to produce various organizational outcomes (e.g., Davenport, 1993). One example of a work process is the process of verifying physician orders in a hospital patient-care unit. The order verification process involves multiple professionals, such as doctors, nurses and unit secretaries, working together to conduct a specific set of activities that need to occur sequentially in order to accomplish a specific outcome, namely verification of orders written by physicians on the unit. A more downstream activity, such as the nurse signing off that he/she has verified the order, cannot be conducted until the more upstream activity in this sequence, for example, the doctor writing this order, has been conducted. In many hospitals, this work process is conducted on paper until the implementation of a clinical information system, such as the one at Model Hospital, brings the process onto the electronic platform. This move to the electronic platform enables certain outcomes from the work process, such as timeliness of order verification, as a result of IT-enabled changes in this work process. Therefore, outcomes such as timeliness of order verification serve as indicators for the extent to which IT-enabled changes in the order verification work process were assimilated by the patient-care unit.

Despite the prevalence of such technologies that transform work processes, organizations continue to struggle with longer-term assimilation of these technologies, following an initial implementation effort that was deemed successful. Such long-term assimilation problems are in some ways more difficult to manage than problems in the initial implementation phase, since by that time many of the resources that were allocated to managing the implementation effort are redirected to other initiatives, leaving the organization vulnerable to longer-term challenges that arise later in the life of the new technology. Moreover, when it comes to technologies that transform work processes, more deeply rooted or complex problems often arise later, once the dust has settled from the initial implementation period and once people have become used to the basic features of the new system. Thus, persistent IT assimilation problems continue well after the technology is in place and operational. At Model hospital, while the initial implementation effort was considered successful -- indeed, it was celebrated as one of the most successful implementation efforts by the organization as well as its technology vendor-- many problems and inefficiencies were emerging, more than a year into the system being in place. Such longer term challenges and inefficiencies are related to significant variations in the ability of different units to adapt to the changes in work processes imposed or enabled by the technology system.

Long-term assimilation of IT requires that units within the organization must adapt to the changes enabled by IT in order to take advantage of the potential for gains that the technology offers. Adaptability to IT-enabled change is defined as the ability to assimilate changes in work processes enabled or imposed by IT (Ashford, 1986; Barley, 1990; Davidson & Chismar, 2007; Fiol & Lyles, 1985; Feldman & Rafaeli, 2002; Orlikowski, 1996). Challenges in the assimilation of IT-enabled changes in work processes is one reason why long-term assimilation of the technology faces problems. For instance, clinical information systems and decision support technologies offer a lot of potential for improving patient safety and quality of care (Davenport & Glaser, 2002).

However, many change efforts involving the implementation of such technologies have failed miserably (Russell, 2005; Simpson, 1991), in part due to the inability of the healthcare organization to let go of old work processes that are incompatible with the new technology, or to modify these processes in order to re-align them with the needs and capabilities of the technology. In the case of Model Hospital, the issue was not that of outright failure to adapt, but of variation in adaptation across units, which implies that certain units were adapting sub-optimally than others. This is a subtler example of failure to adapt, where sub-optimal outcomes may be considered as one form of failure or partial failure. What drives this variation in adaptability from one unit to another within the same organization, despite all units having access to the same resources and concurrently undergoing the implementation effort?

Attitudinal and personality characteristics have often been cited as factors driving adaptation (Ashford, 1986; Griffin, 2005; Spreitzer, Sutcliffe, et al., 2005), where these characteristics represent an individual-level ability to adapt. These factors focus on characteristics of individuals as isolated entities. Relatively little is known about the interactions between individuals, and the enduring relationships between them, which underlie, predispose, enable and constrain adaptability to IT-enabled change (Kraatz, 1998). Yet, these relational factors are more amenable to managerial influence and policy-making than are individual personality predispositions to adaptation.

Structural characteristics of organizations, such as coordination, communication, and embeddedness within social structures, which have been identified in the literature as enablers of adaptation, suggest the importance of patterns of relationships in driving adaptation (Kraatz, 1998; Moon, Hollenbeck, et al., 2004; Uzzi, 1997; Uzzi & Lancaster, 2003). However, we know very little about the specific characteristics of these patterns of relationships that would enable or restrain adaptation.

Addressing the gap in understanding related to social structure as enablers of adaptability, I seek to understand the patterns of social interaction within patient care units that are associated with adaptability of the unit to the technology-enabled change. Examining social structure through the characteristics of social network structure, the specific research question I ask is: *What characteristics of network structure relate to variation in adaptability across units within the organization?*

While adaptability has been studied at different levels of analysis, in this work I am focusing on the unit level of analysis. Adaptability is defined here as the ability to assimilate IT-enabled changes in work processes. Work processes tend to be unit-level phenomena, given that they are comprised of interdependent activities involving the concerted action of multiple professionals. Assimilating IT-enabled changes in these work processes is therefore studied at the unit level.

Significance of the study: The contributions of this study would be of interest to scholars in IS and Management as well as to practicing managers, particularly in healthcare practice. Studies on IT adoption, assimilation and use are core areas of research in the field of IS, to which my study would be significant.

The IT use literature has largely considered use of IT as the one-on-one interaction of the individual with the technology, exploring the factors and conditions driving such use (e.g., Venkatesh, et al., 2003). My study contributes to this literature by considering such human-computer interaction as one aspect of the broader changes in work processes that this system is enabling. From this perspective, therefore, success at using the system does not stop simply at whether, how long, or how often users are interacting with the system, but also encompasses success at accomplishing the work process changes that the system was designed to enable. Interaction with the system is of course an inseparable and significant part of these work process changes, but it is not all of what needs to happen in order to regard the system as being used successfully. For example, at Model Hospital, timely documentation of medication administration activity is one measure of successful use of the new clinical information system. This focus on timeliness of documentation incorporates IT use in the traditional sense of interaction with the computer along with other interdependent aspects of the medication administration work process that need to be suitably modified in order to accomplish the timeliness goal. In taking this approach, this study shifts the focus of our attention from IT success to IT-business success, as has been the recommendation of research in many areas within the IS domain, including the IT use research literature as well.

In addition to the IS literature, the study also contributes to two areas of research commonly studied within the domain of management: technology-induced change and social networks. In the technology-induced change literature, many studies have looked at the consequences of technological change on social structure— for example, how a change in the technology changes the relative power positions of people in an organization (Burkhardt, et al., 1990), or the micro-social dynamics by which a new technology impacts social structure (Barley, 1990, 1986). Although much is known about the alignment of technology and structure from this literature, the causal direction of these studies has largely been from technology to emergent social structure. In contrast, the structures that contribute to *dealing with/adapting to the technology itself*, in turn enabling or constraining assimilation of the technology within the organization, are relatively less well-studied in this literature, and is the subject of this paper. My study therefore contributes to this literature by seeking an understanding of IT and social structure in the reverse causal direction: how social structure impacts assimilation of IT.

The study also contributes to the social networks literature in two ways; first, by showing how social structures enable adaptability to IT enabled change, bringing to light distinct social structural characteristics that are relevant for adaptability, which is a relatively under-explored phenomenon from the relational perspective. Second, by taking a nuanced, directional perspective on knowledge sharing, this study explores the differential structures of knowledge demand and knowledge supply from the point of view of the knowledge recipient. This is a relatively novel perspective in the study of knowledge networks, and one that is likely to generate additional useful insights in the future.

From a practice standpoint, this study is relevant and timely for the healthcare sector, which is currently in the midst of significant changes in the way patient-care is delivered. Traditionally, the management of information and knowledge in healthcare organizations has remained largely low-tech, relying on paper-charts and face-to-face communication in patient-care delivery. However, with increasing volume of medical knowledge and higher acuity of patient conditions, medical information management is fast outgrowing traditional paper-based approaches. Electronic capture and management of medical information, via electronic medical records and clinical decision-support technologies, is expected to change not only the way in which information is managed, but also the way in which care is being delivered in healthcare organizations. These changes are paradigm-shifts for healthcare professionals and organizations. Many have failed to adapt, leading to disastrous outcomes from the IT-enabled change effort. Understanding factors that impact the ability to adapt to technology-enabled process changes, leading in turn to better long-term assimilation of the technologies within organizations, is therefore a timely and significant issue for the healthcare industry. Nonetheless, the contributions of this study are not expected to be exclusive to the healthcare context, and should be of value to organizations in any industry aiming to achieve better long-term assimilation of IT through greater adaptability to technology-enabled process changes.

CHAPTER 2: Literature Review

My study focuses on adaptability to IT-enabled change, defined as the ability to assimilate IT-enabled changes in work processes. In the Information Systems as well as Management literatures, a few different research streams have studied similar concepts. In this section I will discuss how these bodies of work have informed my own. In addition, I will also point out where these extant works depart from the point of focus in this study, revealing gaps in the extant literature that this study hopes to address.

Technology Acceptance

This body of work explains individual-level acceptance of technology by using intention to use or actual use as the dependent variable. A number of determinants of behavioral intention (intention to use) and usage behavior, such as attitude towards behavior, self-efficacy, subjective norm, have been identified through a variety of research models that have been advanced by this stream of work. These determinants are primarily individual-level reactions to using the technology, which are expected to shape intention to use and ultimately actual usage. Some popular models in this tradition of research include the Technology Acceptance Model (TAM), Theory of Reasoned Action (TRA), and Theory of Planned Behavior (TPB). Recently, in an effort to synthesize the vast and sometimes divergent research findings that have emerged in this discipline, Venkatesh and others (2003) proposed and tested a “Unified Theory of Acceptance and Use of Technology” (UTAUT) as a model, synthesized from previous extant models, which they found explained more variance in usage intention than these extant models did in isolation.

Findings from this body of work partially inform the present study. In this study, I am interested in the determinants of adaptability to IT-enabled change. Part of adapting to the changes introduced by IT involves using the technology. The need to use the technology is actually one of the work process changes to which adaptation is necessary, following IT implementation. Certain variables studied in this literature in the context of intention to use IT were therefore also found to be significant as antecedents to adaptability in this study.

However, despite these similarities, there are two key points of departure of this body of work from my study. First, my study focuses on adaptability of the unit as a whole, while the technology acceptance literature focuses on understanding individual level acceptance of technology. As such variables explored in the context of individual-level technology acceptance cannot fully explain unit-level adaptability, since the latter would also be dependent on other unit-level determinants. For example, studies that have considered organizational adaptation have included factors such as coordination, and communication among members of the organization as well as factors pertaining to organizational structure as antecedents, which do not figure in individual-level models.

The second point of departure of my work from technology acceptance studies lies in the dependent variable of interest. My study focuses on understanding what drives assimilation of work process changes that are introduced once the technology is implemented. Part of these work process changes involves use of the technology, which implies that intention to use (a key dependent variable in technology acceptance studies) is also at play somewhere in this process. However, the core focus in my study is not on understanding intention to use. Therefore, factors that do not affect individuals' intention to use the technology, but are important for assimilating work process changes- such as the ability to assimilate changes in non-technical aspects of work processes- would be of interest to my study. These, however, would not figure in studies on technology acceptance.

IS implementation (including Resistance to IT)

Other studies have investigated IS implementation at higher levels of analysis. Of these, studies at the group level are most relevant to the context of my present study. A key group-level dependent variable relating to IS implementation that has been studied in the literature is resistance to IT implementation (Lapointe & Rivard, 2007). Studies in this area focus on how power shifts within the group as a result of technology shape resistance behaviors, reflecting technology as the embodiment of group power structures (Markus, 1983; Lapointe & Rivard, 2005). Related studies have also explored the social structural changes that are caused by such power shifts arising from technology implementation. Changes in power balance imposed by new technology are taken as the basis for understanding resistance to IT implementation in this body of work.

This line of work informs my own research in two ways. First, by focusing on IS implementation, it includes within its domain not just matters of human-computer interaction, as in the case of technology acceptance models, but also other features of micro-social dynamics that impact IS implementation. Moreover, the focus of these studies is at the group level, allowing an understanding of not just individual but also relational or interaction-related factors that shape IS implementation.

However, the present study departs from extant work on group-level resistance to IS in the following way. First, these studies view failure to accept or implement IT at the group level as the outcome of the group's resistance to implementation. However, assimilation of IT-enabled changes in work processes could be affected by other group-level factors besides motivational or resistance-related issues. For example, the need to coordinate (Moon et al., 2004) interdependent changes in work processes, imposed by IT, could limit assimilation of the technology even in motivated or non-resisting groups. In my study, I do not assume group-level resistance as the basis for challenges to adaptability. Moreover, my study does not focus on outright failure to implement, but considers the slower-acting, longer-term and more persistent problems that arise across different parts of an organization after the initial implementation has succeeded.

Adaptability, Change Management

Managing change in response to various internal and external stimuli, such as environmental change, process change, etc., is a topic of rich discussion in research and practice. Information technology has added a new dimension to the study and practice of change management. Technology-induced change (equivalently, technology-driven, technology-enabled, or technology-based change) has been distinguished in extant literature from non-IT-based change in several significant ways, which has drawn considerable attention to the study of information & communication technologies (ICT) and organizational change (Alavi & Palmer, 2000; Markus, 2004; Orlikowski & Yates, 2006; ParÃ© & Jutras, 2004; Tillquist, 2000). For example, the need to "deal with technology", its unique complications and the additional set of technology personnel, like IT vendors, information systems specialists, etc., is recognized as one major point of distinction between change initiatives triggered by IT versus by other non-IT factors. This introduces a significant level of complexity in the change effort, which often causes the technology to become part of the problem, rather than the solution. Managing the technology inadvertently ends up becoming a bigger goal than the organizational change objectives themselves. Finally, IT is also an enabling factor in change efforts triggered by other agents, and, as such, occupies a unique position in the study and management of organizational change, in general (Orlikowski & Hofman, 1997).

Extant studies of adaptability to change in the organizational literature have also varied along levels of analysis, just as they have in the Information Systems literature. At the individual level, behavioral adaptation in response to environmental changes (Ashford, 1986), and performance adaptations in response to changing job requirements (Griffin & Hesketh, 2005) have been documented. At the organizational level, adaptation has been studied as a way of learning from the environment by readjusting goals, attention rules, search rules, strategies and structures (Fiol & Lyles, 1985; Shrivastava, 1983). At the group level, adaptability in terms of structural changes in response to variations in the environment has been studied in experimental settings (Moon et al., 2004). These studies have progressed within a variety of theoretical domains. Tyre and von Hippel (1997) identified three primary domains that have been pursued in extant research: antecedents to adaptability (behavioral theories), process by which adaptability occurs (situated theories) and consequences from adaptability (cognitive theories).

This body of work informs my own by providing an understanding of the organizational and social structural factors that arise in adaptability to IT-enabled change.

Furthermore, close conceptual neighbors of adaptability that have also been studied in this literature, enable clarity in defining the phenomenon of interest in this study. Organizational learning is one such concept. Similar to the idea of learning-bydoing, adaptation is often used interchangeably with learning (Argyris, 1976; Miller, 1992; Sorenson, 2003). Other work has looked at adaptive learning, which refers to learning that occurs as part of problem solving. This distinction draws on notions of situated learning (Brown & Duguid, 1991, 2001) or tacit knowing (Nonaka, 1994) to view learning as a consequence of adaptation to change, problems, etc. Although key distinctions have been drawn between the two concepts, extant literature has treated adaptation the same as learning: "To the extent that the acquisition of a useful adaptation to a changing environment counts as learning, we must say that this is a case of organizational learning." (Hutchins, 1991)

A key point of departure of my study from this literature is that most extant studies in this literature have focused on individual and organizational levels of analysis; work focusing on unit-level adaptability has been relatively limited. Furthermore, most studies in this area have focused on non-relational antecedents (for example, attributes of individuals or firms) to adaptability.

My study seeks to contribute to these literature streams in Information Systems and Management by investigating relational drivers of unit-level adaptability to IT-enabled change. Relational drivers of other related organizational phenomena, such as technological change, have been studied in extant work. This work has considered a variety of types of relationships and the social structures of these relationships that affect organizational outcomes. These are discussed next.

Social Networks and Adaptability

Networks provide a structural and analytical framework that has been used in the study of various relational phenomena, such as communication, friendship, societal issues, innovation, performance, and knowledge-related processes, such as knowledge creation or transfer (Borgatti & Cross, 2003; Borgatti & Foster, 2003; Monge & Contractor, 2000). A variety of different types of social networks have been studied in the context of various organizational phenomena. Within this body of work, a broad distinction is made between work-related networks and informal networks. These have also been referred to as instrumental networks, consisting of links arising in the course of work-role performance, and expressive networks, consisting of informal relations providing friendship and social support (Ibarra, 1993; Ibarra and Andrews, 1993). Work-related networks signify the patterns of relationships arising from various work roles and formal positions within an organization. An organizational chart could be the simplest example of a work-related network, although more complex inter-relationships between people on the basis of their formal work roles within an organization or organizational unit can also be defined, such as people working together on a common project by virtue of their positions in the organization. In contrast, informal networks signify the emergent interactions, irrespective of formally defined roles, which also exist among members within an organization. These informal relations could be for a variety of reasons: friendship, social support, knowledge exchange, etc. Most social network studies focus on informal networks, exploring how different types of these networks drive various organizational phenomena.

In the context of change, such as managing change or adapting to it, extant work has largely focused on a repertoire of a few different types of networks. Several studies have looked at formal or work-related networks in the context of technological change. Using ethnographic and socio-metric data collected in a field study of radiologists using traditional versus computerized imaging devices, Barley (1990) showed how technological change impacts role relations within organizations, by causing changes in, first, the non-relational aspects of work-roles, and then it's relational aspects. These micro-level changes in existing roles, induced by technological change, then lead to larger macro-social changes in network configuration. This was a landmark study linking micro- and macro-level theories in explaining the impact of technology on network configuration.

Other research has also looked at the impact of technological change on network structure. Following the introduction of a computerized data processing system within an organization, Burkhardt and Brass (1990) showed, via a longitudinal study design, that introduction of the technology had an impact, first on formal work roles, and then on power structures within the organization. Interestingly, the technology appeared to stabilize existing work roles and power structures in situations where early adopters of the technology were already in positions of power prior to the introduction of the technology. However, when early adopters were not already in positions of power prior to the technology, introduction of the technology destabilized pre-technology work roles and network positions to bring early adopters into more central positions in the network. Related studies have also shown social influence and interpersonal relationships as being important in the spread of attitudes, beliefs, and behaviors following a technological change (Burkhardt, 1994).

Many of these studies have looked at work-related networks in conjunction with other informal networks, such as collegial relationships, communication and friendship networks. For example, Lincoln and Miller (1979) recognized that multiple types of networks simultaneously exist within an organization and compared the effect of a set of attributes- authority, education, sex, race and branch assignment- on the structures of instrumental networks, arising in the course of performing appointed organizational roles, and of primary networks, which are the informal social relations that arise among members of an organization. They found that the same set of attributes differentially affect the structures of instrumental versus primary ties. This study was interesting and different from most other network studies in comparing a set of five different organizations' networks side-by-side, looking at the structures of instrumental and primary ties among members of each organization. In other words, they performed a side-by-side analysis of ten intra-organizational networks.

Other researchers have looked at the power that individuals are able to derive from their positions in formal versus informal networks and how this influences their involvement in innovations within the organizations (Ibarra, 1993). Formal sources of power arise from positions of authority that people hold within formal work-related networks, and informal sources of power arise from their central locations in informal or emergent networks. This work showed that network centrality, signifying informal sources of power, has a stronger impact on innovation involvement, and partially mediates the impact of formal positional sources of power as well as individual attributes like education, experience or professional activity.

Gender-based differences in the formation of work-related versus social support ties have also been noted in extant research (Ibarra, 1992), where women tend to form instrumental or work-related links to men but expressive links to other women, while men form both types of links with other men in an organization.

Communication networks are another type of network that have been studied in the context of various organizational phenomena, including change (Brass, 1984; Rice & Aydin, 1991). Indeed this is a broad genre of networks, and many other types of networks, such as work or friendship networks are recognized as being variants of communication networks (Lincoln & Miller, 1979). Relatedly, friendship networks have also been considered as mechanisms for the exchange of social support, influence and information, which are particularly significant in the face of uncertainties associated with change efforts in organizations (Brass, 1984; Granovetter, 1973; Krackhardt & Kilduff, 1999; Kilduff, 1992).

Despite all of these different types of networks that have been studied in the context of organizational change, the majority of extant research in this context has focused on knowledge-sharing or information-sharing networks. For example, Kraatz (1998) showed that information sharing and communication via strong inter-organizational ties mitigate uncertainty and promote organizational adaptation in the face of change. Similarly, in a study of embedded relationships among 23 entrepreneurial firms, Uzzi & Lancaster (2003) identified structural embeddedness as the logic of exchange that promotes, among other things, complex adaptation. These authors showed how networks influence knowledge transfer and learning by creating channels for knowledge trade and reducing the risk of learning, which in turn, facilitates adaptation. The importance of network structures of information exchange has also been shown in the context of innovation diffusion (Abrahamson & Rosenkopf, 1997); in the present context, an innovation introduced in an organization could be viewed as one type of change, which further corroborates the importance of information exchange networks in studies of change. Furthermore, even where other types of networks have been explicitly studied, such as communication or friendship, the exchange of knowledge through these networks was often found to play a significant role in the outcomes that were generated, such as innovation output, performance. Finally, a closer look at the antecedents to adaptability that are repeatedly identified in extant literature- for example, mutual coordination or shared interpretation- reveals the importance of the relational element of knowledge sharing in driving adaptability.

My study addresses two gaps in this cumulative literature studying the impact of various types of network structure on organizational outcomes. First, adaptability to IT-enabled change has remained a relatively less well-explored outcome variable in the social networks literature. Although some studies have indirectly suggested the importance of relational enablers as antecedents to adaptability (e.g., Kraatz, 1998), however, these studies have not explicitly investigated the characteristics of the corresponding social structures that are relevant to adaptability. In this study, I address this gap by drawing on social network analysis as a way to systematically examine characteristics of social structure that are relevant to adaptability to IT-enabled change.

Second, despite the lack of prevalence of network studies on the drivers of adaptability to IT-enabled change, studies on close conceptual neighbors of adaptability, such as organizational change, have looked at the relationship between IT and social structures. However, these studies have largely focused on understanding the impact of IT on social structure. In contrast, the impact of social structure on the ability to assimilate IT and associated changes has remained relatively less well explored, and is the subject of the present study.

Table 1 illustrates the different types of networks that have been studied in contexts relating to change within and across organizations, and the network structural characteristics that have been most commonly discussed in these studies. This work provides the foundation on which my choice of social networks of knowledge sharing, as antecedents to adaptability, is based.

In conclusion, therefore, in this study, I investigate the association between social structural characteristics of knowledge sharing networks within organizational units and unit-level variations in adaptability to IT-enabled change.

CHAPTER 3: Research Model

I focus on social networks of knowledge sharing, relating to the IT-enabled change effort, as antecedents to adaptability. Knowledge sharing is known to be a precursor of learning and adaptation (Fiol & Lyles, 1985; Shrivastava, 1983). In the context of my study, IT-enabled transformation of work processes represents complex change, creating new interdependencies and modifying existing ones within and across functional roles. The features of the technology itself are emergent and changing, in order to fit the needs of changing work processes and roles. These complexities make it difficult for any single individual to know everything needed in order to successfully adapt to the changes introduced by the technology. As a result, individuals must make use of the knowledge of others, through knowledge sharing, in order to successfully adapt to IT-enabled change. Making sense of the uncertainties and changes introduced by IT in the work that is conducted within organizational units, through knowledge sharing, shapes the ability of these units to adapt to the change effort. I therefore consider informal patterns of knowledge sharing related to the IT-enabled change effort as the aspect of the social structure within organizational units that is likely to affect units' adaptability to IT-enabled change.

Recent work on knowledge sharing highlights the significance of paying explicit attention to directionality in knowledge sharing. At its simplest level, knowledge sharing involves dyadic interaction between a source and a recipient of knowledge. Each of these actors brings their own distinct motivations, interests and circumstances to the interaction, which in turn enables, shapes and constrains knowledge sharing. Most extant work at the intersection of knowledge sharing and social networks has investigated patterns of knowledge sharing interactions in general, without attending to the source versus recipient considerations from which these patterns emerge. Others have either explicitly or implicitly considered knowledge sharing from the point of view of the donor of knowledge, for example, by focusing on what it would take to get them to share their knowledge (Gray & Meister, 2004). More recently, however, there is growing recognition of the need to supplement this existing work with studies that investigate the recipient's perspective in knowledge sharing, in order to develop a more holistic understanding of knowledge sharing and its impacts on organizational outcomes (Gray & Meister, 2004; Borgatti & Cross, 2003).

Therefore, in this study, I have conceptualized social networks of knowledge sharing from the perspective of the knowledge recipient. The recipient's perspective raises distinct issues in knowledge sharing. For example, one of the difficulties in knowledge sharing arises due to the recipient's reluctance to accept knowledge from another source, either because they don't trust the source, or because they regard their own context as being uniquely different from other contexts where a certain piece of knowledge may have worked- Szulanski and others have called this the 'not-invented-here' syndrome in their studies on stickiness in knowledge transfer (e.g., Szulanski, 1996). Other studies have explored the unique cost and value considerations that underlie an individual's decision to seek information from another (Borgatti & Cross, 2003). The network implications of these issues, arising out of the recipient's perspective in knowledge sharing, are typically under-explored in the literature.

From the recipient's perspective, I conceptualize knowledge sharing from the dual considerations of demand for versus supply of knowledge (Gray & Meister, 2004). These are embodied in two different networks of knowledge sharing, which I study in this work: knowledge demand network (KDN) and knowledge supply network (KSN). One way to think about the distinction between these networks is to consider them as structures where receipt of knowledge occurs through active seeking versus passive receipt. The 'knowledge demand network' (KDN) embodies an active 'demand for knowledge', and consists of a system of interrelated actions and interactions in which people *actively* seek help and advice in order to resolve the problems they are having with the technology and associated changes. The KDN is consistent with studies on knowledge sourcing in the knowledge sharing literature (Gray & Meister, 2004, 2006). On the other hand, the 'knowledge supply network' (KSN) is a system in which people do not have a particular knowledge need, but are nonetheless passively receiving knowledge that is made available (or supplied) to them voluntarily, even without their asking. The recipient is therefore at the *passive* receiving end in the KSN, while they are actively seeking out knowledge in the KDN network.

In both these networks, the direction of knowledge flow is towards the same person (the recipient). However, the directionality of actively seeking versus passively receiving knowledge is important since it highlights distinct social structures through which knowledge is made available to people, and therefore differences in the characteristics of these social structures that are relevant for adaptability in one network versus the other. The two networks are distinguished by the mechanisms through which people engage knowledge in either network. In the knowledge demand network, this mechanism is actively seeking knowledge in response to knowledge needs encountered in the course of adapting to IT-enabled change. This mechanism makes the system of interactions embodied by this network directional. In the knowledge supply network the mechanism is passively receiving knowledge, even without a specific knowledge need, from various others in the network who voluntarily choose to pass along what they have found useful. The social structures characterizing knowledge supply networks therefore determine what knowledge, among all that is being received in these networks, ultimately gets people's attention; for this reason, these networks are directional as well.

As I explore the structural characteristics of knowledge demand and knowledge supply networks within organizational units in this study, my goal is to examine how variations in these structures across units within the same organization are related to variations in the adaptability of these units to IT-enabled change. The structural characteristics of these networks therefore serve as independent variables in my study.

Stemming from the active seeking versus passive receiving of knowledge in either network, a key distinction underlying the structural characteristics of knowledge demand versus knowledge supply networks is the tradeoff between access to knowledge versus motivation to accept knowledge in either network. The knowledge demand network is characterized by the active seeking of knowledge, so people in this network already have the motivation to accept knowledge. However, obtaining access to knowledge is of key concern, and is an issue central to patterns of interaction in this network. Access may be limited by the complexity of the knowledge that needs to be transferred, poor access to suitable knowledge sources, limitations in the trustworthiness of an individual source or of the network as a whole (Szulanski, 1996; Szulanski, Cappetta, et. al., 2004). In contrast, the knowledge supply network is a system where people are passively being exposed to knowledge from others. Here, access to knowledge is not a problem, since the knowledge is being voluntarily shared. However, motivation to accept this knowledge, once received, becomes more of an issue underlying patterns of interaction in the knowledge supply network, since the knowledge being received in this network is not in response to a particular knowledge need, making it more likely to, for example, get set aside and possibly forgotten. This tradeoff between access versus motivation in the knowledge demand versus knowledge supply networks within each unit is used as the basis for theorizing about variations in units' KDN and KSN structures that are related to unit-level variations in adaptability.

Knowledge Demand Networks (KDN)

Problem solving is an iterative and often collaborative process (Brown & Duguid, 1991, 2001; Tyre & von Hippel, 1997). As a unit, dealing with problems relating to the IT-enabled change effort requires that people facing these problems are able to access the knowledge of others who can take the time to engage in collaborative and iterative problem-solving with them. Effective access to knowledge providers becomes lower when providers, on average, face high demands for help with problem-solving. The higher cognitive load on providers, when they are being sought after by many individuals with problem-solving needs, makes it more difficult for them to spend the time and effort needed to provide meaningful help. For this reason, iteration and collaboration that enables adaptation to IT-enabled change is more challenging in units where effective access to knowledge providers is low.

This theoretical idea of highly-sought-after providers is embodied in the network structural characteristic of incloseness centrality. Closeness centrality provides a measure of a node's global centrality within a network (Scott, 2000). In the directed KDN, incloseness centrality measures the extent to which an individual (potential knowledge provider) in the network has a large number of incoming ties from others (knowledge seekers) who seek problem-solving help and advice from them. These knowledge seekers are either approaching the providers directly or are at relatively short social distances from them, placing high levels of cognitive burden on the providers. As users of the system, providers in a knowledge demand network are themselves also adjusting to the system, and likely facing problems of their own. High incloseness centrality adds to this already high cognitive burden of providers, who are now faced with the need to solve their colleagues' problems as well. A knowledge seeker in such a network is therefore likely to get access to less time and attention from a provider burdened in this manner. Furthermore, as a result of being burdened with high levels of problem solving needs from others, not only are the providers able to spend less time with the seekers, but their own adjustment to the system is also limited. As a result, the unit as a whole adapts to lower extents.

I have used average incloseness centrality to characterize patterns of interaction in which people have higher incloseness centralities. Figure 1 shows two network structures that are identical in the number of nodes and the links between them, but differ in their average incloseness centrality values. The two networks in this figure therefore show differences in average incloseness centrality values after holding constant other network characteristics, like network density. Higher value of the average incloseness centrality in a unit's KDN indicates that effective access to the knowledge of others, and therefore, problem solving and adapting to IT-enabled changes in the unit is low. Therefore, *H1: Lower the average incloseness centrality of the knowledge demand network in a unit, greater will be the adaptability of the unit to IT-enabled change.*

Problem solving in the process of adapting to IT-enabled change is often complex. Problems could be related to different aspects of the change effort, ranging from navigating the technological interface to figuring out how patient-care processes must be conducted in the technology-enabled work environment. The focus of this study is on long-term assimilation of the technology, when several months have passed since the initial implementation. At this point, most of the simpler surface-level problems that typically arise due to the newness of the technology are already out of the way, and people have had considerable experience with day-to-day use of the system. Problems that limit adaptation at this stage are therefore more likely to be of a complex nature, involving tacit and context-specific knowledge.

Solving complex problems requires hands-on attention and iterative, collaborative patterns of interaction involving the active seeking of knowledge in response to the problems. Studies on complex problem solving have shown that local information relating to the problem is often difficult or costly to transfer from the context in which it arises (von Hippel, 1998). Furthermore, studies on situated learning have shown how decontextualizing knowledge makes it more difficult to apply in the context of problem solving (Brown and Duguid, 1991, 2001; Orr, 1996). Successful problem resolution therefore requires simultaneous engagement in the problem at-hand between knowledge seekers and providers in the network, interacting within the work context in which the problem arose.

Given these characteristics of problem solving needs, access to better quality knowledge in the knowledge demand network is more likely in networks where patterns of interdependent interaction between knowledge seekers and providers satisfy three conditions (Hansen, 1999). First, knowledge providers should be sufficiently close to seekers so as to have vested interest in the seekers' success at resolving their problems. Second, seekers and providers in the network need to be engaged in patterns of iterative interaction where seekers feel comfortable asking questions of providers, relating to the problem. Third, seekers and providers need to have shared understanding of each other's learning and teaching styles as well as of the context in which the problem arose- this mutual common knowledge provides a foundation on which new knowledge can be easily transferred. When faced with problems, knowledge demand networks characterized by patterns of interaction with the above characteristics would allow better knowledge sharing and problem resolution. Such interactions should be mutually beneficial, and enable better adaptation by helping the seeker learn something new and the provider reinforce what they already knew about the IT-enabled change.

The network structural feature that embodies these relational characteristics on a dyadic level is the strength of the tie between the knowledge seeker and provider, defined and measured as the frequency of knowledge-seeking interactions between them in the knowledge demand network (for example, Monge & Contractor, 2000, 2003; Granovetter, 1983). At the unit level, the concept of dyadic tie strength translates to a related structural characteristic, namely network density. Network density is defined as the average strength of ties between all pairs of nodes in the network. In valued graphs, more dense networks are ones that are high in numbers of ties and/or frequencies of interaction of ties (strength). I use network density (rather than tie strength) as the relevant independent variable in order to theorize about the unit-level network structural characteristic related to adaptability of the unit to IT-enabled change. Figure 3 shows two network structures that are identical in the number of nodes, but differ in their densities. The lower density network has fewer number of interactions and less strong (i.e., less frequent) interactions than the higher density network in this figure. The figure depicts that both the number of interactions between nodes in the network and the frequency or strength of these interactions is taken into account in calculating the density of the network.

The presence of a dense knowledge demand network in a unit suggests that problem solving interactions within the unit are characterized by close, iterative interactions between knowledge seekers and providers who share a common understanding with each other. Such units are therefore more likely to be effective in solving problems relating to the IT-enabled change effort that arise in their work environment. In other words, units with more dense knowledge demand networks are likely to be more adaptable to IT-enabled change.

H2: Greater the density of the knowledge demand network in a unit, greater is the adaptability of the unit to IT-enabled change.

Hypothesis 2 concerns direct interactions between knowledge seekers and providers in the network. However, direct access to knowledge may not always be an option. For example, the nature of problems that arise in the unit may be such that the direct contacts of people facing the problems are not able to solve it. In such cases, obtaining access to knowledge requires search for suitable knowledge providers first. In many cases, direct contacts of seekers, having been unsuccessful at solving the problem themselves, may point out others in the network that may have the answer; then, if these people cannot solve the problem, more distal providers are identified, and so on. In other words, access to knowledge in this situation requires indirect connections between seekers and providers in the network, through one or more intermediaries in the unit who provide the search capabilities necessary for such indirect access.

Having fewer intermediaries separating knowledge seekers and providers in the knowledge demand network may be more conducive to obtaining quick and easy access to knowledge. Patterns of interaction that involve navigation through fewer intermediaries are structures in which people can more quickly zero-in on suitable knowledge providers. Fewer intermediaries are also likely to provide more accurate search results, reducing waste of time and effort in dead-end searches. This is because there is less distortion of knowledge traveling either way through patterns of interaction that involve fewer intermediate links between seekers and providers: First, knowledge characterizing the problems arising in the network, when transmitted through fewer intermediaries, is likely to be more accurately represented to suitable knowledge providers, due to less distortion of this knowledge in the course of transmission (Hansen, 2002). This in turn facilitates more accurate identification of providers who have the knowledge necessary to solve this problem. Moreover, once the knowledge necessary to resolve the problem is located, its communication back to the site of the problem is likely to also involve less distortion, when fewer intermediaries separate seekers and providers in the network. Due to these reasons, patterns of interaction characterized by shorter, rather than longer, indirect interactions between knowledge seekers and providers in the knowledge demand network, are likely to be better for knowledge sharing, problem solving, and therefore, adaptation.

The theoretical idea of patterns of interaction involving shorter indirect connections between knowledge seekers and providers is embodied in the network structural concept of cohesion. The cohesiveness of a network is higher when the average distance between pairs of nodes in the network is shorter. Figure 4 shows two network structures that are identical in the number of nodes and the number of links between them; however, one network is less cohesive than the other, since the average distance between node-pairs in this network is higher than that in the other. The matrices below each network show the distances between corresponding node-pairs in each network. Units where the knowledge demand networks are characterized by higher distance-based cohesion would be more effective in transferring complex knowledge and solving problems relating to the IT-enabled change effort. Such units are therefore more adaptable to the IT-enabled changes they experience.

H3a: Greater the distance-based cohesion of the knowledge demand network in a unit, greater will be the adaptability of the unit to IT-enabled change.

Alternatively, research on situated learning (Brown and Duguid, 1991, 2001; Orr, 1996) would suggest the opposite relationship between distance-based cohesion in knowledge demand networks and adaptability. In the knowledge demand network, the act of seeking knowledge occurs in response to problems that the people in the network are trying to resolve. As such, knowledge seekers in this network are likely to be more open to trying new things or novel ideas to see what works, since their work is potentially at stake unless they can solve the problem they are facing with the system. The new knowledge that distant providers are more likely to bring to a problem in the KDN might help to jumpstart problem resolution by triggering something that seekers may not have been thinking about earlier. In contrast, social structures where people providing knowledge are at relatively short distances from those needing them would be characterized by similarities in thought processes and work experiences between providers and seekers. Providers in such networks may, therefore, be less likely to come up with a different way of thinking about the problem or its solution.

In their study on situated learning in the context of complex problem solving, Brown and Duguid (1991) showed how storytelling, as a rich form of knowledge sharing, could help solve complex problems in relatively unrelated contexts. Using an engaging ethnographic study of repair technicians struggling to fix a technical problem with a photocopy machine as an example, they discussed how stories heard from engineers in other parts of the organization, about something that had happened in the past and how the issue was resolved then, finally gave the repair technicians the clues they needed to solve the present problem. Knowledge providers located proximally to seekers facing problems may not have particularly novel stories to tell. Or, recipients in such social structures may already be aware of the providers' stories, which are more likely to have reached them through the relatively short social distances separating proximal providers from seekers in these social structures. However, more distant providers may have very different experiences to share, of which seekers may be otherwise unaware, and which may therefore be helpful in problem solving. Less cohesive patterns of interaction may also allow the more distal providers to bring an entirely different lens to the way in which they view or define problems in comparison to seekers, which could also simplify the task of solving it. This is perhaps one of the reasons why communities of practice that are spread across multiple organizations, with people located distally from each other and working in very different environments, are so effective at complex problem solving. By this logic then, units with less cohesive KDN structures where the average distance between seekers and providers is higher, would be better at problem solving and more adaptable to IT-enabled change.

Therefore, theory suggests an effect of distance-based cohesion on adaptability in either direction. I state both alternative framings of this research hypothesis, deferring to empirical analysis for further illumination on this issue:

H3b: Lower the distance-based cohesion of the knowledge demand network in a unit, greater will be the adaptability of the unit to IT-enabled change.

Knowledge Supply Networks (KSN)

In contrast to knowledge demand networks, the key issue in the knowledge supply network is motivation to accept the knowledge that is being made available voluntarily by providers in these networks. Unless this knowledge is accepted and applied in the process of adapting to IT-enabled change, supply of knowledge would be futile in enabling adaptation. Motivation to accept is not a trivial issue either, if one considers the need to sift through the large volumes of knowledge that are often made available to people, so that they may find the pieces that are actually useful or relevant.

In units where the supply of knowledge is coming from a variety of sources, a quick and easy way (from the point of view of people receiving this knowledge) to process this would be by focusing on knowledge received from people who are more prominent or central in their network. In general, people who are well connected in the unit, i.e., have relationships with a number of people in the unit, are more likely to provide useful knowledge. These are the more prominent or central people in the unit. Their prominence, by virtue of the relationships they enjoy with others, gives them a certain visibility that other less well-connected people tend not to have. A well-connected person, then, is likely to be aware of more amounts of significant information relating to the change effort. Knowledge about new opportunities is known to travel through direct and indirect informal connections more so than through formal organizational structures (Granovetter, 1983). Well-connected people in knowledge supply networks are more likely to be able to receive knowledge about various insights and developments relating to the change effort, and are therefore better equipped to skillfully read between the lines and understand the unwritten implications of ongoing IT-enabled changes. As a result, the knowledge that they are able to share is pre-sifted for potential dead-ends, and is less likely to waste recipients' time. So, the knowledge that they supply in the network is likely to be of better quality.

Moreover, this knowledge is likely to be reaching well-connected individuals in a more timely fashion. In other words, social structures where people are well-connected are more likely to be ones where people hear about novel insights or new developments sooner in comparison to structures where people are not well-connected - the value of the "grapevine" for flow of knowledge and "gossip" is documented in the research literature (Granovetter, 1973; Ibarra, 1993; Ibarra & Andrews, 1993). This quality is particularly useful for time-sensitive knowledge that allows only a narrow window of opportunity to exploit certain benefits. However, even for non-time-sensitive knowledge, becoming aware of new insights more quickly means that the unit would be left struggling with the older way for less amounts of time. Therefore, units where voluntary knowledge providers are well-connected with others are able to supply high quality knowledge in a timely manner to its constituents. By virtue of being well-connected, these individuals are likely to have built up a strong reputation for themselves as resourceful people who always share valuable insights. This strong reputation helps establish greater credibility of the knowledge they are supplying to colleagues in the network. Finally, well-connected individuals are also more powerful and exercise considerable influence in the unit (Ibarra & Andrews, 1993). So, when they speak (i.e., supply knowledge), others are more likely to listen (i.e., pay attention to the knowledge they supply). For all the above reasons, knowledge supply networks where knowledge is being voluntarily supplied by people who are well-connected in the network are likely to be ones where people have higher motivation to accept this knowledge and apply it while adapting to IT-enabled change. In other words, people who are connected to other well-connected people in the unit are more likely to accept the knowledge that is made available to them by these individuals.

The network structural characteristic that embodies the above theoretical mechanism is eigenvector centrality. Eigenvector centrality is defined as the centrality of a node (a recipient in the KSN) connected to other highly central nodes (potential well-connected knowledge providers in the KSN) in the network. This measure of centrality not only takes into account the connectedness of the focal actor but also the connectedness of other actors to which the focal actor is connected. In the context of the knowledge supply network, eigenvector centrality of individuals would be higher when they are connected to voluntary knowledge providers who are more central, i.e., well-connected, in the network. As an example, nodes A and D in the network depicted in Figure 2 have different eigenvector centralities. Although both nodes are connected to the same number of other nodes in the network, node A has higher eigenvector centrality than node D, since the contacts of node A (nodes E and F) are more well-connected in the network than are the contacts of node D (nodes G and H).

I have used average eigenvector centrality of the KSN in a unit to denote the overall extent to which people in the unit are receiving voluntary knowledge from other highly central people in the network. As a unit, acceptance of knowledge that is being voluntarily pumped into the KSN would be higher when people are, on average, receiving this knowledge from other highly central people; in other words, when the average eigenvector centrality of the KSN in the unit is higher. Under these conditions, more of this knowledge is accepted and applied in the context of the work that is performed on the unit, which means that the unit is able to adapt better to the changes that IT is introducing in this work.

H4: Greater the average eigenvector centrality of the knowledge supply network in a unit, more will be the adaptability of the unit to IT-enabled change.

When people are busy and not faced with an immediate knowledge need, they will have less motivation to "try out" knowledge that is supplied to them simply because it is novel. In efforts to make sure this knowledge does not waste their time by yielding worse results (e.g., complicating their work even more) or sending them down a dead-end, they will want to ensure two things about the knowledge before accepting it. One, that it is useful to their context. A piece of knowledge can be novel and interesting, but it may be unrelated to the work context in which the recipient would apply it, thereby rendering it insightful, but useless. This phenomenon has been discussed in the research literature under the label "Not-Invented-Here" or NIH syndrome, as one of the causes leading to stickiness in knowledge transfer (O'Dell & Grayson, 1998; Szulanski, 1996).

Two, recipients would also want to ensure that the knowledge they are being supplied is from a source they can trust. A trusted source, from whom they often receive useful knowledge, is a cost-effective filtering mechanism, that allows recipients to quickly hone-into the few useful and relevant pieces of knowledge from the large volumes of perhaps interesting but irrelevant knowledge to which they might otherwise be exposed.

Furthermore, the effective usefulness of the knowledge that is supplied to people in a unit can also be enhanced based on the way in which it is shared. If suppliers of this knowledge are not simply stating the knowledge (for example, telling people that a short-cut for navigating the system exists) but are also able to take the time to walk people through how this knowledge is to be applied in the context of their work, pointing out any potential pitfalls to the application, then the job of assimilating this knowledge is made much easier. People in such social structures would in that case be much more motivated to accept this knowledge, since the effective usefulness of the knowledge has just been enhanced by the time that suppliers were able to invest in conveying this knowledge. Of course, such close interactions are not always possible or desirable due to the cognitive demands they place on knowledge sources (see H1) as well as on recipients in the network. However, all else equal, recipients and sources may be more likely to invest this time if the source is a trusted one; and when they do, the resulting patterns of interaction would be more likely to allow for higher motivation to accept knowledge in this network. Thus, units where the knowledge being voluntarily supplied is contextually useful and from trusted sources who can invest the time and effort to convey this knowledge in a rich manner, would be likely to be more adaptable.

These theoretical mechanisms are manifested in the structural property of network density. More dense knowledge supply network structures imply that voluntary knowledge providers in these networks are, on average, strongly tied to the recipients. They are therefore more trusted or trustworthy sources (Granovetter, 1983), perhaps due to previous successful contributions of useful knowledge. Patterns of strong ties between sources and recipients in this network also make it more likely for people to be able to take the time to transfer the knowledge in a rich way, exploring applications and potential pitfalls of the knowledge. Moreover, being strongly tied implies that recipients know that sources share a common understanding of the unique work context in which this knowledge is to be applied. Recipients in units with dense KSN structures are therefore less likely to use the "not-invented-here" excuse for not accepting knowledge supplied in these networks. Due to these reasons, the knowledge supplied in dense KSN structures is more likely to be accepted and applied, thereby enabling better adaptation.

H5: Greater the density of the knowledge supply network in a unit, more adaptable the unit is to IT-enabled change.

H5 considers knowledge supplied only via direct ties in the knowledge supply network. This knowledge suffers from an important limitation: it is useful and relevant to the context of recipients in the network, but is not particularly novel. New ways of thinking about the IT-enabled change effort could facilitate better adaptation. However, such knowledge is lost on recipients through direct ties in a KSN due to considerations of not-invented-here and lack of trust of the source, discussed earlier, which make network structures characterized by strong rather than weak *direct* ties more favorable. As we know from prior literature, strong direct ties are less conducive to the transfer of novel knowledge (Granovetter, 1983; Hansen, 1991).

However, knowledge supplied in network structures involving more distal relations (i.e., through multiple intermediaries) between providers and recipients can help overcome this limitation, allowing for better overall knowledge supply in the unit and therefore better adaptability. First, indirectly-connected knowledge providers are likely to be able to provide novel knowledge (this is similar to what patterns of weak direct connections between sources and recipients could have also accomplished, if not for the limitations above). Second, and in contrast to the weak direct tie situation, the indirectness of these relationships is likely to be able to overcome the motivational issues that would have arisen in the direct tie context. This is because the intermediaries that link indirectly connected knowledge providers and recipients are more proximal to the recipients' contexts in comparison to the providers (by definition), and therefore, able to translate the novel knowledge of distal sources in a form that is relevant to the context of the recipients. This facility provided by intermediaries in indirect connections is lost when sources are directly tied to recipients through weak interactions. The presence of intermediaries therefore allows the knowledge supplied by providers in the unit to have wider reach, by allowing knowledge obtained from distal sources in this unit to be accepted and applied in the process of adapting to IT-enabled change. Therefore, patterns of interaction characterized by more distal connections between knowledge providers and recipients (i.e., greater reach) allow for more novel knowledge to be shared, and enable better adaptation of the unit in which such interaction patterns occur.

This characteristic of indirect connections between sources and providers is represented by the network structural characteristic of distance-based cohesion. Higher distance-based cohesion in the knowledge supply network within a unit implies that indirect connections between knowledge providers and suppliers are shorter, i.e., involving fewer intermediaries. This means that these are patterns of interaction where sources are relatively more proximal to recipients, in turn implying that they may not have much novel information to share. Patterns of interaction involving longer distances between sources and recipients are, on the other hand, better for the transfer of novel knowledge, which the recipient is also likely to be motivated to accept, due to the facility provided by the proximal intermediaries in the network. These intermediaries also serve as filters for the knowledge received from distal providers, allowing the knowledge that finally reaches the recipient to be useful and contextualized. Therefore, units where the distance-based cohesion of knowledge supply networks is higher would be likely to be less adaptable.

H6: Lower the distance-based cohesion of the knowledge supply network in a unit, greater is the adaptability of the unit to IT-enabled change.

I have also included additional control variables suggested in prior literature as impacting IT-enabled change, which are discussed next:

<u>Psychological Safety:</u> This is a group level construct that has been used in prior literature to signify the extent to which people in a group feel safe to ask questions and even to make mistakes. Team psychological safety has been shown to positively impact learning in prior studies (Edmondson, 1999). In the present context, greater psychological safety would allow for people in the unit to feel comfortable about asking questions relating to the change effort, or to expose their vulnerabilities by making mistakes and learning from them in the process. Such an environment would also engender a feeling of being cared for and respected, which makes people feel more accepting of the change effort.

Therefore, units where psychological safety is high are expected to be better able to adapt to IT-enabled change.

Facilitating conditions: This denotes the extent to which adequate resources (both human and technical) are available on the unit to support the IT-enabled change. Studies on technology acceptance (e.g., Venkatesh et al., 2003) have used this construct to explain individual level IT use. In the present context, having more resources available on the unit can help the unit navigate the challenges encountered in adapting to the system and associated changes, and therefore to adapt better.

Self-efficacy: This construct has also been used in studies of technology acceptance to explain individual level IT use. It is defined as the extent to which an individual is comfortable using technology. Greater comfort level with technology is more likely to make the process of adapting to changes enabled by technology easier. The more that individuals in a unit are self-efficacious with respect to their use of technology, the easier adaptation to IT-enabled change is likely to be for the unit. The average of self-efficacy values for all individuals in the unit was used to construct the unit-level measure for self-efficacy. Units with higher average self-efficacy levels are likely to be more adaptable to IT-enabled change.

Social Influence: Social influence is another construct that has been studied in a variety of fields, including technology acceptance (Venkatesh et al., 2003), and social networks studies on workplace performance (Mehra, Kilduff, et. al., 2001). It measures the extent to which members in a unit are influenced by those important to them on various dimensions, such as peers, supervisors, subordinates, etc. Social influence has been found to have different effects on different organizational outcomes and in different contexts in existing literature. Studies on technology acceptance have shown that the importance of social influence on intention to use technology is more likely to be significant in mandatory use settings, but not in voluntary use settings.

In the context of my study, which is a mandatory use context, I would expect social influence to have a significant effect on adaptability. Furthermore, with respect to adaptability to IT-enabled change as the dependent variable, social influence is likely to generate a negative effect. Strong influence from important stakeholders adds to the stress of adapting to the new system, particularly in high demand work environments. A negative relationship between stress and performance is well documented (Gilboa, Shirom, et al., 2005). With this burden of stress, while people could still intend to use the system (in fear of the negative repercussions if they do not), their actual performance with it, in terms of successfully assimilating IT-enabled changes in work processes, may be worsened. This negative directionality of the effect of social influence has not been explicitly discussed in extant research on technology acceptance and intention to use, but may be relevant in the context of the dependent variable in this study.

Finally, the conceptual basis for the dependent variable in this study is discussed below.

<u>Dependent variable:</u> Information technologies often enable certain outcomes to be realized from work processes, which were not possible to be either realized or tracked

consistently prior to the technology enablement. The realization of these improved outcomes requires that appropriate changes in the corresponding work processes, which are aligned to the improved outcomes, be assimilated first; in this case, by units in the organization, since work processes tend to be unit-level phenomena. Successful assimilation of IT-enabled changes in work processes is therefore linked to the outcomes that these changes enable. Thus, IT-enabled outcomes from these work processes serve as indicators of successful assimilation of IT-enabled changes in the work processes-- the latter is defined as adaptability to IT-enabled change. Using this logic, two different outcome-based measures of adaptability, corresponding to two core work processes that were transformed as a result of the information technology, were used in this study. Each is captured at the unit level:

a) Timeliness of order verification (TOV): Timeliness with which orders are verified on each unit provides a measure of how effectively the unit is able to utilize the system to conduct this interdependent work process. Units that are better adapted to the system and related changes would be able to conduct this work process in a more timely manner. Number of orders verified in a timely manner/unit size was used as a measure of the unit's adaptability to IT-enabled change.

b) Timeliness of medication administration (TMA): Timeliness with which medications are administered on each unit provides a measure of how effectively the unit is able to utilize the system to conduct this interdependent work process. Units that are better adapted to the system and related changes would be able to conduct this work process in a more timely manner. Number of medications administered in a timely manner/unit size was used as the other measure of the unit's adaptability to IT-enabled change in this study.

Figure 5 depicts the research model for this study.

CHAPTER 4: Methods

Research Setting

The research setting for this study is a large urban hospital currently implementing clinical information systems, including electronic medical records and associated decision-support technologies, in a phased manner. The hospital employs over 6000 healthcare professionals and includes two campuses. Overall, the organization is known for its progressive and research-oriented approach to patient-care, winning many awards for being a “learning organization”. The hospital used to be two entirely different organizations until they were merged about 10 years ago. Since then, although both “campuses” are part of the same overall administration, distinctive cultures and practices continue to persist at each location. One of the campuses is an academic/teaching facility while the other comprises largely of private practicing physicians, who have a contract relationship with the hospital. Each hospital campus continues to offer the full range of patient care services, including general care, intensive care and ancillary services. Given this organizational structure, in the past, multiple work processes and different established practices have persisted throughout different parts of the hospital, often unbeknownst to their counterparts within the same hospital or even to hospital administration.

Implementation of the new clinical information system at this hospital was motivated by the goal of standardizing and integrating organization-wide work processes in order to accomplish better information management, patient safety and quality of care. This was a major, multi-year implementation initiative. The first phase provided view-only capabilities to healthcare providers, allowing them to electronically access results from laboratory tests and other procedures, like X-rays and CT-scans. Phase II brought on the first set of interactive-use applications, enabling clinicians to document patient care information electronically, instead of on paper- the set of functionalities in this phase included the medication administration record, patient admissions database and the order management system. Finally, with Phase III, all of the clinician documentation, such as daily patient care assessments, vitals, exception reports, for all non-physician healthcare providers, including nurses, respiratory therapists, social workers, child life specialists, etc., were brought onto the electronic system. Table 2 presents a more detailed view of the different applications that comprise the clinical information system, the functionalities they provide, and principal users of these functionalities throughout the hospital.

My data collection efforts at this organization were focused on the in-patient organization of the hospital, where this system has been implemented. Also, within the in-patient units, I have focused primarily on the non-physician clinician workforce, including nurses, respiratory therapists, unit secretaries, and patient-care technicians, since they were the ones actively using the system and were impacted the most by the technology functionalities in place. I undertook a multi-method approach in this study by combining qualitative and quantitative modes of data collection and analysis. Of these, the quantitative methods were actively used to test my research model, while the qualitative work informed the design of the quantitative study.

Measurement

Table 3 summarizes key variables included in this study and how they were measured. Data on these variables were collected using survey questionnaires sent out to all employees within the units under study.

Independent (Network) Variables: In social networks research, defining the boundary of the social network is one of the first tasks facing the researcher. Since my research model concerns the patterns of social interactions within each patient-care unit at this hospital that contribute to the unit's adaptability to IT-enabled change, therefore, each unit provided a natural boundary for each knowledge demand and knowledge supply network considered in this study.

Separate name generator questions were asked to capture the knowledge demand and knowledge supply networks. In order to measure the strength of each reported interaction, I followed each name generator question with a name interpreter question that asked respondents to indicate on a scale from 1 (Rarely) to 7 (Often), "how often they interacted with each person on the list" for the purpose asked in each question.

Control (Non-network) Variables: My research model focuses on patterns of social interactions associated with adaptability to IT-enabled change. In choosing control variables for the study, I made a comprehensive effort to consider all major non-relational factors that are known, from prior literature, to also impact adaptability to IT-enabled change. The set of non-network variables included as controls in this study were selected after consulting multiple relevant literature domains, such as technology acceptance (e.g., Venkatesh et al., 2003), IS implementation and total quality management (e.g., Wixom & Watson, 2001), control variables used in the network literature on technology change (e.g., Burkhardt & Brass, 1990), and management/organizational studies (e.g., Edmondson, 1999). All items measuring control variables included in the survey were either taken directly from empirical studies in one or more of these literature streams, or were modified versions of these existing items.

<u>Data Collection</u>

Data collection for the independent and control variables in this study was conducted via a socio-metric questionnaire that was administered to the entire population of in-patient units (including general care and intensive care units) within this hospital. This comprised a total of 27 units, representing 1167 employees. Data collected from each unit represented a minimum of 80% response rate for that unit, as is a general rule-of-thumb requirement for conducting whole network analysis with this data.

In this sub-section, I will describe in detail the methods that I used to collect data on the independent and control variables in this study, breaking up the discussion into pre- and post-data collection work.

<u>Pre-data collection work- survey preparation and testing, pre-launch activities at field-site:</u>

Validity & Reliability Testing: The Process

As far as possible, measures for each construct in my research model, including network and non-network variables, were obtained from instruments that were already validated in related literature. In order to maintain a priori validity in choosing these measures, I also conducted in-depth theoretical analysis of the research literature including discussions with academic experts in order to ensure completeness and appropriateness of chosen constructs as well as their measures. The chosen measurement items were then subject to intense validity and reliability testing in the specific context of my study. This is in accordance with methodological guidelines in the literature, which state that the validity of an instrument is only relevant to the particular context or study in which it is used. When the same instrument is used in a different study or research context, its validity needs to be re-established in the new context.

Pre-launch testing of the survey was conducted in three phases. Phase I involved content validity testing. In this phase, experts from academia (who knew the theoretical area of study) as well as from practice (who knew the empirical context of study) were carefully selected to participate in systematic examination of content validity of the chosen items. A group of four academic experts and four experts from practice were selected for Phase I. In Phase II, wording and layout of the questions was tested. Additional content related issues identified in these stages were also taken into account. I interviewed another set of seven people, as part of Phase II testing, in order to review the questionnaire with them, requesting them to focus on wording and layout of the questions and of the associated instructions provided in the survey for answering these questions. Their suggestions led to further modifications to the survey document. Finally, in Phase III, construct validity testing and reliability testing were conducted. I collected data by asking a random sample of 47 respondents from my field site to take the survey in a pre-test. I then conducted several statistical tests on the pre-test data in order to assess the reliability of the items as well as various aspects of the instrument's validity, including construct validity. Many of the people participating in Phase III pre-testing also provided additional insights on layout, survey length, etc., which contributed to significant revisions in the final survey. I incorporated the feedback from each phase of testing before moving to the next phase. All people participating in any phase of validity testing were excluded from the final sample. Details of the methods from each phase of validity testing are discussed next.

Phase I: Content Validity

In this phase, I wanted to test for the following: a) if the operationalization of each variable fitted its conceptual definition, b) if the items were clearly worded, c) if I had sampled the domain of the variable appropriately; this included ensuring comprehensiveness as well as appropriateness of the items chosen to measure each variable, and d) if the overall direction of the hypothesized relationship between the control variable and my dependent variable, based on how they had been defined in the study, made conceptual sense.

Each expert chosen for phase I testing was provided with a deck of PowerPoint slides, which began by briefly stating the research purpose of the overall study, including the definition of my dependent variable, 'adaptability to IT-enabled change', and where the survey questionnaire fit within this "big picture". Then, the purpose of the pre-testing round- in other words, what they needed to do- was explicitly stated to the content experts. Finally, for each variable included in the survey questionnaire, the following information was provided sequentially: a) the conceptual definition of the variable, b) each item used to measure the variable, including the top-level instructions for answering that item (one per slide), c) the overall hypothesized direction of the relationship between this variable and the dependent variable. Finally, in the case of some variables, I had conceptual questions of my own about whether I was sampling the domain appropriately, or if other sets of items would be better suited to my purpose, or if two variables were conceptually distinct, etc. I included these questions at the end of the sub-sections for the appropriate variables in order to seek insights from content experts about these questions as well.

Two evaluation scales were used to capture feedback from content experts in a consistent manner - these evaluation scales were also given to each respondent as separate documents in addition to the PowerPoint slide-deck. For each item, respondents were asked to rate, on a scale from 1 (not relevant) to 4 (highly relevant), the extent to which they thought the item was a relevant measure of the corresponding variable, given the provided conceptual definition of the variable. Content validity experts were also provided with a second evaluation scale, where they indicated whether they agreed with the proposed direction of each hypothesis linking each of the variables to the dependent variable of the study- they provided this feedback on a scale of “yes”, “no” or “undecided”. Using these scales ensured comprehensiveness and comparability of feedback received from multiple content experts.

In addition to this systematic feedback, content experts were asked to write-in any revisions to the wording of the items, or to suggest any re-statements of the items, as well as to comment on any other aspects of the survey content provided to them. They were also encouraged to suggest any items that I may have missed, but which they thought would be important to fully measure the variable in question. In providing this feedback, they were asked to stick to the conceptual definition of the variable that was provided to them. However, if they did come across situations where the conceptual definition of a variable did not make sense, given how it was labeled, they were encouraged to point these out, and recommend any changes.

All content experts returned the entire stack of materials provided to them, filling out the two evaluation scales as requested and also “scribbling-in” additional comments and notes on the PowerPoint slides themselves, as needed. I also conducted several face-to-face meetings with many of the content experts to engage in semi-structured discussions of the feedback they had provided via the structured evaluation scales. These interviews lasted between one to several hours and for some experts involved multiple sittings.

Following methodological guidelines for testing content validity, I analyzed the feedback from the evaluation scales as follows: I used the item evaluation scores to construct the “Content Validity Index” (CVI), where items that were rated below a 3 or 4 by the majority of experts were re-evaluated, through follow-up face-to-face meetings, and if needed were dropped, replaced or re-worded, as suggested by experts. I used caution in dropping items based on this feedback, given that I was still in the early stages of my validity testing, and decided to retain some of these items, at least for the time-being, in order to subject them to further feedback and statistical testing. In addition, other qualitative feedback was also considered and incorporated as appropriate.

Phase II: Wording, layout, etc. of survey questionnaire

After incorporating the feedback from Phase I content validity testing, I sent the revised survey questionnaire document to a different set of respondents, requesting them to carefully read through the document and provide feedback on the wording, layout and any other aspects of the questionnaire. I sent each Phase II test-taker a set of open-ended questions as a guideline for reviewing the questionnaire document and in order to maintain comparability in feedback received from multiple testers. After giving them a few days to review the documents, I then met with testers in Phase II via face-to-face interviews, to discuss their feedback. More changes were made to the document based on this feedback, although the nature of these changes were more cosmetic at this point, concerning layout, readability, typographical and other such errors; most of the substantive content changes had already been made following Phase I pre-testing.

Phase III: statistical tests on construct validity and reliability

Finally, in Phase III of the testing process, 47 randomly chosen respondents from all over my field-site organization were asked to fill out the survey as a test. They were also encouraged to keep note of how long it took them to complete the survey and also to put down any comments, questions or concerns they may have with any aspect of the survey as they were filling it out. In addition to the data collected in this pre-testing phase, I also received qualitative information from testers about their survey-taking experience.

The data obtained from Phase III pre-testing were used to test for validity and reliability of items. Cronbach’s Alpha values ranged from 0.62 to 0.82 (reported in Table 4), indicating acceptable reliability levels close to the cut-off Alpha value of 0.70, which is considered appropriate for social science data.

Finally, following this multi-phase validity testing, I interviewed several test respondents intensively, to ask for additional feedback on the survey questionnaire. I asked them the following questions in these follow-up interviews: a) explain to me in your own words, what each of the network questions was asking you to do, b) did you enter all the names you wanted to enter in response to the network questions, or did you feel like you could have written more? If you felt that you could have written more names, why didn't you? Additionally, I also informed testers of the theoretical logic underlying the network questions in the survey questionnaire, and obtained feedback on whether the questions made sense or needed to be re-worded, given their theoretical purpose.

In addition to this formal validity testing process, I also made numerous attempts at making the wording clear and getting feedback on layout and instructions in the survey, per the recommendation of methodological literature pertaining to network as well as non-network research.

Validity Considerations: Network Data

A number of steps were taken to ensure the validity of the network data collected in this questionnaire. One issue that was discussed during instrument development and pre-testing was whether the socio-metric questions in the questionnaire would be presented via roster method or free recall method. Network researchers have used one, the other or a combination of both methods to collect network data, each with its own advantages and drawbacks. The roster method is where respondents are provided the entire list of names of all the people that are in the network, and are asked to answer the question for each person in the list provided. This method is more likely to yield whole network data (including data on weak ties) without the risk that the respondent may have forgotten to mention the names of some pertinent people in the network, or may have gotten tired of writing names in response to the question. Despite its advantages, the roster method could be cognitively demanding on respondents, since they are required to answer every network question for the entire list of people, many of whom may even be irrelevant for a particular question. As such, this method becomes infeasible to follow with networks of large size. In such cases, the free recall approach is more suitable. Here, respondents are not given a preformed list of names from which to choose, but are asked to write-in the names of all the people that are applicable in response to a particular question. Although cognitively less demanding, one of the limitations of this approach is that people are likely to forget to write down the names of those with whom they only have weak interactions- weak tie data is said to be under-represented in network data collected via the free recall method.

In my study, the typical networks ranged between 30 and 120 people, which are too large to be able to follow the roster method. However, in order to reduce the potential validity issues that could arise when people are trying to remember names from memory, I did not follow the free recall method either. Instead, I have followed the aided recall method as an in-between approach to the above two options. In this method, respondents are not provided with a full list of all people in the network, like in the roster method, nor are they asked to respond entirely from memory either, as in the free recall method. Instead, respondents are provided a ‘reference list’ that contains the names of everyone with whom they are likely to interact. In response to each question, then, respondents are asked to write down the names of everyone that they believe is pertinent to the question using the reference list to help them remember names and to ensure completeness of their response. The advantage of this method is that it reduces the cognitive load on the respondent, particularly given the large size of the networks of interest in this study. This also helps with response rates, which need to be very high in network data analysis, and can be especially challenging for large networks. At the same time, this method also ensures completeness of the data by providing a list of all the names within the patient care unit to which the respondent belongs, as well as the names of other people beyond their units, with whom the respondent may be likely to interact. Moreover, the list is provided only for reference and does not restrain the response choices available to the respondent- as such, researcher bias in defining network boundaries, at least at the point of data collection, is minimal.

I undertook several precautions to ensure that the completeness and validity of responses to network questions was not compromised due to the use of the aided recall approach. First, the reference list was specifically constructed for each unit, based on my best knowledge of the people that respondents within the unit are most likely to interact with. I chose not to construct a single Master List for all units that listed all of nearly 2000 people who worked in the various inpatient units at this hospital. This would have been a very large list, continuing over several pages, and would have likely defeated the purpose of following an aided recall approach, creating similar cognitive demand issues for the respondent, as the roster method. In order to avoid researcher-imposed bias in the unit-specific reference lists, and to construct meaningful and comprehensive lists, I conducted in-depth face-to-face interviews with the leadership of every unit that participated in this study. During these interviews, which lasted for about an hour to hour-and-a-half, I asked interviewees to tell me more about their unit, the work that they do, how they are organized. I also asked them to tell me which other units, groups or individuals people in their unit are likely to typically interact with throughout their day. I then asked them to provide me with the latest updated employee roster for their unit. The reference lists for each unit were put together in light of all this information taken together. Also, in the overall section-level instructions in the questionnaire, I specifically urged people to write all names, and told them how important completeness and accuracy of responses was. Per the recommendation of network methods scholars (Marsden, 1990), I did not restrict the number of alters that the respondents were asked to enter. I also left enough space for as many names as people wished to write, so they did not subconsciously get any cues to the contrary from the amount of space that I had left for them to write in responses. All this together, was expected to help me get all ties, not just strong ones. This was corroborated in the results of the pre-tests and the final survey as well, where respondents would indicate contacts with whom they only interacted "rarely" or "sometimes", just as they would indicate the people with whom they interacted "often". Finally, post-survey validity-testing interviews further confirmed the completeness of the networks reported by survey respondents.

Among other considerations, in keeping with literature on network methodology and survey design, network questions in the survey ask about actual exchanges that respondents engage in, rather than asking about the role relationships or affect-based links that people have with each other. Studies on network research methodology have found that people are able to report actual exchanges with the most accuracy, and may be less accurate in their ability to report affect-based interactions with others. Also, in questions pertaining to actual exchanges, respondents are asked about what they currently do rather than what they would do in various situations. According to the methodological literature (Marsden, 1990), questions worded in terms of what people *would do* in different situations may not generate responses about ties that currently exist; instead, it could prompt people to talk about what they would do in the future or in an ideal state.

The network questions in the survey are worded so as to ask respondents about the typical or more likely exchanges that they "tend to" engage in, on average, rather than about their interactions at a particular point in time. The questions urge respondents to think about their day-to-day use of the technology and who they "tend to" interact with. This helps to overcome limitations to the validity of network survey data which arise when respondents report the interactions that they happened to have at a certain point in time, for example, who they spoke with that day or week. Such reports may be idiosyncratic and not truly representative of the stable patterns of interactions that persist among people, regardless of whether or not those people happened to have spoken with each other on a particular day.

Finally, a distinction of network data is that the respondent needs to be uniquely identifiable in some way in order to be able to construct the network from the cumulative responses. Asking people to write their names in the survey, however, would be too burdensome and may cause people to hesitate to complete the survey at all or answer cautiously. To avoid such validity issues, the surveys are kept anonymous, but a unique ID number is used on each survey. The same ID number also appears on the corresponding consent form, which is signed by the respondent and maintained separately from the survey once it is returned, to protect the confidentiality of the respondent.

Other pre-launch preparations

Knowing that this would be a major data collection effort, I followed a systematic multi-step process for spreading the word about the survey in order to ensure maximum response rates. I began by obtaining permission to conduct the survey from senior leadership, at the vice-president and director-level, in my field organization. After getting the survey approved, I contacted the Directors overseeing the four broad areas into which the entire inpatient area (my area of focus) at the hospital was organized: The critical care area and the general patient care area at campus 1 and at campus 2. I explained to them my research needs, the fact that the survey has received the approval of top leaders at the organization, and also explained the very high response rate needs as one of the constraining factors for this study. The directors, who were very receptive to the study, introduced me and my research needs to their leadership team in various staff meetings. The leadership team included the managers, assistant managers and other members of the leadership team within each unit comprising the given inpatient area of the hospital. I prepared a brief PowerPoint presentation in order to introduce my research study, how it might be of value to them and what I would need from them in terms of support for data collection, explaining again, my need for high response rates in order to perform the network analyses. After gaining the support of the managers and assistant managers in this manner, I then attended as many staff meetings across the different units in the hospital as I could to then be introduced to as many staff-level people in the organization as I could before the study. The leadership team within each unit helped to introduce me to everyone and request for their cooperation and participation in the study.

I also sent flyers advertising my survey as well as another flyer containing a brief “bio” about myself to the leadership teams on the different units, who posted these flyers all over their units- bathroom walls, notice boards in staff lounges, nurses’ stations- and included them in the weekly newsletters in order to give as many people as possible enough chance to be aware of the survey before it was launched.

Following this survey development and pre-testing work, I then administered the survey at my field-site.

<u>Post-data collection work: Post-collection validity checks</u>

Following data collection, I conducted several interviews with randomly chosen respondents from my field site as part of post-survey validity testing. During these interviews, I asked the respondents: a) could they have entered other names in response to the network questions, b) looking back, are the names they entered what they wanted to enter? c) what did they think the questions were asking?, d) did they encounter difficulty understanding any of the questions in the survey? The feedback I received indicated that, in general, people were comfortable answering all the questions in the survey. They also confirmed the completeness and accuracy of their network responses during these post-survey interviews.

I also spoke to a few randomly selected non-respondents to ask them why they chose not to participate. The most common responses were lack of time, or losing track of the end-date of the survey period. As such, no systematic difference between the respondent versus non-respondent pool could be detected.

Once collected, data from the paper-based surveys were entered into Excel as a prelude to analysis. A separate column was created on the Excel spreadsheet for each question asked in the survey. I created a set of instructions for how the data were to be entered, including how missing data were to be reported on the spreadsheet. Using this set of instructions, I coached a set of student research assistants to enter the data, encouraging them to keep track of any questions, comments or notes they came across during data entry. I kept track of data entry work and these ongoing questions and comments throughout the data entry period.

CHAPTER 5: Analysis & Results

Treatment of Data

Dependent variable: Square root transformations of both measures were taken in order to bring the values of the dependent variable measures on the same scale as the values for other independent and control variables in the model.

Independent variables: Responses to the network questions in the survey were loaded onto UCINET 6.191 (Borgatti, Everett, et. al., 2002) in the form of unit-level matrices. In this way, I had 27 knowledge demand networks and 27 knowledge supply networks, one for each unit included in the study. Membership within the unit provided natural boundaries for each network, with each respondent belonging to only one unit. The networks are valued and directed. The values on each tie indicate the frequency of that particular interaction. The direction of ties in the knowledge demand networks is from the knowledge seeker to the provider, in order to capture the directionality of knowledge demand. The direction of ties in the knowledge supply networks is from the voluntary knowledge provider to the knowledge recipient, in order to capture the directionality of knowledge supply. From these matrices, different characteristics of network structure, as discussed in the research model section, were calculated using the functionalities available in UCINET 6.191. These network structural characteristics were used as independent variables in the analysis.

Control variables: Control variables consisted of non-network data collected on a 7-point Likert scale anchored by "strongly disagree" (1) to "strongly agree" (7). For each variable, some items had been reverse-coded in the survey questionnaire. My first step in the data analysis was to reverse code the responses on these items for use in the analysis.

Averages of individual-level responses were then used to construct unit-level measures for the control variables.

A correlation table, along with descriptive statistics, for all variables is shown in Table 7.

Model Specification

Multiple regression models were used to analyze the data. My first consideration was to use ordinary least squares (OLS) estimation method. To test for the appropriateness of using OLS estimation, I conducted the following checks to see if my data satisfied the standard assumptions underlying OLS regression.

First, OLS estimation is based on the assumption that error terms in the model are normally distributed. This assumption was tested by using the Kolmogorov-Smirnov test, or K-S test. This is a goodness of fit test, which compares the empirical distribution function with the normal distribution function. Significant difference suggests that the data are not normally distributed. Error terms related to both the TOV and TMA models were normally distributed.

Normally distributed errors must also be independent and identically distributed (homoskedastic)- this is another assumption underlying OLS estimation. Independence or non-autocorrelation of error terms was tested using the Durbin-Watson statistic, which tests for the presence of autocorrelation in the error terms in a regression analysis. The values of this statistic in the regression models were greater than 2, which is above the rule-of-thumb value for the presence of autocorrelation.

Also, plots of standardized residuals versus fitted values for both OLS regression models did not suggest the presence of heteroskedasticity. I also checked the bivariate plots of the dependent variables versus each of the independent variables. Telling signs of heteroskedasticity would have been any “funneling effect” (or other diverging shapes) in the distribution of the actual data points about the OLS regression line. However, examination of these plots suggested that heteroskedasticity is not likely to be a problem in my dataset.

Linearity (in the parameters) of the relationship between the dependent and independent variables is another assumption of OLS estimation. This was checked by examining scatter plots of the dependent variables against each of the independent variables. Plots of the predicted values against residuals were also checked. These plots did not show any evidence of non-linearity between the dependent and independent variables.

Finally, the regression models were tested for the presence of multicollinearity. Although independent variables in almost any model are correlated to each other to some extent, very high correlations cause the variables to be highly collinear, leading to problems of multicollinearity. This would violate OLS assumptions, leading to unreasonable coefficient estimates and large standard errors. The correlation table for all variables in my model (Table 7) indicated that the binary correlations between some of the independent variables were high. In order to check if these or other correlations presented significant multicollinearity problems in the data analysis, I applied three tests to the results from my regression models. First, I checked the Variance Inflation Factors (VIF) values for all variables in my model- the largest VIF was much less than 10. Second, I checked the tolerance levels for all variables in my model- the smallest tolerance was greater than 0.1. Finally, the average of VIFs for all the variables in my model was reasonably close to 1. These three tests taken together confirmed that multicollinearity was not a problem in these models.

Having performed all necessary diagnostics, I proceeded to analyze the data using these regression models.

Results

Tables 5 and 6 present the results of the TOV and TMA regressions. For each measure of the DV, I ran separate models sequentially. First, I ran the control only model, which I used to interpret the effects of control variables. Then, I ran a model including the control variables plus the knowledge demand network variables. Separately, a model including the control variables plus the knowledge supply network variables was also run. Finally, I ran the combined model, where I first started with the controls and KDN variables, and sequentially added the KSN variables, leading ultimately to the full model with all control, KDN and KSN variables.

Only in the fully combined models (KDN plus KSN), the KDN Density and KSN Density variables were highly correlated. In order to overcome multicollinearity issues arising out of this problem, I replaced the KDN Density and KSN Density variables with a new variable KDNKSNDensity, which is the average (i.e., a linear transformation) of the KDN Density and KSN Density variables. This transformation took care of the multicollinearity problem in the full model, while allowing me to capture the contribution of network density on adaptability in presence of the combined KSN and KDN variables.

Three out of four control variables were significant in the TOV regression model and two were significant in the TMA regression model. Psychological Safety and

Facilitating Conditions were found to have significant positive effect on adaptability to IT-enabled change, as expected from prior studies. For social influence, prior studies have shown varied results. In this dataset, my expectation of significant negative effect of social influence on adaptability is found to hold, suggesting that employees in healthcare organizations (respondents in my survey) are high self-monitors, who are negatively affected by social influence. This is not surprising, since strong influence from different parts of the organization may add to the stress of adapting to a new system, particularly in high demand work environments. Also, people exerting this influence in the hospital are typically not the ones who are actually using the system and struggling with the changes it is introducing in patient-care work. This creates ill-feeling and a sense that the demands being placed on people by influencers in the organization are unreasonable, which could hurt adaptability. For these reasons, the significant negative effect of social influence on adaptability to IT-enabled change in this dataset is not surprising.

Self-efficacy is the only control variable that did not show significant effects in either model. Self-efficacy is an individual level construct, measuring the computer proficiencies of people within each unit. This suggests that with other factors like facilitating conditions and psychological safety at play, average self-efficacy is not a significant predictor of unit-level adaptability to IT-enabled change. This also suggests that although self-efficacy may be an important factor driving individual level technology use, its impact is insignificant when it comes to adaptability of the unit as a whole to IT-enabled change. This finding with self-efficacy suggests that individual level studies could be recast at the unit-level in order to generate more insights.

Having interpreted the control variables, I proceeded to interpret results from the independent variables. As shown in Table 8, which summarizes the findings from this study, four out of the six hypotheses in my research model were supported when the TOV measure of adaptability to IT-enabled change was used. When the TMA measure was used, however, two of these four hypotheses were significant. The lack of support for larger numbers of hypotheses in the TMA model could be because this model, in general, shows weaker results throughout, including for control variables, in comparison to the TOV model.

Density of knowledge demand networks as well as of knowledge supply networks was significant and positively related to both measures of adaptability. Hypothesis 2 and Hypothesis 5 are supported.

Average incloseness centrality of the knowledge demand networks had a significant negative impact on adaptability to IT-enabled change. In preliminary analyses, the average incloseness centrality variable was highly correlated with other variables in the model, leading to multicollinearity problems. In order to overcome this problem, this variable was transformed by taking its inverse function, when the multicollinearity problem was resolved. Due to this transformation, the directionality of the effect of the KDN average incloseness centrality measure should be interpreted as the opposite of the sign on its coefficient. Thus, Table 5 shows that average incloseness centrality of the KDN has a significant negative effect on adaptability to IT-enabled change. Hypothesis 1 is supported in the TOV model.

Average eigenvector centrality of KSNs also produced significant positive effect on adaptability in the TOV model, but not in the TMA model. Hypothesis 4 is therefore supported, at least in the TOV model.

Hypothesis 3 (KDN distance-based cohesion) was partially supported in my empirical analysis, showing an effect in the negative direction. This implies that mechanisms relating to situated learning predominate in the context of adapting to IT-enabled change in this organization. Interestingly, however, the significance of the KDN distance-based cohesion coefficient is very weak in my analysis, and is visible only in partial models. This suggests that perhaps both mechanisms are simultaneously operative in the data, with one mechanism pulling the impact of this variable on adaptability in the positive direction and the other pulling it in the negative direction, so that the overall effect is only slightly significant in the negative direction.

Distance-based cohesion in the KSN (Hypothesis 6) was found to be insignificant in both models. In my hypothesis, I had theorized that longer distances (i.e., lower cohesiveness) in the knowledge supply network would be beneficial for adaptation, since longer distances between recipients and knowledge providers would increase the reach of the knowledge that was being supplied by the providers. I had further argued that positive effect on adaptability was to be expected in the case of providers more distally connected to the recipient in the KSN in part due to the intermediaries connecting them, who were relatively more proximal to the recipient's context. These intermediaries, who were familiar with the context of the recipient's work, were expected to be able to translate the novel knowledge supplied by the distal provider into a more meaningful and contextualized format relevant to the recipient's work context. The ability to do so was expected to overcome the recipient's inhibitions to accepting knowledge from the distally connected source, in turn, allowing the recipient to benefit from the novelty of this knowledge. Lack of support for this hypothesis suggests, however, that this mechanism is either not occurring or is weak in this dataset. This could occur for several reasons. For example, the intermediaries between the knowledge provider and recipient may be unable to fulfill the role of translators of knowledge. Alternatively, given that the effect of density of KSN ties is so prominent in this dataset, it may be that when it comes to accepting knowledge that is voluntarily supplied to them, direct tie mechanisms of knowledge supply are the most important.

Table 8 summarizes the key findings from hypothesis testing.

CHAPTER 6: Discussion & Conclusion

In this section, I will discuss the findings from my research study, the limitations of this study and possible future research directions.

This study examines the impact of social structures within patient-care units on variations in the units' adaptability to IT-enabled change. Answers to such questions have important implications for many research areas within the domain of Information Systems and Management, including IT use and assimilation, IT adoption, social networks and organizational change. Social networks were used to systematically examine the characteristics of social structure within each unit that were relevant to adaptability. I focused on social structures of knowledge sharing as antecedents to adaptability. Since the exchange of help and insights is essential to adapting, therefore, social structures underlying such exchange would be relevant for adaptability. In considering knowledge sharing networks, I have taken the less well-studied perspective of the knowledge recipient. From the vantage point of the knowledge recipient, two kinds of networks- knowledge demand networks and knowledge supply networks- were hypothesized to be important for adaptability. The tradeoff between access to knowledge versus motivation to accept knowledge in KDN and KSN provided the basis for theorizing about the relationships between structural characteristics of these networks and unit-level variations in adaptability. I have examined the structural characteristics of each of these networks within each unit as antecedents to adaptability. The empirical study was conducted in a large hospital implementing electronic medical records and associated decision support technologies in a phased manner.

Empirical findings from this study support most, though not all, hypotheses. With respect to knowledge demand networks, results support the hypotheses that lower average incloseness centrality and higher network density are positively related to adaptability. With respect to knowledge supply networks, results support the hypotheses that higher average eigenvector centrality and higher network density are positively related to adaptability. The hypothesis claiming negative effect of KDN cohesion on adaptability was supported only as long as network density was not included as one of the independent variables in the empirical analysis- in other words, the negative effect of KDN cohesion on adaptability was only partially supported. The hypotheses stating positive effect of KDN cohesion on adaptability (since this hypothesis had been included in both its variant forms) and negative effect of KSN cohesion on adaptability were not supported in empirical analysis.

Contributions to multiple literature domains

A common gap that had been identified in the social networks literature as well as in the change management literature was that relational factors had remained relatively underexplored in the study of adaptability. In the social networks literature, this gap exists because little attention has been paid to adaptability as a dependent variable of interest. In the change management literature, although studies have focused on adaptability as the dependent variable, they have not systematically examined the role of patterns of relationships as drivers of adaptability, focusing instead on non-relational factors (for example, characteristics of individuals) as antecedents. This study addresses this gap by identifying specific characteristics of social structures of knowledge sharing that are relevant to adaptability. Findings from my study suggest that even after commonly understood non-relational factors characterizing the unit are held constant, there is something about the specific pattern of relationships within the unit that is related to its extent of adaptability. Moreover, the specific characteristics of these relational patterns that are relevant to adaptability vary depending on the type of relationships considered. Thus, relevant structural patterns that are significant antecedents to adaptability could vary depending on whether the structure embodies knowledge demand networks versus knowledge supply networks. Findings from this study therefore suggest the importance of relational as well as non-relational characteristics in driving adaptability. This contributes to social network research by identifying an additional organizational phenomenon on which social networks have an influence. It contributes to the change management literature by identifying additional sets of factors (relational characteristics) that explain more of the variance in unit-level adaptability than could be explained by previously known (non-relational) factors.

Although adaptability to IT-enabled change has not been studied in the social networks literature, related concepts such as technological change have been studied in this literature. Indeed, the relationship between IT and social structure has been examined in some well-known works within organizational studies (e.g., Barley, 1990) and social networks research (e.g., Burkhardt & Brass, 1990). However, these studies have focused on understanding the impact of IT on social structure. In contrast, the impact of social structure on the ability to assimilate IT has remained relatively less well-explored. This is another gap in extant literature that has been addressed in the present study, where specific characteristics of social structure relating to knowledge exchange are explicitly investigated in the context of adaptability. The dependent variable in this study measures the assimilation of IT in terms of assimilation of IT-enabled changes in work processes. The assimilation of these IT-enabled work process changes is in turn indicated by the accomplishment of certain IT-enabled goals from these work processes that are possible only after the changes have been assimilated. The findings from this study reveal the relationship between specific characteristics of social structure and the extent of accomplishment of IT-enabled goals from work processes. This brings to light the impact of these social structures on the ability of units to assimilate IT-enabled changes in work processes, which is defined in this study as the unit's adaptability to IT-enabled change. In this way, the findings from this study complement the works of such researchers as Barley (1990) and Burkhardt & Brass (1990) to expand our understanding of the interrelationship between social structure and IT.

The focus on unit-level adaptability in this study addresses another gap in the change management and IT acceptance literatures, where many studies have focused on understanding individual-level adaptability and related constructs at the individual-level, such as IT use. Results from this study show that factors like self-efficacy, commonly studied as antecedents to individual-level IT use, are not significant when it comes to unit-level adaptability to IT-enabled change. This suggests that other findings from this study regarding antecedents of unit-level adaptability may also provide unique insights beyond what was previously known about adaptability from individual-level studies.

Much of existing literature on technology acceptance (e.g., Venkatesh, et al., 2003) has taken an atomistic view towards IT use, viewing use as the individuals' interaction with the technology. By focusing on adaptability to IT-enabled change, this study relates to the IT acceptance and use literature but also extends beyond it by considering the individual's use of the technology, not in isolation, but as one part of the broader process changes enabled by the technology. Findings from this study relate not only to the assimilation of the technology, but to the assimilation of the work process changes that the technology enables. In taking this focus, my study relates not only to IT success but also to IT-business success, which is of increasing importance to the IS literature.

This study also relates to group-level research on IS implementation that has identified group resistance as an antecedent to adaptability. Group resistance has received much attention as a key driver of IS implementation (Lapointe & Rivard, 2005, 2007). My study shows that resistance may not necessarily be the cause of poor implementation of the technology at the group level, and that non-resisting groups may also face adaptability problems if the social structures through which they interact do not allow effective knowledge sharing relating to the IT-enabled change effort. The social structural factors that I identify in this study do not necessarily deal with resistance behaviors towards the technology, but are associated with other challenges that arise in sharing knowledge and insights relating to the implementation. Even in the case of the knowledge supply network, where motivation to accept knowledge is the key driving factor, the issue is not one of resisting the technology, but rather of uncertainties and difficulties associated with accepting unsolicited knowledge about the change effort in the process of adapting.

The overall results from this study also provide other interesting insights. The results show similarities as well as differences in the structural characteristics of KDN versus KSN that are related to adaptability. This suggests that these are indeed distinct social structures with different implications for organizational outcomes. For example, network density of both KDN and KSN are beneficial for adaptability to IT-enabled change. However, while average incloseness centrality is important in KDN, average eigenvector centrality is important in KSN in terms of their relationships to adaptability (KSN average incloseness centrality and KDN average eigenvector centrality, were tested and did not show an effect on adaptability; not reported here). These distinctions between the two networks in the context of adaptability to IT-enabled change indicate the value of taking a directional approach towards knowledge sharing in the context of other organizational outcomes as well.

My results also suggest that prominence or centrality in a unit's informal network of connections could be a mixed blessing. Being central in the KSN due to connections to other well-connected people (high eigenvector centrality) allows individuals in the network to obtain timely access to quality knowledge, strong reputation and higher power. Such individuals would therefore be able to receive more and better knowledge, from their well-connected resources in the knowledge supply network, which they could then share with others in this network. However, such individuals are also more likely to be approached by a lot of people in the knowledge demand network for help and advice (high incloseness centrality). It is likely then, that although such individuals may have timely access to high quality information, they may not have as much time to voluntarily share these insights with others, being overburdened by other responsibilities.

Limitations of the study

With 27 cases, the sample size for this study is relatively small. However, this study is conducted at the unit level of analysis. In order to ensure consistency of macro-social factors across all units, a single organization was chosen, and all patient-care units within this organization were studied. As such, the 27 units represent the population of all relevant units within the organization that are currently adapting to IT-enabled change. Moreover, the units in my study range in size from 30 to 120 employees, and have their own internal leadership structure, cost centers, etc. They are therefore mini-organizations within a large organization, rather than teams. In extant work, group-level research has largely been done using data from teams, and various conventions have arisen on acceptable sample sizes in team-level social network research. However, it is very rare to have this kind of data across organizations at the network level, as in my dataset. I have been fortunate to be able to collect data from the entire population of units at this organization- indeed, the 27 units represent close to 1200 people that work in them. This uniqueness of the dataset is likely to be able to generate new insights about how organizations, particularly organizational networks, work.

Interestingly, despite the size, I was able to obtain significant results for many hypotheses in my data analysis, suggesting that the effects that I have modeled theoretically and statistically in this study do exist in the real world.

In conducting this unit level study, I have focused on units within a single organization. A potential drawback of this research design could arise from the limits to generalizability of the results of this study to other organizations. In order to safeguard the study from such limitations, I took care in the research design to select an organization that is fairly typical among the larger body of healthcare organizations. As a large urban hospital, my field-site is quite similar to a number of other large urban hospitals. Since this study is at the level of units within an organization, the choice of a single organization was viewed as a strength of the research design, which allowed me to control for common macro-social and environmental factors that could affect the ability of the units to adapt. Having controlled for these factors, I could then focus my research on the micro-social dynamics within each unit, showing how variations in micro-social factors across units were related to variations in the units' adaptability to IT-enabled change.

Future Directions

A number of promising research directions might be explored in the future. In this study, I have looked at knowledge demand and knowledge supply networks separately. Future research could investigate the interaction between KDN and KSN, exploring how variations in these interactions affect adaptability to IT-enabled change and other organizational phenomena. This line of research would contribute to multiple areas of extant research. The knowledge sharing literature would be one area. Recent work in this area has called for a more nuanced investigation of different aspects of the knowledge sharing relationship. This line of work would also contribute to the social networks literature as well as to research at the intersection of knowledge management and social networks. Studying KDN and KSN in concert provides an opportunity to investigate multiplex relations simultaneously, thereby adding to the existing body of social networks research that has primarily investigated relationships in isolation. Also, although the social network implications of knowledge transfer have been studied in prior literature, more recent nuanced approaches, such as the literature on knowledge sourcing, could benefit from a social network perspective on these concepts.

Multi-level drivers of adaptability to IT-enabled change could be another area for future study. Prior research on adaptability has studied individual-level drivers of adaptability. In this study, I have focused on understanding the factors that are related to adaptability of units as a whole to IT-enabled change. Not surprisingly, this cumulative research has shown that different factors are significant in the context of adaptability at different levels of study. In future work, interactions across different levels could be explored. For example, how does the healthcare unit within which an individual healthcare provider is located impact the ability of the provider to adapt to IT-enabled change? Answers to questions such as these would also impact other areas of core interest to IS research, such as research on technology acceptance. Most work in this area has focused on individual-level use of IT; studies exploring drivers of multi-level IT use could generate interesting insights.

Also, network and non-network characteristics have often been studied separately in terms of their impact on various organizational phenomena, such as adaptability to IT-enabled change. In the future, the interaction effects between relational aspects of social structure and non-relational attributes of people embedded in those social structures could be studied in terms of their impact on organizational outcomes. In addition to contributing to their respective substantive domains, such research would also contribute to social networks research by showing how the impact of network structural characteristics is contingent upon the attributes of individuals occupying these structures.

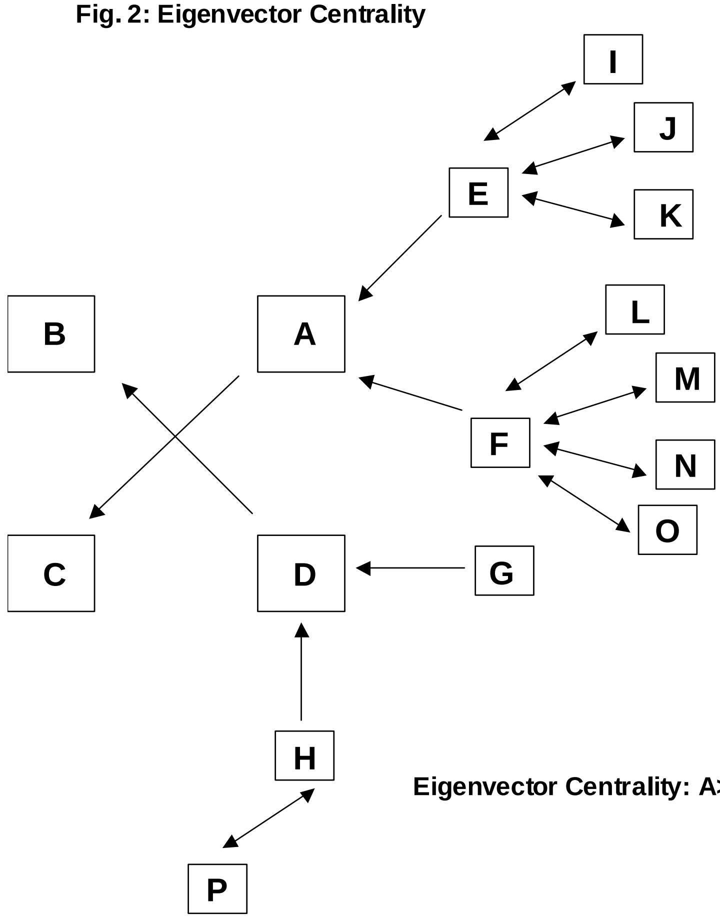
In conclusion, my study finds that social structures of knowledge demand versus supply have distinct impacts on the ability of units within an organization to adapt to IT-enabled change, even when other relevant macro-social factors are held constant. It is hoped that this work would contribute to multiple areas of research within the Information Systems and Management domains, and inspire future work that contributes further to these domains.

Fig. 1: InCloseness Centrality

Lower Average InCloseness Centrality | **Higher Average InCloseness Centrality**

Nodal InCloseness Centrality: B>C | **Nodal InCloseness Centrality: B>D**

Fig. 2: Eigenvector Centrality



Eigenvector Centrality: A>D

Fig. 3: Density

Low **High**

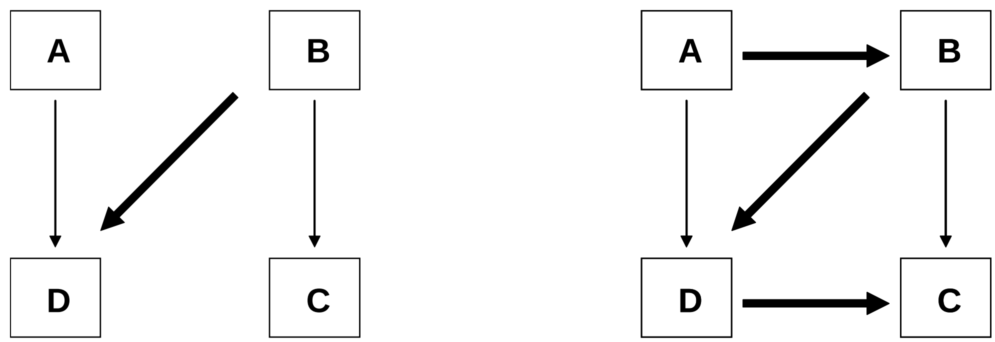
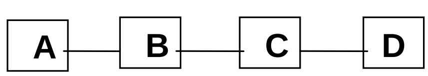


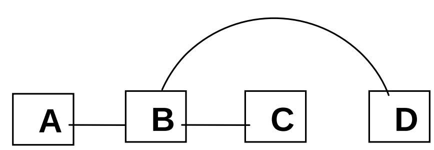
Fig. 4: Distance-based Cohesion

Low



	A	B	C	D	
A		1	2	3	= 6
B	1		1	2	= 4
C	2	1		1	= 4
D	3	2	1		= 6
				Total Distance	20

High



	A	B	C	D	
A		1	2	2	= 5
B	1		1	1	= 3
C	2	1		2	= 5
D	2	1	2		= 5
				Total Distance	18

Fig. 5: Research Model

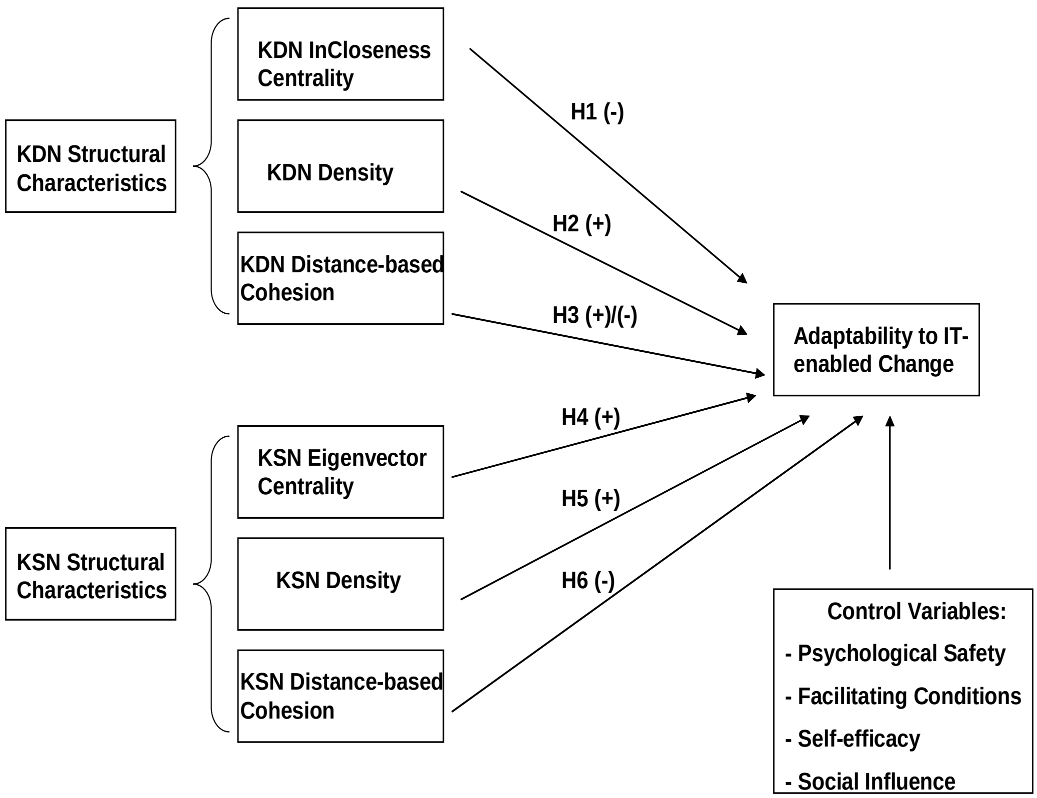


Table 1: Network studies related to technology-based change

Type of network	Characteristics studied	Context of study	References
Interorganizational network, social information sharing	Network size Network homogeneity Tie strength Age of network	How network ties drive adaptation of organizations to change and the social learning of adaptive responses from other organizations in the network	Kraatz, AMJ, 1998
Work-related interactions: Collegial relations Formal, organizational relations	Frequency of interaction	Impact of technology on change via relational and non-relational aspects of work roles	Barley, ASQ, 1990
Workflow Communication Friendship	Node characteristics-supervisor vs. non-supervisor Centrality of network position	Relation between organization structure and individual influence	Brass, ASQ, 1984
Social influence	Network position-cohesion vs. structural influence	Role played by cohesive vs. structurally equivalent network positions in spreading beliefs, attitudes and behavior following technology change	Burkhardt, AMJ, 1994
Job-related communication	Network centrality: closeness, in-degree Power	Longitudinal study of effect of a change in technology on organizational structure and power	Burkhardt and Brass, ASQ, 1990
Interorganizational networks of knowledge transfer	Embedded vs. arm's-length ties, based on social closeness	How networks influence knowledge transfer and learning processes by creating channels for knowledge trade and reducing the risk of learning	Uzzi and Lancaster, MS, 2003

Information networks	Number of network links Small, seemingly insignificant idiosyncracies	Impact of the structure of social networks through which potential adopters find out information about social networks, on the extent of an innovation's diffusion among members of the network. The innovation could be a change, in which case we would be talking about diffusion of change or the extent to which people embrace that change.	Abrahamson and Rosenkopf, OS, 1997
Collaboration networks	Direct ties Indirect ties Structural holes	Longitudinal study of the effect of the structural aspects of inter-firm collaboration networks (from an ego network perspective) on its innovation output. Again, innovation could be one example of change, in which case this would be about the amount of change produced in a firm.	Ahuja, ASQ, 2000
Friendship networks	Strong ties Weak ties Degree of overlap between two ego friendship networks	Investigates the macro-network implications of the strength of dyadic ties in friendship networks. Study has implications for diffusion of influence and information, mobility opportunity, and community organization. The idea of diffusion of information and influence may be relevant in change management situations, where adaptability to change is important.	Granovetter, AJS, 1973

Formal, work-related networks Informal or emergent networks	Centrality Rank of individuals-formal position	Role of individual attributes, formal position and network centrality of involvement in innovations, where the latter indicates exercise of individual power.	Ibarra, AMJ, 1993
Informal networks of knowledge transfer	Social cohesion Network range- ties to different knowledge pools dyadic tie strength	The characteristics of informal networks that impact (ease) knowledge transfer processes.	Reagans and McEvily, ASQ, 2003
Communication networks, networks of social influence	Attitudes of specialized others Attitudes of generalized others Structurally equivalent position Organizational proximity Spatial proximity Communication and work-unit mechanisms	How individuals' attitudes towards an integrated health information ssytem is influenced by the attitudes of proximate sources of social information	Rice and Aydin, ASQ, 1991

Table 2: Overview of Clinical Information System

Phase	System	Description	Key users
I	Results Review	Lab results, X-ray results, CT scans, etc.	Nurses, Respiratory Therapists, Physicians
II	Medication Administration Record	Record of patient medications administered	Nurses, Respiratory Therapists
	Admissions Database	Record of clinical/bio/history information on patient upon admission to the hospital	Nurses; Patient care technicians
	Order Management System	Patient Orders and Department Charge Entry	Unit secretaries, nurses
III	Nursing/Respiratory Therapy Documentation	Assessments, vitals, nursing notes	Nurses, respiratory therapists

<u>**Table 3: Variable Definitions and Measures**</u>

	Variable Name	Variable Type	Definition	Measurement
CONTROL VARIABLES	Psychological Safety	Continuous	A shared belief held by members of a unit that the unit is safe for inter-personal risk-taking.	PS1: Working with members of my unit, my unique skills and talents are valued and utilized. PS2: Members of my unit are able to bring up problems and tough issues relating to the technology. PS3: No one in my unit would deliberately act in a way that undermines my efforts. PS4 (r): If you make a mistake on my unit, it is often held against you. PS5 (r): It is difficult to ask other members of my unit for help.
	Facilitating Conditions	Continuous	The degree to which there exists a shared belief within the unit that adequate resources (human and technical) have been available to support technology-related changes in the unit.	R.FC1: Since after "go-live", members of my unit have enough ongoing resources (for example, sufficient time and ongoing support personnel, like super-users, IS&T, etc.), as well as the knowledge we need, in order to use the technology and adjust to IT-related changes in our work. R.FC2 (r): Much of what we need to do in the system was not adequately covered in the pre-go-live training sessions. R.FC3: The system is compatible with other relevant systems that are in use throughout the hospital. R.FC4 (r): The system does not fit well with certain aspects of our work in my unit. R.FC5: Overall, the training sessions prior to the technology's go-live were well managed and supported, in terms of the resources available to members of my unit during training (for example, enough training classes, adequate staffing, limited or no need for overtime, etc.).
	Self-Efficacy	Continuous	The degree to which an individual feels he/she could competently use computers in the workplace.	R.SE1 (r): Using a computer on my own makes me uncomfortable. R.SE2: If I want to, I can easily operate a computer on my own. R.SE3: I can use a computer even if no one is around to help.

	Social Influence	Continuous	The degree to which there exists a shared perception within a unit that others in the organization, who are important to the unit, support and encourage use of the new system.	R. SI1: People in the hospital who are important to my unit think that we should use the system and adjust to system-related changes. R.SI2: In general, senior leadership at the organization (that is, leaders above the leadership team within my unit) has been helpful and supportive of the use of the technology and of adjusting to technology-related changes to work in my unit. R.SI3: Members of the leadership within my unit (for example, my immediate supervisor, unit manager, educators, department champions, etc.) give us the support and encouragement we need on my unit in order to use the system and adjust to system-related changes in our work. R.SI4 (r): Many of my peers in my unit find that the system wastes time and is not very helpful in their work.
INDEPENDENT VARIABLES	KDN InCloseness Centrality	Continuous	The average value of the incloseness centralities of all nodes in the KDN. Incloseness centrality of a node in the KDN is a measure of the extent to which a number of knowledge seekers are connected to this at relatively short distances.	The inverse of the sum of the geodesic distance of a node to every other node in the network.
	KDN Density	Continuous	Defined as the general level of linkage among the points in a graph, i.e., among knowledge seekers and providers in a KDN	The number of links in a network expressed as a proportion of the maximum possible number of links

	KDN Distance-based Cohesion	Continuous	The extent to which knowledge seekers are located at relatively short distances from potential knowledge providers within the KSN network.	Based on the average distance between pairs of nodes in the network, where distance is measured as the strongest path between a knowledge seeker and provider in the KDN
	KSN Eigenvector Centrality	Continuous	The extent to which a node (knowledge recipient) in a KSN is connected to other nodes (knowledge providers) that are well-connected (i.e., central) in the network is the eigenvector centrality of the (knowledge-recipient) node in the network. Mean eigenvector centrality scores across all nodes is the unit-level measure.	Eigenvector centrality of a knowledge recipient in the KSN is the sum of all nodes (potential knowledge providers) it is connected to, weighted by the centralities of these nodes.
	KSN Density	Continuous	Defined as the general level of linkage among the points in a graph, i.e., among knowledge recipients and providers in a KSN	The number of links in a network expressed as a proportion of the maximum possible number of links
	KSN Distance-based Cohesion	Continuous	The extent to which knowledge providers are located at relatively short distances from potential knowledge recipients within the KSN network.	Based on the average distance between pairs of nodes in the network, where distance is measured as the strongest path between a knowledge provider and a recipient in the KSN
DV	TOV	Continuous	The unit's timeliness of order verification	Actual number of timely orders verified/unit size
	TMA	Continuous	The unit's timeliness of medication administration	Actual number of timely meds administered/unit size

<u>Table 4: Reliability Analysis (Non-network data)</u>

Variable	Cronbach's Alpha
Psychological Safety	0.62
Facilitating Conditions	0.68
Self-efficacy	0.70
Social Influence	0.82

Table 5: OLS Regression Results for TOV

Variables	Model: 1 (Control only)	2 (Controls + KDN variables)	3 (Controls+ KSN variables)	4 (Controls+KDN+ sequentially added KSN variables)[1]
Controls:				
Psychological Safety	6.01***	2.49	1.24	0.39
	(2.2)	(1.74)	(2.54)	(2.00)
Facilitating Conditions	5.311*	6.07***	3.20	5.61**
	(2.66)	(1.97)	(2.42)	(2.06)
Self-Efficacy	-0.660	0.306	0.91	0.33
	(2.38)	(1.63)	(2.12)	(1.68)
Social Influence	-10.19***	-8.19***	-5.37	-6.04**
	(3.69)	(2.67)	(3.61)	(2.86)
KDN Variables:				
KDN Distance-based Cohesion		-10.38 (7.97)		-5.52 (9.48)
KDN Density		22.67***		
		(5.36)		
KDN Average Incloseness Centrality (inversely transformed)[2]		5.85** (2.2)		7.09*** (2.41)
KSN Variables:				
KSN Distance-based Cohesion			-2.42 (23.08)	0.185 (19.53)
KSN Density			17.72***	
			(6.31)	
KSN Average Eigenvector Centrality			14.94* (7.85)	16.79** (7.30)
KDN+KSN Overall Density				30.11*** (6.87)
Number of observations	27	27	27	27
R-square	0.347	0.756	0.599	0.779
Adjusted R-square	0.228	0.667	0.451	0.661
Change in adjusted R-square		0.439	0.223	0.433
F	2.918**	8.424***	4.054***	6.641***
Df	*4,22*	*7,19*	*7,19*	*9,17*

* p<.10; ** p<.05; *** p<.01. Standard errors are in parentheses below unstandardized coefficients.

1: 'KDN Density' and 'KSN Density' are highly correlated, leading to multicollinearity problems in the full model. In order to correct this problem, a new variable, KDNKSNDensity, was computed as the mean of KDN Density and KSN Density. The full model includes this combined Density variable.

2: The average incloseness centrality variable was inversely transformed. The directionality of the variable's effect on adaptability should be interpreted as the reverse of the sign on the coefficient.

Table 6: OLS Regression Results for TMA

Variables	Model 1 (Control only)	Model 2 (Controls + KDN variables)	Model 3 (Controls+ KSN variables)	Model 4 (Controls+KDN+ sequentially added KSN variables)[1]
Controls:				
Psychological Safety	3.36**	0.45	0.54	0.08
	(1.52)	(1.35)	(1.77)	(1.64)
Facilitating Conditions	2.41	1.47	0.95	0.85
	(1.83)	(1.53)	(1.69)	(1.69)
Self-Efficacy	0.10	1.17	1.26	1.44
	(1.64)	(1.26)	(1.48)	(1.38)
Social Influence	-5.30**	-2.69	-2.28	-1.71
	(2.54)	(2.07)	(2.52)	(2.35)
KDN Variables:				
KDN Distance-based		-9.58		-12.38
Cohesion		(6.19)		(7.77)
KDN Density		9.10**		
		(4.16)		
KDN Average InCloseness		0.40		0.09
Centrality (inversely		(1.71)		(1.97)
transformed)[2]				
KSN Variables:				
KSN Distance-based			2.48	13.63
Cohesion			(16.10)	(16.02)
KSN Density			12.83***	
			(4.40)	
KSN Average Eigenvector			7.89	2.05
Centrality			(5.48)	(5.99)
KDN+KSN Overall Density				10.27*
				(5.64)
Number of observations	27	27	27	27
R-square	0.234	0.635	0.516	0.631
Adjusted R-square	0.094	0.501	0.338	0.435
Change in Adjusted R-square		0.407	0.244	0.341
F	1.676	4.730***	2.894**	3.224**
Df	*4,22*	*7,19*	*7,19*	*9,17*

* p<.10; ** p<.05; *** p<.01. Standard errors are in parentheses below unstandardized coefficients.

1: 'KDN Density' and 'KSN Density' are highly correlated, leading to multicollinearity problems in the full model. In order to correct this problem, a new variable, KDNKSNDensity, was computed as the mean of KDN Density and KSN Density. The full model includes this combined Density variable.

2: The average incloseness centrality variable was inversely transformed. The directionality of the variable's effect on adaptability should be interpreted as the reverse of the sign on the coefficient.

Table 7: Correlation Matrix with Study Variables (N = 27 Units)

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
1. Psychological Safety	5.44	0.29	1											
2. Facilitating Conditions	4.93	0.37	.503 **	1										
3. Self-Efficacy	6.34	0.21	-.014	.285	1									
4. Social Influence	4.95	0.31	.639 **	.874 **	.307	1								
5. KDN Density_	0.17	0.11	.362	.077	-.287	.044	1							
6. KDN Distance-based Cohesion	094	0.05	-.361	.072	.238	.097	-.611 **	1						
7. KDN InCloseness Centrality	0.59	0.27	-.400 *	-.328	.238	-.206	-.792 **	.437 *	1					
8. KSN Density	0.10	0.08	.273	.086	-.270	.029	.956 **	-.476 *	-.776 **	1				
9. KSN Distance-based Cohesion	0.98	0.02	-.261	-.048	-.052	-.139	-.464 *	.463 *	.369	-.487 **	1			
10. KSN Eigenvector Centrality	0.03	0.06	.413 *	-.048	-.187	-.071	.197	-.534 **	-.268	-.004	-.021	1		
11. TOV	10.73	2.74	.270	.020	-.210	-.129	.716 **	-.647 **	-.432 *	.596 **	-.270	.429 *	1	
12. TMA	9.55	1.74	.222	-.023	-.139	-.129	.714 **	-.651 **	-.536 **	.601 **	-.268	.329	.843**	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 8: Summary of Findings

Hypothesis	Independent Variable	Order Verification DV measure	Medication Administration DV Measure
1	KDN InCloseness Centrality	Supported	Not Supported
2	KDN Density	Supported	Supported
3	KDN Distance-based Cohesion	Supported only in partial model	Supported only in partial model
4	KSN Eigenvector Centrality	Supported	Not Supported
5	KSN Density	Supported	Supported
6	KSN Distance-based Cohesion	Not Supported	Not Supported

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