# THE RELATIONSHIP AMONG CULTURAL DISTANCE, SOCIAL TIES, AND TACIT KNOWLEDGE SHARING IN A MULTINATIONAL CORPORATION

by

Larry R. Buzan

A Dissertation Presented in Partial Fulfillment

of the Requirements for the Degree

DOCTOR OF MANAGEMENT IN ORGANIZATIONAL LEADERSHIP

UNIVERSITY OF PHOENIX

June 2005

UMI Number: 3194290





ProQuest Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

# THE RELATIONSHIP AMONG CULTURAL DISTANCE, SOCIAL TIES, AND TACIT KNOWLEDGE SHARING IN A MULTINATIONAL CORPORATION

by

Larry R. Buzan

June 2005

Approved:

JAY KLAGGE, Ph.D, Mentor

MARIE J. ABRAM, Ph.D, Committee Member

ANTHONY KORTENS, Ph.D, Committee Member

Accepted and Signed: Jay Klagge, 06 09 05
Jay Klagge, Ph.D. Month, Day, Year

Accepted and Signed: Marie J. Abram, 06 02 05
Marie J. Abram, Ph.D. Month, Day, Year

Accepted and Signed: Anthony Kortens, 06 02 05
Anthony Kortens, Ph.D. Month, Day, Year

Dawn Iwamoto, 6-27-05
Dawn Iwamoto, Ed.D. Month, Day, Year
Dean, School of Advanced Studies
University of Phoenix

Abstract

This study examined the extent to which strong social ties improved tacit knowledge sharing among a social network of 252 process engineers in a multinational corporation (MNC) in the semiconductor industry, with operations in Germany, the United States, Singapore, and Japan. The study measured the strength of social ties and the extent to which tacit knowledge related to improving manufacturing yields was shared. The hypothesized relationship among the study variables was tested using network correlation and regression techniques. The results indicate that strong social ties improve tacit knowledge sharing and also mediate the slightly negative effect that cultural distance has on tacit knowledge sharing. These findings may help MNCs to realize a sustained competitive advantage from shared tacit knowledge.

## Dedication

This dissertation is dedicated to the God of all creation, for providing the inspiration and ability to complete this work. It is hoped that this work may be useful in His service.

Acknowledgements

I am extremely thankful to my wife Judith for her patience, love, and encouragement during the past three years. This journey would not have been possible without her as my life's partner.

I am thankful to my mentor and committee members for their support and advice; their reviews were thorough and timely. I am grateful to Dr. Jay Klagge, my mentor, for his continual encouragement, counsel, and dedicated support of my efforts. I thank Dr. Marie Abram for her questions and advice concerning the unusual methodology employed in this study, and for her careful review of my work. I thank Dr. Anthony Kortens for pointing me in the direction of social networks during one of my residencies, and for his helpful comments. Additionally, I would like to acknowledge Dr. Val Burris, who provided an independent review of the methodology.

A quantitative social network study of this size and complexity would be extremely difficult to accomplish without the use of a web-based questionnaire integrated with an electronic database. I am extremely grateful to Scott Buzan for lending his professional abilities to the development of the website and the database that supported the study. I am also grateful to Jason Kirkwood, who ensured the successful operation of the database server. I also want to acknowledge Mika Jarmusz and Dr. Annette Bridges, certified translators who converted the English text for the website and all communications with the participants into Japanese and German languages.

Finally, I want to acknowledge the excellent faculty and staff at the University of Phoenix. Dr. Dawn Iwamoto, Dr. William Pepicello, Dr. Richard Schuttler, Dr. Freda Turner, Dr. Lloyd Williams, and others in School of Advanced Studies deserve special

thanks for their efforts. The professors in the program have encouraged the best efforts from each learner in terms of academic rigor, research, and writing. The academic advisors, financial office, information technology, Doctoral residency support, and the Dean's office continually worked to support the learner during this journey.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

# CHAPTER 1: INTRODUCTION

For multinational corporations (MNCs), there was a time when globalization meant "teaching the world from headquarters or from subsidiaries in advantaged locations or dominant clusters" (Doz, Santo, & Williamson, 2001, p. 10). As globalization has increased, the knowledge necessary to compete in the global economy no longer resides in one location; rather, it is globally dispersed. The MNC's sustained competitive advantage (Barney, 1991) has become increasingly tied to its ability to share knowledge among its globally dispersed operations (Barney, Wright, & Ketchen, 2001; Bhagat, Kedia, Harveston, & Triandis, 2002). Unfortunately, much of the knowledge that can lead to a competitive advantage is *tacit* and not easily shared (Kogut & Zander, 1992, 1993; Nonaka & Takeuchi, 1995; Polanyi, 1966). The ability to share globally dispersed tacit knowledge in MNCs is further limited by differences in national culture (Hampden-Turner & Trompenaars, 1993; Hampden-Turner, Trompenaars, Lewis, & Trompenaars, 2000; Hofstede, 1980, 2001; Simonin, 1999; Subramaniam & Venkatraman, 2001; Trompenaars, 1996). The semiconductor industry is an example of this problem. The knowledge related to successful, high-yielding semiconductor manufacturing is highly tacit (Appleyard, Hatch, & Mowery, 2000), and often not shared beyond individual teams of engineers, supervisors, and workers (Khurana, 1999).

The intent of this quantitative correlational study, using quadratic assignment procedure (QAP) (Hubert, 1987; Hubert & Schultz, 1976; Krackhardt, 1988) and multiple regression quadratic assignment procedure (MRQAP) (Krackhardt, 1993; Borgatti, Everett, & Freeman, 2002) for non-parametric analysis of social network data, was to determine the relationship among *cultural distance* (Hofstede, 1980, 2001; Kogut &

Singh, 1988; Morosini, Shane, & Singh, 1998), the *strength of social ties* (Marsden & Campbell, 1984), and the extent to which *tacit manufacturing process knowledge* (Appleyard et al., 2000; Hatch & Mowery, 1998) is shared among process engineers in a multinational manufacturing company in the semiconductor industry. The significance of this study is its contribution toward helping MNCs to create a sustained competitive advantage through better understanding of the role that strong social ties play in cross-border tacit knowledge sharing.

## Problem Statement

Multinational corporations are increasingly dependent upon globally dispersed knowledge to compete in the global economy (Bhagat et al., 2002). In the traditional view, a strategic advantage for MNCs was their ability to replicate and transfer superior knowledge from headquarters to international subsidiaries (Cantwell & Narula, 2001; Doz et al., 2001; Kogut & Zander, 1993; Prahalad & Lieberthal, 2003; Zander & Solvell, 2000). It is increasingly difficult for MNCs to realize a strategic advantage because much of the knowledge that MNCs need to compete in the global economy is highly tacit, context-specific (Nonaka & Takeuchi, 1995), globally dispersed, and difficult to share (Almeida, Song, & Grant, 2002; Doz et al., 2001). Little is understood about how MNCs can effectively harness globally dispersed tacit knowledge (Subramaniam & Venkatraman, 2001).

The sharing of globally dispersed tacit knowledge in MNCs is impeded by *cultural distance* (Hofstede, 1980, 2001; Kogut & Singh, 1988; Manev & Stevenson, 2001; Morosini et al., 1998; Simonin, 1999). Social networks with strong social ties are believed to be an effective means for sharing tacit knowledge within the local context of

an organization (Argote, McEvily, & Reagans, 2003; Hansen, 1999; Lave & Wenger, 1991; Marsden & Campbell, 1984; Reagans & McEvily, 2003), and may be effective within the global context of a MNC. The knowledge related to process yield improvements in the semiconductor industry is highly tacit (Almeida et al., 2002; Appleyard et al., 2000; Hatch & Mowery, 1998; Khurana, 1999; West, 2002). This quantitative study of tacit knowledge sharing among process engineers in a multinational corporation in the semiconductor industry examined the extent to which strong social ties are effective at overcoming cultural distance to increase the sharing of tacit manufacturing process knowledge. This understanding might help leaders in all MNCs to understand the role of strong social ties as a means for increasing tacit knowledge sharing.

## Background of the Problem

### *The Importance of Knowledge in MNCs*

Global competition has made cross-border knowledge transfer among business units increasingly important to the success of MNCs (Bhagat et al., 2002). In the traditional multinational paradigm, firms were viewed as benefiting from superior technology developed in the home country and replicated in other national markets through foreign direct investment (Cantwell & Narula, 2001). Multinational corporations have traditionally been projectors of knowledge created at home and transferred to foreign operations (Doz et al., 2001; Kogut & Zander, 1993; Zander & Solvell, 2000). The corporate home was seen as the source of all innovation, control, technical skills, and leadership talent. Consequently, MNCs failed to realize the potential of their globally dispersed sources of talent (Prahalad & Lieberthal, 2003). That paradigm is being

replaced by a view of the MNC as a network, where knowledge-building requires integrating contextually-specific knowledge from subsidiaries in different national cultures (Almeida et al., 2002; Doz et al., 2001).

*Resource-Based View of the Firm*

The traditional view of the MNC was based on the theory that firms benefit from transaction cost advantages (Coase, 1937) related to ownership, control of technology, and a network of global assets. An alternative to the Coasian, transaction cost theory evolved out of strategic management researchers' efforts to understand the firm's sources of sustained competitive advantage. Barney (1991) proposed that a firm's sustained competitive advantage comes from resources that are valuable, rare among competing firms, imperfectly imitable, and have no strategically equivalent substitutes. Kogut and Zander (1992) proposed that, from a resource-based view, an organization's sustained competitive advantage comes from its ability to create and transfer knowledge. In the area of international business, the resource-based view has shown the importance of knowledge flows among subsidiaries in MNCs (Barney et al., 2001).

*Obstacles to Knowledge Sharing in MNCs*

*Tacitness*. Much of the knowledge that leads to sustained competitive advantage is know-how, or tacit knowledge (Nonaka & Takeuchi, 1995; Polanyi, 1966), embedded in the social relationships among individuals and groups (Kogut & Zander, 1992). Tacit knowledge can be a source of competitive advantage because it is difficult for competitors to imitate, but it is also more difficult for organizations to codify, transfer, and redeploy (Martin & Salomon, 2003b). As a result, the ability to transfer and redeploy tacit knowledge has become a strategic concern for MNCs. At the same time, little is

understood about how MNCs can effectively harness globally dispersed tacit knowledge (Subramaniam & Venkatraman, 2001).

*Cultural distance*. Cultural differences between countries are a key obstacle to the transfer of tacit knowledge (Subramaniam & Venkatraman, 2001). Bhagat et al. (2002) suggested that the type of knowledge transferred is the most important factor, with strong interaction also coming from cultural patterns and cognitive differences. Simonin (1999) proposed that tacitness and cultural distance (Kogut & Singh, 1988) are both antecedents of "knowledge ambiguity" (Simonin, 1999, p. 463). Cultural distance has been expressed as the aggregate affect of differences in Hofstede's (1980, 2001) dimensions of national culture: *power distance*, *uncertainty avoidance*, *individualism*, *masculinity*, and *long-term orientation* (Kogut & Singh, 1988; Manev & Stevenson, 2001; Morosini et al., 1998). Triandis (2000, 2004) suggested that cultural differences influence how people are likely to sample what is occurring in their environment. These differences are often the cause of miscommunication between people of different national cultures. As the sources of knowledge become globally dispersed, rather than centered on the corporate home, MNCs must encourage and develop the means for meshing the knowledge from culturally different contexts (West, 2002). Social networks may play an important role in cross-border tacit knowledge sharing in MNCs (Coff & Laverty, 2000; Holden, 2001).

*Social Ties and Tacit knowledge Transfer*

*The social nature of knowledge*. Kogut and Zander (1992) argued that the persistence of a firm's capabilities is related to the social fabric of personal relationships, which are supported by the firm's organizing principles and structures. Firms are more effective than markets at transferring knowledge, because they create a social community

where knowledge can be created and transferred (Kogut & Zander, 1993). The firm's organizing principles must support the social knowledge of cooperation and knowledge sharing (Zander & Kogut, 1995). Nonaka and Takeuchi (1995) proposed that new organizational knowledge is continually created through an informal process of socialization, externalization, combination, and internalization of tacit knowledge. A firm should be understood as "a social community specializing in the speed and efficiency in the creation and transfer of knowledge" (Kogut & Zander, 1996, p. 503). One way in which organizations can create strategic knowledge-based assets is through the support of social networks (Coff & Laverty, 2000), and the building of social capital among individuals (Lesser & Storck, 2001).

*Social ties*. A social network is comprised of a set of social actors and the relations or ties among them (Fienberg, Meyer, & Wasserman, 1985; Wasserman & Faust, 1999). The strength of social ties between actors is theorized to be a function of time spent in the relationship and emotional closeness (Granovetter, 1973; Marsden & Campbell, 1984), with closeness being the best overall indicator of tie strength. Researchers differ on the effectiveness of strong versus weak social ties for transferring non-codified or tacit knowledge between individuals (Granovetter, 1973; Hansen, 1999, 2002; Reagans & McEvily, 2003). Some researchers have suggested that tie strength may also be related to other contextual variables in dyadic relationships (Argote et al., 2003), including cultural distance (Manev & Stevenson, 2001).

*Semiconductor Process Knowledge*

The semiconductor industry is an example of a knowledge-based industry with globally dispersed operations and the challenges of cross-border knowledge building

(Almeida et al., 2002). Semiconductor manufacturing involves complex, yield sensitive production processes that have been described as an "intertwining of codified and tacit knowledge" (p. 147). With each successive stage of semiconductor miniaturization, the codifiability of semiconductor manufacturing process knowledge is further reduced, and manufacturing process knowledge becomes increasingly difficult to transfer between sites (Martin & Salomon, 2003b). As the semiconductor industry adopts 300 mm diameter wafers, the feature size of devices fabricated on these wafers has shrunk to below 0.l µm (Solomon, Rosenthal, Spartz, Bosch-Charpenay, Bosch, & Richter, 2001). Short product lifecycles, from one to two years (Appleyard & Kalsow, 1999), and increasing chip density (number of devices per chip area) and operating speed, combined with global price competition make manufacturing process knowledge a source of competitive advantage in semiconductor manufacturing (West, 2002).

Yield losses are a significant obstacle to cost-effective manufacturing processes in the semiconductor industry (Hatch & Mowery, 1998). According to West (2002), semiconductor manufacturing costs are a function of "defect density and gate density" (p. 164). Defect density refers to the number of defective circuits per chip area. Gate density is a measure of the number of transistors, or circuits, per surface area. Superior yielding manufacturing processes enable semiconductor manufacturers to introduce new products, while also lowering costs through improved ratios of defect density and gate density. Hatch and Mowery (1998) cited two major causes for yield losses: (a) unwanted random particle contamination and (b) parametric processing problems.

Flaherty (2000) defined *process knowledge* as "the knowledge workers, managers, and engineers possess regarding why and how particular conditions in the process result

in products with particular characteristics" (p. 99). Of particular concern is the knowledge necessary to prevent processes from naturally drifting out of control. Process knowledge is typically increased over time through problem solving and experimentation (Hatch & Mowery, 1998; Khurana, 1999). Much of the knowledge related to successful, high-yielding semiconductor manufacturing remains tacit among individual teams of engineers, supervisors, and workers (Khurana, 1999), and is difficult to transfer between sites (Appleyard et al., 2000). Knowledge management strategies have typically focused on codifying tacit knowledge so that it can more easily be transferred and redeployed (Evans, 2004; Hansen, Nohria, & Thomas, 1999; Schultz & Jobe, 2001; Seely Brown, & Duguid, 2000). Despite the efforts by most semiconductor companies to codify processes and replicate them at other manufacturing sites, significant differences in yield performance normally exist between sites (Appleyard et al., 2000).

## Purpose Statement

The purpose of this quantitative correlational study, using social network data, was to determine the extent to which strong social ties are effective for overcoming cultural distance between individuals and increasing the sharing of tacit manufacturing process knowledge among 252 process engineers in a multinational semiconductor manufacturing company with operations in Germany, the United States, Singapore, and Japan. The independent variable is *cultural distance* (Hofstede, 1980, 2001; Kogut & Singh, 1988; Morosini et al., 1998), the intervening variable is the *strength of social ties* (Marsden & Campbell, 1984), and the dependent variable is the extent to which *tacit manufacturing process knowledge* is shared (Appleyard et al., 2000; Hatch & Mowery, 1998). Participants completed a web-based survey comprised of Likert-scale questions

concerning their relational ties with other process engineers at the participating company's manufacturing sites in Germany, the United States, Singapore, and Japan. Data for each of the relational variables is represented as a N x N sociomatrix, where $X_{ij}$ describes the relational tie among all possible pairs of participants *i* and *j*. Network correlation and regression using quadratic assignment procedure (QAP) (Hubert, 1987; Hubert & Schultz, 1976; Krackhardt, 1988) and multiple regression quadratic assignment procedure (MRQAP) (Borgatti, et al., 2002; Krackhardt, 1993) were employed for nonparametric analysis of social network data.

## Significance of the Study

Tacit knowledge, which can be a source of competitive advantage for MNCs, resides as a cognitive ability of globally dispersed individuals who are embedded in the context of national cultures (Holden, 2001). If MNCs are to achieve a sustained competitive advantage from this globally dispersed tacit knowledge, they must understand how to transfer it from one cultural context to another (Ensign, 1999; West, 2002). The significance of this study is its contribution toward helping MNCs create a sustained competitive advantage through better understanding of the role that strong social ties play in cross-border tacit knowledge sharing.

## Significance of the Study to Leadership

Globalization is causing the converging of economic and social systems, making it necessary for leaders to have a global mindset and the cross-cultural skills to facilitate and coach in an international environment (Marquardt & Reynolds, 1994). In the global economy, it is important that MNCs develop leaders who can "guide organizations that span diverse countries, cultures, and customers" (Gregersen, Morrison, & Black, 1998, p.

21). Managers in MNCs are responsible for creating the organizational environment where social interaction among individuals supports the creation, utilization, and accumulation of globally dispersed tacit knowledge (Ensign, 1999). The significance of this study for leadership is its potential to help global leaders understand the role of strong social ties for improving cross-border tacit knowledge sharing in MNCs.

## Nature of the Study

This quantitative correlational study, using social network data, attempted to determine the extent to which there is a relationship among cultural distance, strong social ties, and the sharing of tacit manufacturing process knowledge among 252 process engineers from four culturally distant manufacturing sites in Germany, the United States, Singapore, and Japan. Cultural distance, social ties, and tacit knowledge sharing were treated as relational ties among the study participants who, by virtue of the organizational structure, comprise a complete social network.

A quantitative approach was selected over a qualitative one for the study. According to Creswell (2003), a quantitative approach is appropriate when measurements can be collected to statistically analyze testable theories. Linear correlation is appropriate for inference testing of hypotheses when sample data are paired, normally distributed, and hypotheses concern the statistical significance of the relationship between pairs of variables (Triola, 2001). According to Triola, multiple regression analysis is appropriate when analyzing the relationship among multiple variables and the statistical significance of that relationship as a predictor of results from similar studies. In this study, a set of null hypotheses are offered concerning the relational ties among the network of study participants. The null hypotheses concern pairs of relational variables; the model

concerns the multivariate relationship among these variables. The hypotheses were inference tested using data from survey questionnaires and correlation and regression techniques especially suited for network data.

A social network approach was selected for this quantitative correlational study because it differs from other empirical approaches in two important ways. First, social network studies focus on the *relations* among actors, rather than the attributes of individual actors (Wasserman & Faust, 1999). Second, because the focus is on relations, actors cannot be sampled independently concerning their relational ties; therefore observations are not independent (Hanneman, 2001). Standard statistical methods for inference testing of hypotheses are not appropriate for network data, because the observations of dyadic relations within a network are not independent (Borgatti & Cross, 2003; Dekker et al., 2003; Krackhardt, 1988). Varying amounts of interdependence in network observations create an autocorrelation problem that may be significant when testing a null hypothesis that two network variables are unrelated (Krackhardt, 1988). Krackhardt proposed a non-parametric solution to the autocorrelation problem; one that employs the quadratic assignment procedure (QAP) proposed by Hubert and others (Hubert, 1987; Hubert & Schultz, 1976) for estimating the significance of correlation and regression coefficients. Krackhardt (1988) adapted this technique to regression in multivariate network studies through a variation called multiple regression quadratic assignment procedure (MRQAP). Network correlation and regression techniques are based on non-parametric randomization to create a probability distribution used for inference testing. The QAP and MRQAP are discussed in greater detail in chapter 3. The QAP was used for inference testing of the hypothesized relationships; MRQAP was used

for testing the predictive ability of the model. In this study, both analyses were performed using UCINET 6 software (Borgatti et al., 2002).

The study employed a web-based survey questionnaire using Likert-scale questions. Questionnaires are the most common method of data collection used in social network studies (Wasserman & Faust, 1999), and "are most useful when the actors are people, and the relation(s) that are being studied are ones that the respondent can report on" (p. 45). Likert-scale questions are appropriate for social network studies that measure the perceptions of social actors concerning their relational ties with others (Marsden, 1990). According to Wasserman and Faust (1999), "social network analysis provides a precise way to define important social concepts, a theoretical alternative to the assumption of independent social actors, and a framework for testing theories about structured social relationships" (p. 17), such as those found in this study.

## Research Question

The study attempted to answer the following question: What is the relationship among cultural distance, the strength of social ties among process engineers, and the sharing of tacit manufacturing process knowledge in a multinational manufacturing company in the semiconductor industry?

## Hypotheses

Three hypotheses established the basis for quantitative testing of the theoretical relationship among cultural distance, the strength of social ties among process engineers, and the sharing of tacit manufacturing process knowledge in a multinational company in the semiconductor industry. The hypothesized relationship among the study variables is shown in Figure 1.

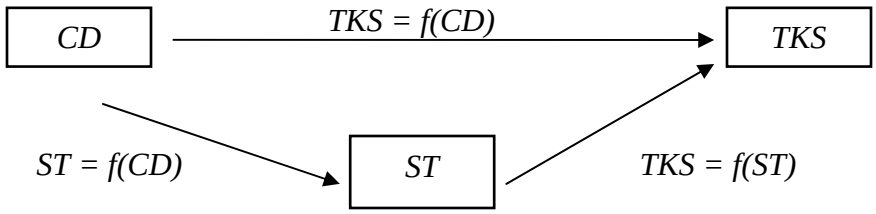


*Figure 1*. Hypothesized relationship among the study variables. *Note*. Cultural Distance = *CD*; Strength of Social Ties = *ST*; Tacit Knowledge Sharing = *TKS*

*Hypothesis 1H - Cultural Distance and Tacit Knowledge Sharing*

The first null hypothesis, $1H_0$, is that differences in national culture, defined as cultural distance, will have no significant affect upon tacit knowledge sharing among process engineers in a multinational corporation in the semiconductor industry. The alternative hypothesis, $1H_1$, posits that differences in national culture do affect the sharing of tacit knowledge. This hypothesis draws upon Hofstede's (1980, 2001) dimensions of differences in national cultural, constructs for these differences termed as cultural distance (Kogut & Singh, 1988; Morosini et al., 1998), and several authors who have suggested that cultural distance is an obstacle to knowledge transfer in MNCs (Almeida & Grant, 1998; Bhagat et al., 2002; Garcia & Vano, 2002; Holden, 2001; McDonough, Kahn, & Griffin, 1999; O'Keeffe, 2003; Palich & Gomez-Mejia, 1999; Persaud, Kumar, & Kumar, 2001; Salk & Brannen, 2003; Simonin, 1999; Subramaniam & Venkatraman, 2001; Triandis, 2000, 2004; West, 2002; Zander & Solvell, 2000).

*Null hypothesis* $1H_0$. There is no statistically significant relationship between cultural distance and the sharing of tacit manufacturing process knowledge in a multinational company in the semiconductor industry.

*Alternative hypothesis 1H$_1$*. There is a statistically significant relationship between cultural distance and the sharing of tacit manufacturing process knowledge in a multinational company in the semiconductor industry.

*Hypothesis 2H – Cultural Distance and Social Ties*

The second null hypothesis, *2H$_0$*, assumes that cultural distance is not significantly related to the formation of strong social ties among process engineers in a multinational corporation in the semiconductor industry. The alternative hypothesis, *2H$_1$*, posits that cultural distance is related to the formation of strong social ties. This hypothesis draws upon two previous studies. In one study, Manev and Stevenson (2001) suggested that more culturally distant managers were likely to develop strong instrumental ties related to the transfer of work related information. In a second study, Salk and Brannen (2003) suggested that the development of socioemotional bonds and advice seeking patterns are reflective of cultural differences.

*Null hypothesis 2H$_0$*. There is no statistically significant relationship between cultural distance and the strength of social ties among process engineers in a multinational company in the semiconductor industry.

*Alternative hypothesis 2H$_1$*. There is a statistically significant relationship between cultural distance and the strength of social ties among process engineers in a multinational company in the semiconductor industry.

*Hypothesis 3H – Social Ties and Tacit Knowledge Sharing*

The relationship between cultural distance and tie strength is theorized to be directional, whereby strong social ties are an intervening or mediating variable in the relationship between cultural distance and tacit knowledge sharing. This leads to the third

null hypothesis, $3H_0$, that strong social ties have no significant affect upon tacit knowledge sharing among process engineers in a multinational corporation in the semiconductor industry. The alternative hypothesis, $3H_1$, posits that strong social ties are related to tacit knowledge sharing. This hypothesis draws upon the work of several authors who have suggested that knowledge transfer is improved in the presence of strong social ties (Argote et al., 2003; Borgatti & Cross, 2003; Levin, Cross, & Abrams, 2002; Reagans & McEvily, 2003).

*Null hypothesis* $3H_0$. There is no statistically significant relationship between the strength of social ties among process engineers and the sharing of tacit manufacturing process knowledge in a multinational company in the semiconductor industry.

*Alternative hypothesis* $3H_1$**.** There is a statistically significant relationship between the strength of social ties among process engineers and the sharing of tacit manufacturing process knowledge in a multinational company in the semiconductor industry.

## Theoretical Framework

This section outlines the theoretical framework that is the basis for this research. The theoretical basis from which this research is derived is found in the fields of organizational knowledge, specifically *tacit knowledge* (Castillo, 2002; Nonaka & Takeuchi, 1995; Polanyi, 1966), *national culture and cultural distance* (Hampden-Turner & Trompenaars, 1993; Hampden-Turner et al., 2000; Hofstede, 1980, 2001; Kogut & Singh, 1988; Morosini et al., 1998; Shenkar, 2001; Triandis, 2000, 2004; Trompenaars, 1996), and *social networks and the strength of social ties* (Granovetter, 1973; Hansen, 1999, 2002; Marsden & Campbell, 1984; Reagans & McEvily, 2003). Chapter 2 contains a detailed review and discussion of the related literature. The framework establishes the

theoretical link between these fields and the study, and proposes a theoretical model for the relationship among cultural distance, the strength of social ties, and tacit knowledge sharing in multinational corporations.

*Tacit Knowledge*

The resource-based view of the firm (Barney, 1991) suggested the value of organizational knowledge and know-how as a source of sustained competitive advantage (Conner, 1991). This advantage comes from tacit knowledge (Polanyi, 1966), which is difficult for competitors to imitate but also difficult for firms to replicate and redeploy (Kogut & Zander, 1992). Organizational knowledge is a mixture of explicit and tacit knowledge (Nonaka & Takeuchi, 1995). According to Nonaka and Takeuchi, explicit knowledge can be codified or expressed in symbols, making it transmittable to other people through systematic language. Tacit knowledge, on the other hand, is difficult to transfer to other people because it is experiential, personal, and context-specific. Castillo (2002) argued that research concerning tacit knowledge has strayed from the seminal ideas put forth by Polanyi (1966). Castillo (2002) proposed a typology that classified tacit knowledge into four categories: nonepistle, sociocultural, semantic, and sagacious.

This study focuses on what Castillo (2002) termed *Sociocultural tacit knowledge*; the collective knowledge or knowing that a group develops over time through the interactions of individuals, that resides in dispersed bits of tacit knowledge or knowing. In this study, the level of tacitness is assumed to be related to the codifiability of knowledge (Kogut & Zander, 1993).Tacit knowledge is “difficult to understand and codify” (p. 636); consequently, it is likely to remain un-codified. Knowledge that is not likely to be codified lies in the realm of know-how (Crossan, Lane, & White, 1999).

Hatch and Mowery (1998) described much of the knowledge associated with achieving yield improvements in semiconductor manufacturing as tacit and based in know-how rather than science. Semiconductor manufacturing processes are highly codified, so they can be replicated at other sites with no discernible product differences (Appleyard et al., 2000; Khurana, 1999). The effectiveness of codifying semiconductor processes is limited, because much of the knowledge related to successful high-yielding semiconductor manufacturing is tacit and difficult to transfer between sites (Appleyard et al., 2000). In this study, tacit semiconductor process knowledge is defined as knowledge related to manufacturing yield problems or improvements that are *not* explicitly documented and shared between manufacturing sites.

*National Culture and Cultural Distance*

Kogut and Singh (1988) suggested that differences in national culture have an influence on a MNC's choice of entry mode in foreign markets, and that cultural distance may be a factor in other types of managerial decision-making in MNCs. A study by Simonin (1999) suggested that both tacitness and cultural distance impede knowledge transfer in MNCs. Kogut and Singh's (1988) measure of the cultural distance between two countries was based on the arithmetic average of the deviations, adjusted for variance, along each of Hofstede's (1980) four indices for differences in national cultures: *power distance*, *uncertainty avoidance*, *individualism*, and *masculinity*. In a study of the relationship between cultural distance and firm performance in cross-border acquisitions, Morosini et al. (1998) computed cultural distance as the total Euclidian measure of Hofstede's four indices between two countries. Hofstede (2001) expanded his research to include a fifth dimension of national culture: *long-term orientation*. Hofstede concluded

that all five dimensions are present to varying degrees in the 50 cultures that he studied. To date, however, no studies have included the dimension of long-term orientation as a component of cultural distance.

Shenkar (2001) was critical of what he termed the "assumption of equivalence" (p. 525) implicit in the aggregating of Hofstede's (1980) indices by Kogut and Singh (1988). Shenkar (2001) argued that the aggregating of indices must be theoretically justified or else be replaced by the selected use of one or more of Hofstede's (2001) indices, as appropriate. Several authors have suggested that Hofstede's (1980, 2001) dimension of individualism-collectivism may have the most influence on knowledge transfer between different cultures (Bhagat et al., 2002; Shenkar, 2001; Triandis, 2004). Shenkar (2001) further recommended that Hofstede's (2001) index of long-term orientation should be included in future studies involving cultural distance.

In this study, cultural distance was measured as both the average, adjusted for statistical variance, (Kogut & Singh, 1988) and the Euclidean (Morosini et al., 1998) computations for cultural distance. These measures were based on all five of Hofstede's (1980, 2001) dimensions of differences in national culture. In addition, the study tested for the individual influence from each of Hofstede's cultural dimensions.

*Social Networks and the Strength of Social Ties*

*Social ties*. Fienberg et al. (1985) defined a social network as "a construct of social actors…and the various relations that exist among them" (p. 51). Wasserman and Faust (1999) defined a social network as a "set of actors and the ties among them" (p. 9). Granovetter (1973) suggested that social ties between pairs of actors, or dyads, are able to explain larger phenomena, such as the diffusion of knowledge. Granovetter defined tie

strength as "a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie" (p. 1361). Building on Granovetter's intuitive definition, Marsden and Campbell (1984) identified two primary indicators of tie strength: (a) time spent in the relationship and (b) closeness. They suggested that closeness is the best overall indicator of tie strength. Closeness is defined as a measure of the intensity of a relationship, ranging from an acquaintance to a very close friend. This study used Marsden and Campbell's definition of tie strength, based upon the measure of closeness. Specific measures for tie strength were adapted from the General Social Survey (National Opinion Research Center, 2004) and a study by Reagans and McEvily (2003).

*Strong vs. weak ties*. Granovetter (1973) argued that weak ties, rather than strong ties, enable knowledge to travel over greater social distance. According to Granovetter, in a social network supported by both strong and weak ties the knowledge shared between individuals with strong ties is likely to be redundant, while the knowledge shared between those with weak ties is likely to be unique. In a study of international development teams, Hansen (1999, 2002) concluded that *weak* ties are effective for *locating* widely distributed knowledge, and *strong* ties are effective for *transferring* complex tacit knowledge. The results of a study by Reagans and McEvily (2003) suggested that tie strength has a strong positive effect on the ease of transferring both tacit and codified knowledge. They concluded that tacit knowledge is in general more difficult to transfer, and that strong ties are not more effective, but rather they are more efficient.

*Social networks and cultural distance*. Manev and Stevenson (2001) investigated the relationship between cultural distance and social networks among 457 managers of 41

different nationalities in a MNC with operations in 36 countries. In their study, the strength of social ties was the dependent variable. The results of their study suggested that managers who were more culturally distant were likely to develop strong instrumental ties related to accomplishing tasks, while managers who were less culturally distant were likely to develop strong expressive ties related to friendship and personal support. Argote et al. (2003) suggested that dyadic relationships can vary along several dimensions including the frequency and intensity of contact between individuals and their social similarity. They suggested that future research on knowledge transfer should include the relationship between tie strength and other contextual variables.

*Theoretical Model*

The focus of this research is the relationship among cultural distance, the strength of social ties, and tacit knowledge sharing in a multinational corporation. Several authors have suggested that cultural distance is an impediment to tacit knowledge sharing (Almeida & Grant, 1998; Bhagat et al., 2002; Garcia & Vano, 2002; Holden, 2001; McDonough et al., 1999; O'Keeffe, 2003; Palich & Gomez-Mejia, 1999; Persaud et al., 2001; Salk & Brannen, 2003; Simonin, 1999; Subramaniam & Venkatraman, 2001; Triandis, 2000, 2004; West, 2002; Zander & Solvell, 2000). Knowledge transfer seems to depend upon knowledge partners having close interpersonal relationships (Almeida & Grant, 1998; Almeida et al., 2002). Little is known, however, about the effectiveness of interpersonal relationships for overcoming cultural distance. Tacit knowledge sharing in organizations may be influenced by the social ties between individuals in social networks (Argote et al., 2003; Borgatti & Cross, 2003; Levin et al., 2002; Reagans & McEvily,

2003). Researchers' opinions differ, however, on the effectiveness of strong versus weak ties (Granovetter, 1973; Hansen, 1999, 2002; Reagans & McEvily (2003).

This dissertation is based on a proposed model of knowledge transfer in MNCs that is depicted in Figure 2. The model assumes that codification is effective for transferring explicit knowledge between knowledge partners from different national cultures, but it is not effective for transferring non-codified or tacit knowledge. Tacit knowledge transfer in MNCs requires the sharing of personal knowledge supported by strong social ties between individuals. This latter assumption is the subject of this study.

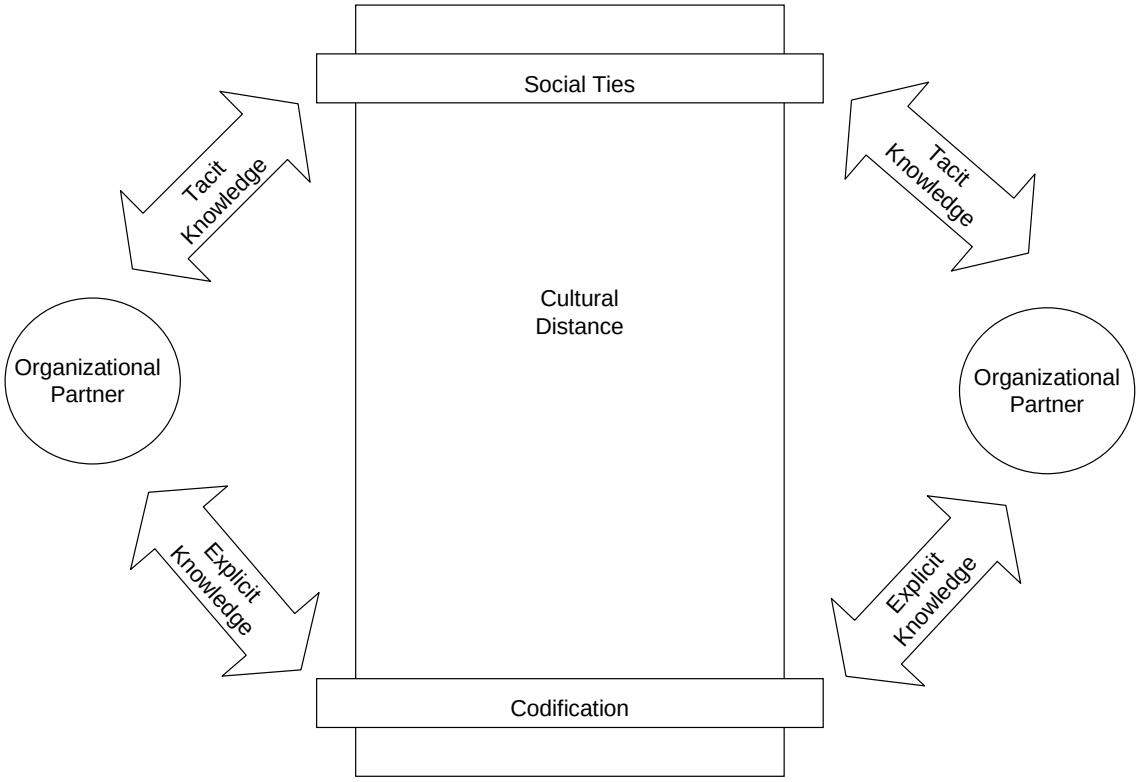


*Figure 2.* Model of knowledge transfer in MNCs

## Definition of Terms

### *Cultural Distance*

Cultural distance is a composite index that measures the aggregate difference between the cultural norms of one country and another. It is based upon Hofstede's (1980) four dimensions of national culture: *power distance*, *uncertainty avoidance*, *masculinity/femininity*, and *individualism/collectivism*. Cultural distance can be computed as the average (Kogut & Singh, 1988) or the Euclidean distance (Morosini et al., 1998) for Hofstede's (1980) dimensions between individuals of different national culture. Both formulas are modified in this study to include Hofstede's (2001) fifth dimension of *long- versus short-term orientation.*

*Average distance*. Kogut and Singh (1988) proposed a composite index for the cultural differences between two countries "based on the deviation along each of the four cultural dimensions...corrected for differences in the variances of each dimension and then arithmetically averaged" (p. 422) as shown in Figure 3.

$$CD_{ju} = \sum_{I=1}^{4} \{(I_{ij} - I_{iu})^2 / V_i$$

*Figure 3*. Equation for average cultural distance. *Note.* Proposed by Kogut and Singh (1988). $CD_{ju}$ is the cultural distance of the *j*th country from the *u*th country. $I_{ij}$ is Hofstede's (1980) index for the *i*th cultural dimension and *j*th country. $I_{iu}$ is Hofstede's index for the *i*th cultural dimension and the *u*th country. $V_i$ is the statistical variance of the index data for the *i*th cultural dimension.

*Euclidean distance*. Morosini et al. (1998) proposed a variation of the original formula. The formula by Morosini et al. computes the total or Euclidean cultural distance based on Hofstede's (1980) four dimensions of national culture, as shown in Figure 4.

$$CD_{ju} = \sqrt{\sum_{I=1}^{4} (I_{ij} - I_{iu})^2}$$

*Figure 4.* Equation for total or Euclidean cultural distance. *Note*. Proposed by Morosini et al (1998). $CD_{ju}$ is the cultural distance for the *j*th country from the *u*th country. $I_{ij}$ is Hofstede's (1980) index for the *i*th cultural dimension and *j*th country. $I_{iu}$ is Hofstede's index for the *i*th cultural dimension and from the *u*th country.

*Tacit Knowledge*

Tacit knowledge is a concept based on the work of the philosopher Michael Polanyi (1966). "Tacit knowledge is personal, context-specific" (Nonaka & Takeuchi, 1995, p. 59), and difficult to codify for transmission to others (Kogut & Zander, 1993). Researchers have associated the degree of tacitness with the codifiability of knowledge (Kogut & Zander, 1993; Zander & Kogut 1995). In this study, tacit knowledge is assumed to be *uncodified* knowledge related to manufacturing yield improvements in the semiconductor industry. This definition is consistent with the nature of semiconductor yield improvements, as cited by several authors (Almeida et al., 2002; Appleyard et al., 2000; Hatch & Mowery, 1998).

*Explicit Knowledge*

Nonaka and Takeuchi (1995) suggested that "explicit or 'codified' knowledge…refers to knowledge that is transmittable in formal, systematic language" (p. 59). In organizations, knowledge normally becomes explicit when it is proceduralized or embedded in drawings and documents (Kogut & Zander, 1993).

*Social Network*

Wasserman and Faust (1999) defined a social network as "a finite set or sets of actors and the relation or relations defined on them" (p. 20). Social network analysis

focuses on the relationships among a set or sets of actors "and on the patterns and implications of these relationships" (p. 3).

*Actor*

Social networks are composed of social entities, termed actors (Wasserman & Faust, 1999). The term actor includes various possible types including individuals, corporations, or any social unit. Most social network studies focus on groups of actors of a single type; these are termed "one-mode networks" (p. 17).

*Group*

A group consists of "a finite set of actors who for conceptual, theoretical, or empirical reasons are treated as a finite set of individuals on which network measurements are made" (Wasserman & Faust, 1999, p. 19). Wasserman and Faust suggested that defining a finite group is a necessary part of setting boundaries for a social network study. Without such boundaries the web of personal interactions theoretically includes all of society.

*Subgroup*

A subgroup is a subset of a group of actors and the relational ties among them (Wasserman & Faust, 1999).

*Relational Tie*

A relational tie is any relational feature that links pairs of actors (Wasserman & Faust, 1999). There are few limits on what constitutes a relational tie; "the defining feature of a tie is that it establishes a linkage between a pair of actors" (p. 18).

*Tie Strength*

When a relational tie is described using valued data, the relational value is termed *tie strength* (Wasserman & Faust, 1999). Tie strength in social relations has been defined as a measure of the closeness or emotional intensity of a relationship, ranging from an acquaintance to a close personal friend (Marsden & Campbell, 1984).

*Dyad*

A dyad is any pair of actors and the tie(s) between them (Wasserman & Faust, 1999). According to Wasserman and Faust, in social network studies the unit of analysis is said to be the dyad. The focus of social network analysis is "understanding the ties among pairs" (p. 18) of actors, or dyads, rather than attributes of individual actors.

## Assumptions

Kogut and Zander (1993) suggested that the level of tacitness in any source of knowledge is related to the codifiability of that knowledge. In this study, when manufacturing process knowledge related to achieving yield improvements remains *uncodified*, it is assumed to be tacit knowledge. This definition is consistent with the nature of semiconductor yield improvements, as cited by several authors (Almeida et al., 2002; Appleyard et al., 2000; Hatch & Mowery, 1998). In this study, tacit manufacturing process knowledge is assumed to have been shared when undocumented yield improvements were discussed between process engineers.

## Scope and Limitations

The boundaries of this study are the complete group of process engineers at four international manufacturing sites of a single MNC in the semiconductor industry, and the relational ties among them. A fifth site, located in the former East Germany, was

excluded from the study because Hofstede's (1980, 2000) indices for differences in national culture do not include data from the German Democratic Republic. The results and conclusions from this study could be influenced by four factors that were not considered in the study. First, organizational differences were not considered in the study. The research was conducted within a single MNC that has a strong corporate culture and a centralized international hierarchy controlled by policies and procedures. Despite this strong corporate culture, local variations in organizational culture or practices may have an influence on social interaction among individuals from different locations. Second, the study was limited to four international locations where the MNC being studied has manufacturing operations: Germany, the U.S., Singapore, and Japan. Third, the psychological or emotional condition of individuals may influence their willingness to establish and maintain strong social ties. Finally, personal attributes of actors, such as age, education, and general experience were not controlled for in the study.

## Delimitations

A multinational manufacturing company in the semiconductor industry was selected for this study because of the important role that tacit and explicit knowledge have in semiconductor manufacturing processes. Only individuals with the title of process engineer were selected for the study because they are believed to be most likely to possess tacit knowledge acquired through continued yield optimization efforts. General application of the findings from this study for all MNCs and for other types of tacit knowledge, such as market knowledge, may only be suggested.

## Summary

Multinational corporations have traditionally been projectors of technology developed in the home country and replicated in other markets through foreign direct investment (Cantwell & Narula, 2001; Doz et al., 2001; Kogut & Zander, 1993; Zander & Solvell, 2000). The projection strategy that has been an underlying assumption of technology transfer in MNCs is no longer effective in the increasingly competitive global economy (Doz et al., 2001; Prahalad & Lieberthal, 2003). Much of the knowledge that can create a sustained competitive advantage for MNCs is tacit (Kogut & Zander, 1992; Nonaka & Takeuchi, 1995) and globally dispersed (Doz et al., 2001) among employees who are separated by differences in national culture (Bhagat et al., 2002; Hofstede, 1980, 2001; Subramaniam & Venkatraman, 2001). If MNCs are to realize a competitive advantage from tacit knowledge, they must find ways to transfer it from one cultural context to another (Almeida et al., 2002; Doz et al., 2001 Subramaniam & Venkatraman, 2001).

Manufacturing processes in the semiconductor industry are among the most complex and yield sensitive of any industry (Almeida et al., 2002; Appleyard et al., 2000; Hatch & Mowery, 1998; Khurana, 1999). Tacit knowledge related to reducing yield losses in manufacturing is a potential source of competitive advantage for semiconductor companies (West, 2002). It is imperative, therefore, that multinational semiconductor companies find ways to support and encourage tacit knowledge sharing among globally dispersed process technology experts.

The research in this dissertation may increase the understanding of how MNCs can effectively share tacit knowledge, by providing a quantitative study of the

relationship among cultural distance, the strength of social ties, and the sharing of tacit manufacturing process knowledge in a MNC in the semiconductor industry. A theoretical framework for the study is constructed in chapter 2 around a detailed literature review of existing theory and research concerning organizational knowledge, national cultures and cultural distance, and social networks and the strength of social ties.

# CHAPTER 2: LITERATURE REVIEW

Chapter 1 introduced the study and summarized the theoretical framework that led to the following research question: *What is the relationship among cultural distance, the strength of social ties among process engineers, and the sharing of tacit manufacturing process knowledge in a multinational manufacturing company in the semiconductor industry*? Chapter 2 expands on this framework by reviewing the literature and prior research that pertain to the research question and the hypothesized relationship among the independent variable cultural distance, the intervening variable strength of social ties, and the dependent variable tacit knowledge sharing.

Multinational corporations are increasingly dependent upon globally dispersed knowledge to compete in the global economy (Bhagat et al., 2002). In the traditional view, a strategic advantage for MNCs was their ability to replicate and transfer superior knowledge from headquarters to international subsidiaries (Cantwell & Narula, 2001; Doz et al., 2001; Kogut & Zander, 1993; Prahalad & Lieberthal, 2003; Zander & Solvell, 2000). It is increasingly difficult for MNCs to realize a strategic advantage because much of the knowledge that MNCs need to compete in the global economy is highly tacit, context-specific (Nonaka & Takeuchi, 1995), globally dispersed, and difficult to share (Almeida, Song, & Grant, 2002; Doz et al., 2001). Little is understood about how MNCs can effectively harness globally dispersed tacit knowledge (Subramaniam & Venkatraman, 2001).

The sharing of globally dispersed tacit knowledge in MNCs is impeded by *cultural distance* (Hofstede, 1980, 2001; Kogut & Singh, 1988; Manev & Stevenson, 2001; Morosini et al., 1998; Simonin, 1999). Social networks with strong social ties are

believed to be an effective means for sharing tacit knowledge within the local context of an organization (Argote, McEvily, & Reagans, 2003; Hansen, 1999; Lave & Wenger, 1991; Marsden & Campbell, 1984; Reagans & McEvily, 2003), and may be effective within the global context of a MNC. Knowledge related to process yield improvements in the semiconductor industry is highly tacit (Almeida et al., 2002; Appleyard et al., 2000; Hatch & Mowery, 1998; Khurana, 1999; West, 2002).

This quantitative correlational study, using social network data, attempted to determine the extent to which strong social ties are effective for overcoming cultural distance between individuals and increasing the sharing of tacit manufacturing process knowledge among 252 process engineers in a multinational semiconductor manufacturing company with operations in Germany, the United States, Singapore, and Japan. The independent variable is *cultural distance* (Hofstede, 1980, 2001; Kogut & Singh, 1988; Morosini et al., 1998), the intervening variable is the *strength of social ties* (Marsden & Campbell, 1984), and the dependent variable is the extent to which *tacit manufacturing process knowledge* is shared (Appleyard et al., 2000; Hatch & Mowery, 1998). This understanding might help leaders in all MNCs to understand the role of strong social ties as a means for increasing tacit knowledge sharing.

## Historical Overview

Tacit knowledge sharing in MNCs is not discussed in the literature until the late 1980s. Prior to that time, the multinational advantage was thought to come from transaction cost advantages (Coase, 1937) related to ownership, control of technology, and a network of global assets. Multinational corporations were projectors of knowledge created at home, subsequently codified, and transferred to foreign operations (Doz et al.,

2001; Kogut & Zander, 1993; Zander, 2002; Zander & Solvell, 2000). Ghoshal and Bartlett (1988) proposed that subsidiaries of MNCs have a three-fold role that includes the creation, adoption, and diffusion of innovation. The resource-based view of the firm (Barney, 1991), and the related knowledge-based view (Kogut & Zander 1992) established know-how as a source of sustained competitive advantage for MNCs. This view presented researchers and MNCs with a dilemma: Know-how, that is a potential source of sustained competitive advantage, is also tacit in nature (Polanyi, 1966) and difficult to codify and transfer to other sites (Kogut & Zander, 1993; Zander & Kogut 1995).

Researchers have attempted to divide organizational knowledge into two categories: explicit knowledge and tacit knowledge. *Explicit knowledge* can be codified or expressed in symbols, making it transmittable to other people through systematic language. *Tacit knowledge*, on the other hand, is subjective and experiential (Nonaka & Takeuchi, 1995). It is difficult to codify and transmit to others because it is personal and context specific. The degree of tacitness has become associated with the codifiability of knowledge (Kogut & Zander, 1993; Zander & Kogut 1995). Consequently, knowledge transfer in MNCs has followed two courses: (a) codification and (b) personalization (Cowan, David, & Foray, 2000; Hansen et al., 1999).

Codification strategies have focused on converting large amounts of tacit knowledge into explicit knowledge (Schultz & Jobe, 2001). Codification efforts typically emphasize the use of information and computer technologies to store knowledge so that it can be easily accessed by others (Butler, 2003). According to Hansen et al. (1999),

codification strategies are based upon the "economics of reuse" (p. 110), whereas personalization is based upon the "economics of expertise" (p. 110).

Personalization strategies have focused on creating an organizational environment that supports personal interaction and knowledge sharing (Ghoshal & Bartlett, 1988; Hansen et al., 1999). Personalization strategies view organizational knowledge as "socially produced" (Abou-Zeid, 2002, p. 33), within an "activity systems" (Blackler, 1993, p. 866) that is contextually bound to an organization's culture. The challenge for MNCs is to create a "shared space" (Gill, 2004, p. 2) in which "emerging relationships" (Nonaka & Konno, 1998, p. 40) and tacit knowledge sharing and transfer can occur. Successful transfer of tacit knowledge has been linked to having the organizational structure, practices, and culture that encourage direct or indirect contact and informal networks (Argote et al., 2003; Holden 2001).

Tacitness and organizational differences are only two of the major obstacles to knowledge transfer. In MNCs, these are combined with differences in national culture to create what Simonin (1999) called "knowledge ambiguity" (p. 463). Hofstede (1980, 2001) identified five common dimensions that empirically defined the differences in national cultures: (a) *power distance*, (b) *uncertainty avoidance*, (c) *individualism*, (d) *masculinity*, and (e) *long-term orientation*. Researchers working in the area of foreign direct investment developed a composite index for these differences that is known as *cultural distance* (Kogut & Singh, 1988; Morosini et al., 1998). Several authors have also pointed to differences in national culture or cultural distance as an obstacle to knowledge transfer in MNCs (Almeida & Grant, 1998; Bhagat et al., 2002; Garcia & Vano, 2002; Holden, 2001; McDonough et al., 1999; O'Keeffe, 2003; Palich & Gomez-Mejia, 1999;

Persaud et al., 2001; Salk & Brannen, 2000; Simonin, 1999; Subramaniam & Venkatraman, 2001; Triandis, 2000, 2004; West, 2002; Zander & Solvell, 2000). In one closely related study, Manev and Stevenson (2001) examined the relationship between nationality, cultural distance, expatriate status, and the formation of strong ties in a network of 457 managers in a MNC. They suggested that work related knowledge is transferred regardless of cultural distance. Conversely, Holden (2001) suggested that cultural distance does inhibit cross-border knowledge transfer. Neither of these studies, nor any others found in the literature search, has examined the relationship between cultural distance and tacit knowledge sharing.

Social network theory, which has its roots in cultural anthropology, (Moreno, 1934) has been applied to the study of relational and social ties among individuals. Granovetter (1973) defined the strength of social ties as "a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie" (p. 1361). He suggested that the strength of social ties between individuals was related to the diffusion of knowledge in a social network, and that weak ties are instrumental in the diffusion of knowledge. Building on Granovetter's intuitive concept, Marsden and Campbell (1984) suggested that tie strength is related to time spent in the relationship and the degree of closeness, with closeness being the best overall indicator of tie strength. Tacit knowledge sharing has been associated with both strong and weak ties (Augier & Vendelo, 1999; Droege & Hoobler, 2003; Granovetter, 1973; Hansen, 1999, 2002; Levin et al., 2002; Rindfleisch & Moorman, 2001). More recently, research studies have confirmed the relationship between social ties and tacit knowledge transfer (Argote et al., 2003; Levin et al., 2002;

Reagans & McEvily, 2003), and have suggested that the sharing of knowledge that is tacit, ambiguous, or non-codified is improved by strong social ties. In the literature search, no studies were found, however, to have examined the relationship among cultural distance, the strength of social ties, and tacit knowledge sharing.

A MNC in the semiconductor industry was selected for this study. Semiconductor manufacturing process knowledge has been described as an "intertwining of codified and tacit knowledge" (Almeida et al., 2002, p. 147). Several authors discussed the yield losses that semiconductor manufacturers incur because they have difficulty transferring tacit knowledge related to yield improvements among their manufacturing sites (Almeida & Grant, 1998; Almeida et al., 2002; Appleyard et al., 2000; Hatch & Mowery, 1998; Martin & Salomon, 2003b). Some authors have suggested that national culture is one of the obstacles to cross-border sharing of semiconductor process knowledge (Almeida & Grant, 1998; West, 2002). The semiconductor industry has emphasized codification strategies and the use of information and computer technologies to manage knowledge (Almeida et al., 2002; Appleyard et al., 2000). In contrast to this strategy, some authors have pointed to the need for interpersonal relationships and face-to-face communication (Almeida & Grant, 1998; Almeida et al., 2002). Taking all of these factors into consideration, a MNC in the semiconductor industry represented an excellent opportunity to study the relationship among cultural distance, the strength of social ties, and tacit knowledge sharing in MNCs.

## Theoretical Framework

This study is related to the broad general area of international business management. The theoretical basis from which this research is derived is found in the

fields of organizational knowledge, national culture, and social network theory. The literature map is shown in Figure 5. The literature review begins with the topic of knowledge, from the resource-based view of the firm, and discusses the role of tacit knowledge as a source of sustained competitive advantage. Theories concerning the explicit and tacit nature of knowledge are summarized, followed by a discussion of knowledge transfer, including strategies and media for transferring knowledge. The exploration of knowledge transfer is narrowed to the specific case of the MNC, and the obstacles to knowledge transfer in MNCs. Tacitness and differences in national culture are established in the literature as significant obstacles to knowledge transfer in MNCs. Construction of the framework continues with a review of the germinal works concerning differences in national culture and the concept of cultural distance. The importance of social interaction and social networks for transferring tacit knowledge are suggested in the knowledge transfer literature. The framework continues with a review of germinal works in the area of social network theory and the strength of social ties. This literature includes the relationship between strong vs. weak ties and tacit knowledge transfer. Recent research concerning social networks and knowledge sharing are reviewed, followed by a review of recent research concerning social networks and cultural distance. Finally, the context of the study is discussed, establishing the tacit nature of semiconductor process knowledge, the difficulties of its transfer, and works that point to differences in national culture as possible obstacles to transferring process knowledge related to yield improvements in semiconductor manufacturing. The framework establishes the theoretical links between these fields and the study, and identifies gaps in the existing literature. It also identifies alternative viewpoints found in the literature.

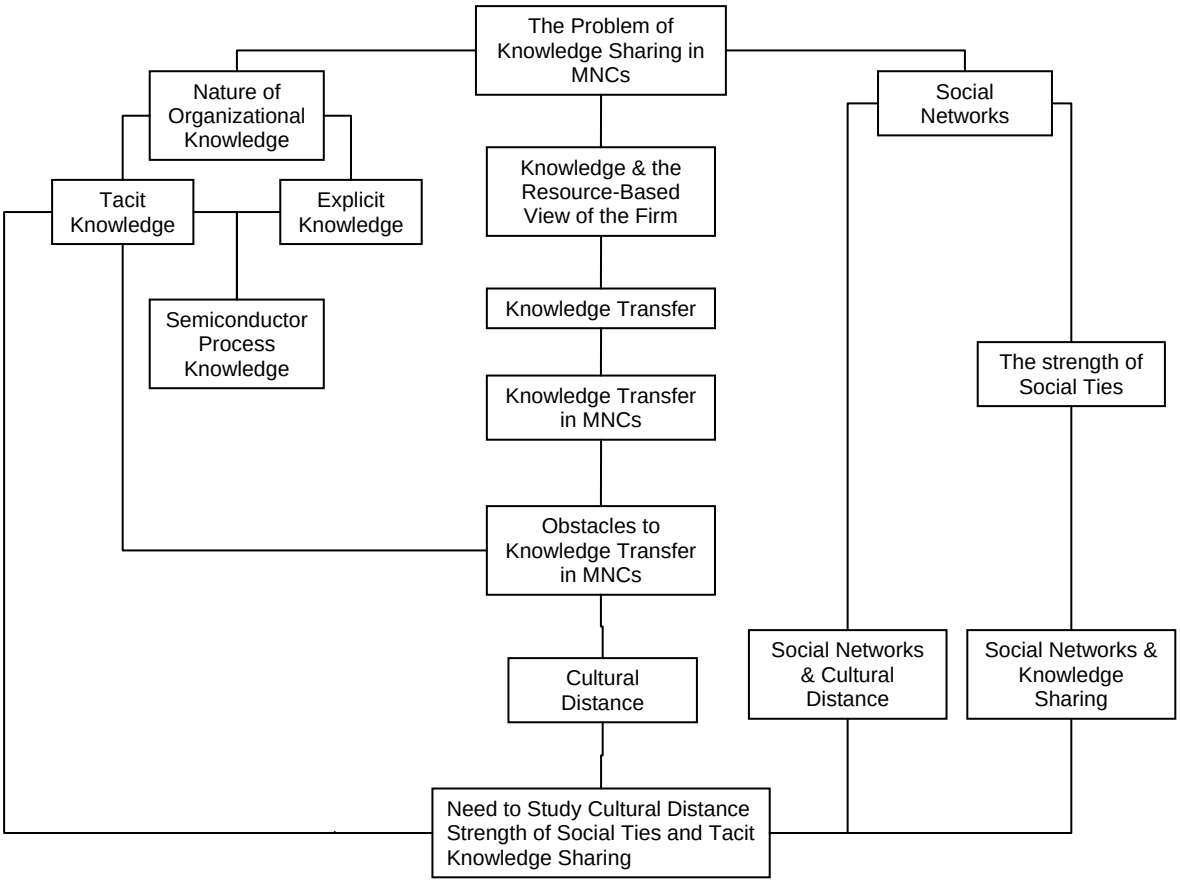


*Figure 5*. Literature review map

## Tacit Knowledge Sharing in MNCs

### *A Resource-Based View of Organizational Knowledge*

*Coasian transaction theory*. The traditional view of the MNC is based on the theory that firms benefit from transaction cost advantages (Coase, 1937) related to ownership, control of technology, and a network of global assets. Coase challenged economic price theorists of his day with a theory of the firm based on transaction costs. Coase proposed that firms come into existence when the costs of organization and production are lower than the cost of negotiating short-term contracts.

*Resource-based view*. An alternative to Coasian, transaction cost theory evolved out of strategic management researchers' efforts to understand the firm's sources of

sustained competitive advantage. A resource-based theory of the firm (Barney, 1991) differs from transaction cost theory in two fundamental ways (Conner, 1991). Transaction cost theory assumes that the same resources are available to all firms, and that markets are capable of carrying out the same activities as firms. Resource-based theory, on the other hand, assumes that resources are heterogeneous among competing firms, and that firms may be more efficient at creating unique combinations of resources. Differences in performance among firms can be explained by the varied capabilities and resources of firms (Barney, 2001). Successful firms are able to maintain these differences as a sustained competitive advantage. In the area of international business, the resource-based view has shown the importance of knowledge flows among subsidiaries in multinational corporations (Barney et al., 2001).

Barney (1991) proposed a resource-based model of sustained competitive advantage. Barney's resourced-based model is built on two key assumptions: (a) resources are heterogeneous and not evenly distributed among competing firms, (b) these heterogeneous resources are not highly mobile. The heterogeneity and immobility of resources does not ensure that they will become sources of sustained competitive advantage. To be a potential source of sustained competitive advantage, a resource must have four characteristics: (a) it must be valuable, (b) it must be rare among competing firms, (c) it must be imperfectly imitable, and (d) it must have no strategically equivalent substitutes. According to Barney, physical technology alone cannot be a source of sustained competitive advantage, because it is possible for others to obtain the same technology. On the other hand, if a firm's advantage arises from the social structure where this technology is embedded, this cannot easily be imitated by other firms.

*Know-how as a resource*. Know-how is a heterogeneous resource that is embedded in the social structure of the firm (Conner, 1991). It is an intangible asset that can lead to value creation (Marr, Schiuma, & Neely, 2004). Know-how is both a potential source of competitive advantage and a problem for firms (Kogut & Zander, 1992). Because know-how is embedded in the social relationships among individuals and groups, it is difficult for competitors to imitate. At the same time, it is also more difficult for firms to transfer and replicate know-how for their own purposes.

*Combinative capabilities*. Kogut and Zander (1992) proposed that from a resource-based view of the firm, an organization's sustained competitive advantage comes from the ability to create and transfer knowledge. They called this the firm's "combinative capability" (p. 384). A firm's combinative capability depends upon the ability to share and synthesize two types of knowledge: information and know-how. At the heart of the difference between these two types of knowledge is the distinction of whether knowledge can be easily codified and communicated to others. According to Kogut and Zander, codified knowledge is supported by symbolic representation. Know-how, on the other hand, is personal knowledge that is generally difficult to represent symbolically. When firms codify personal knowledge for replication it becomes easier for competitors to imitate. Kogut and Zander contended that firms stay ahead of imitators by increasing the speed with which groups within the organization cooperate and share personal knowledge and continuously innovate. Zander and Kogut (1995) argued that a firm's capabilities are the result of individual competencies and the firm's organizing principles that support and coordinate knowledge sharing through social interaction.

*Social community as an advantage*. Kogut and Zander (1996) proposed that a firm should "be understood as a social community specializing in the speed and efficiency in the creation and transfer of knowledge" (p. 503). They suggested that learning and knowledge transfer occur in the social community created by a firm. Communicative action among the members of a social collective is "the source of the processual flows of knowing from which intellectual capital is created" (O'Donnell, 2004, p. 300). Firms can achieve a sustained competitive advantage by creating an environment for discourse and learning. Much of the knowledge that contributes to a firm's sustained competitive advantage is know-how-based tacit knowledge that is difficult to transfer (Kogut & Zander, 1996). Coff and Laverty (2000) proposed that organizations can create strategic knowledge-based assets through the building of social networks to facilitate the diffusion of tacit knowledge.

*Explicit and Tacit Knowledge*

Organizational knowledge includes explicit knowledge that is easily articulated, and tacit knowledge that is difficult to communicate because it is embedded in the social context of the firm (Lane & Lubatkin, 1998). As tacit knowledge has become recognized as a source of sustained competitive advantage, researchers have been drawn to the works of the philosopher Michael Polanyi (1966) and his distinction between tacit and explicit knowledge. The essence of this distinction is captured in Polanyi's (1966) assertion that "we can know more than we can tell" (p. 4). According to Polanyi, tacit knowing has both a functional structure and a phenomenal structure. The functional structure accounts for one's skills and abilities to perform a task. The phenomenal structure is the *un-specifiable* tacit knowing that is the source of this skill or ability. *Explicit knowledge* can be codified

or expressed in symbols, making it transmittable to other people through systematic language (Nonaka & Takeuchi, 1995; Schultz & Jobe, 2001). *Tacit knowledge*, on the other hand, is subjective and experiential (Nonaka & Takeuchi, 1995). It is difficult to codify and transmit to others because it is personal and context specific.

Kogut and Zander (1993) defined tacitness in terms of the codifiability, teachability, and complexity of knowledge. They defined codifiability as the extent to which knowledge can be proceduralized or embedded in drawings and documents. Teachability is a measure of how easily know-how can be taught to workers at other sites. In manufacturing, complexity is related to the type of manufacturing process. In a study of 44 innovations developed by 20 Swedish firms, and subsequently transferred to wholly owned subsidiaries in other countries, Zander and Kogut (1995) found that codifiability and teachability were the most related to tacitness and ease of knowledge transfer.

Blackler (1993) was one of the first to suggest that the rational, cognitive approach to knowledge was being challenged by the tacit and socially constructed nature of knowledge. The implication for organizational management was a shift in focus from objective knowledge to expertise, acquired by individuals working within the social activity system of the organization. Blackler argued that the expert cannot be separated from the context of the activity system, and knowledge cannot be separated from the knower.

Nonaka and Takeuchi (1995) proposed a theory of *knowledge creation*, whereby new organizational knowledge is continually created in a process of *socialization*, *externalization*, *combination*, and *internalization*. Knowledge creation involves sharing tacit knowledge, converting tacit knowledge to explicit knowledge, combining explicit

knowledge to create new knowledge, and converting new knowledge into tacit knowledge.

Cook and Seely Brown (1999) proposed a model of *knowledge* and *knowing* that described the interaction of explicit and tacit knowledge between individuals and groups. In making a distinction between knowledge and knowing, they argued that knowledge is something people possess for the purpose of using in action; where as, *knowing* is a part of action or *epistemic work*. The essence of epistemic work is illustrated in Polanyi's (1966) analogy of riding a bicycle - having *knowledge* of how to ride a bicycle is not the same as *knowing* how to ride a bicycle.

These and other theories that attempt to explain tacit and explicit knowledge in terms of economics and the social sciences have led to two contrasting models of knowledge: (a) an "algorithmic model" (Cowan et al., 2000, p. 216) based on explicit declarative statements that can be transmitted, and (b) an "enculturation model" (p. 216), based on the premise that some knowledge cannot be separated from social context. Cowen et al. suggested that these simplistic models fail to address the distinction between knowledge that is uncodified and knowledge that is likely to *remain* uncodified. Knowledge that is not likely to be codified lies in the realm of know-how and learning by doing. Malerba and Orsenigo (2000) were also critical of the two-dimensional model of knowledge. They suggested that knowledge varies in degrees of *accessibility*, *transformability*, and *cumulativeness* or ease with which it can be combined with or complement other knowledge. These various forms of knowledge may uniquely influence the creation of new knowledge and the innovation and productivity of the firm in ways

that cannot be explained by the simplistic two-dimensional model of tacit and codified knowledge.

Castillo (2002) argued that researchers have strayed from the germinal ideas put forth by Polanyi (1966). Castillo (2002) improved upon existing two-dimensional models by proposing a typology that classified tacit knowledge into four categories: nonepistle, sociocultural, semantic, and sagacious. *Nonepistle tacit knowledge* is very personal, to the point of being an indescribable and unconscious sense of knowing. *Sociocultural tacit knowledge* is the collective system of knowledge or knowing that is held by a group. It develops over time through the interactions of individuals and resides in dispersed bits of tacit knowledge that produce a collective form of unconscious knowing and actions. *Semantic tacit knowledge* is un-verbalized knowledge that requires no explanation beyond a few words, because the meaning is implicit to the receiving party or parties. *Sagacious tacit knowledge* is present in the case of observing a situation, analyzing it at a glance, and arriving at an intuitive or novel solution without conscious consideration. Castillo suggested that this typology should serve as a guide for researchers investigating tacit knowledge.

*Knowledge Transfer*

*Knowledge transfer and organizational learning*. Tacit knowledge transfer is closely associated with organizational learning. Huber (1991) made the following set of assertions concerning organizational learning:

> An organization learns if any of its units acquires knowledge that it recognizes as potentially useful to the organization…more organizational learning occurs when more of the organization's components obtain this knowledge and recognize it as

> potentially useful…more organizational learning occurs when more and more varied interpretations are developed…more organizational learning occurs when more organizational units develop uniform comprehension of the various interpretations. (pp. 89-90)

Through dialog with others and shared understanding, intuitive insight can be integrated into group action and eventually institutionalized by the consensus of the organization (Crossan et al., 1999). Shared understanding requires individuals to communicate, through language and actions. Crossan et al. argued that it is "social processes and group dynamics…that facilitate or inhibit organizational learning" (p. 534). According to Crossan et al., organizational learning has three overlapping processes and levels: (a) Intuiting and interpreting are part of individual learning, (b) interpreting and integrating are part of group learning, and (c) integrating and institutionalizing are the essence organizational learning (Crossan et al., 1999).

*Knowledge transfer strategies.* According to Hansen et al. (1999), knowledge transfer follows two general strategies: a codification strategy or a personalization strategy. Seely Brown and Duguid (2000) argued that these two extremes represent a process versus practice approach to knowledge management. Codification typically relies upon electronic databases to store knowledge so that it can easily be accessed by others. Personalization relies upon the practice of person-to-person contact for tacit knowledge sharing. Codification strategies are based upon the "economics of reuse" (Hansen et al., 1999, p. 110), whereas personalization is based upon the "economics of expertise" (p. 110). Hansen et al. argued that codification strategies are appropriate when knowledge is explicit. When knowledge is tacit, personalization strategies should be employed. They

cautioned that attempts to transform inherently tacit expertise into explicit knowledge may fail if the nuances of face-to-face communication are overlooked.

According to Schultz and Jobe (2001), following a codification strategy requires a MNC to codify large amounts of organizational knowledge in many forms. They identified three principle weaknesses in a codification strategy: (a) All knowledge is not equally important, (b) too much knowledge flow can lead to information overload, and (c) the cost of codifying large amounts of knowledge may be considerable. Additionally, Cummings (2002) found that codified knowledge is not internalized by the recipient during transfer.

Schultz and Jobe (2001) suggested that an organization might prefer to avoid codification, electing instead to keep most knowledge in tacit form. Aside from the weaknesses inherent in codification, an organization might prefer to keep knowledge in tacit form for strategic reasons. Once codified, knowledge is more likely to be imitated.

Hansen and Haas (2001) suggested that task efficiency or productivity is improved through the sharing of codified knowledge, while task quality is improved by sharing personalized knowledge. Personalized knowledge that will improve productivity or quality is distributed across the organization, but may be difficult or time consuming to access. Codified knowledge that is archived in electronic databases for easy access can potentially improve productivity. To realize improved productivity, people must have a way to search for these data. Hansen and Haas argued that codified data from electronic databases will not improve work quality; only personal advice from a colleague can provide insights and the benefit of experience that can lead to improvements in quality.

*Knowledge transfer and information technology.* Most efforts to manage organizational knowledge have focused on information / communication technology (ICT) solutions for building repositories of codified knowledge (Butler, 2003). At the same time, there is evidence that organizations have difficulty motivating workers to use ICT-based knowledge management systems (Huber, 2001). Doz et al. (2001) suggested that companies often make the mistake of believing that ICT is the solution. They argued that ICT-based systems rely upon well articulated information, require standardization, and are not able to convey tacit and context-specific knowledge from which competitive advantage is usually derived. Several authors pointed to the need for face-to-face contact and levels of social interaction that are not supportable by ICT (Butler, 2003; Evans, 2004; Mylonopoulos & Tsoukas, 2003; Persaud et al., 2001; Roberts, 2000). Denning (2001) stated, "ironically, at the very moment that it becomes technologically possible to move information instantaneously around the world, comes the recognition that the context in which knowledge arose is often crucial to understanding or exploiting it" (p. 135).

Roberts (2000) asserted that ICT-based solutions are suited for transferring information and explicit knowledge, but they are not suited for transferring tacit knowledge. According to Roberts,

> The transfer of tacit knowledge often requires proximity between the transmitter and receiver. Videoconferencing and virtual project rooms may aid the transfer of tacit knowledge. Nevertheless, such technologically facilitated communication cannot at present replace the direct face-to-face contact that is often a prerequisite for the successful transfer of tacit knowledge. (p. 434)

Information and communications technologies attempt to achieve knowledge management by disembedding information and knowledge from knowledge work, and knowledge from the knower (Mylonopoulos & Tsoukas, 2003). The tacit and non-deterministic nature of knowledge makes it difficult to disembed knowledge from the knower and from its organizational context. Mylonopoulos and Tsoukas argued that the social nature of knowledge requires that ICT-enabled knowledge management systems must support social interaction. Haythornthwaite (2002) contended that, from a social network perspective, the use and effectiveness of electronic and non-electronic forms of communication depend more upon the strength of social ties between individual than on the type of media.

Many organizations realize that technology-supported media are not a substitute for face-to-face personal interaction (Persaud et al., 2001). In a study of 231 research and development labs in 45 Canadian, U.S., Japanese, and European high-technology MNCs, Persaud et al. found that once personal relationships have been established, technology based solutions may become more effective for knowledge sharing. They cautioned that technology solutions may not produce the desired outcomes in terms of knowledge sharing and sustained competitive advantage. The U.S. Department of the Navy acknowledged in their Information Management & Information Technology Strategic Plan FY2002-2003 (as cited in Evans, 2004) that superior performance cannot be achieved alone through the use of information technology.

Butler (2003) challenged ICT professionals' claims that knowledge management systems can capture organizational knowledge and render it useable by organizations. Butler studied the experience of an Irish software developer in implementing case-based

reasoning systems (CBR). Butler found that these systems did not meet the developer's claims for capturing, transferring, and, deploying organizational knowledge held by domain experts. Butler argued that ICT solutions, such as CBR, are functionalist in nature and are only able to deal with data. He suggested that "knowledge management requires social as opposed to technical support, in the appropriate institutional mechanisms" (p. 145) that can support the social context of knowledge.

*Knowledge transfer and communities of practice*. A community of practice is defined as a group of individuals informally united around an action in which they find common meaning (Lave & Wenger, 1991). According to Wenger and Snyder (2000), communities of practice existed among corporations of craftsmen in Greek society and in the form of guilds in the Middle Ages. Communities of practice differ from teams and other organizational forms in that they emerge around areas of practice, they grant authority based on expertise, are responsible only to one another, and develop their own processes (Lesser & Storck, 2001). Communities of practice have become associated with virtual communities connected via ICT (Ardichvili et al., 2003), which may not necessarily result in the formation of actual communities. Several authors have cited the failure of virtual communities of practice to live up to expectations as a knowledge management tool (Ardichvili et al., 2003; Bansler & Haven, 2003; King, 2002; Somekh & Pearson, 2002; Ward, 2000).

According to Ward (2000), strong communities of practice require physical collocation, or at least occasional face-to-face contact. Somekh and Pearson (2002) argued that a virtual community lacks the sense of accountability that individuals normally feel when they are collocated.

The World Bank implemented an extensive web-based system of communities of practice around thematic groups (King, 2002). King argued that much of the data found in the Bank's thematic sites was information rather than knowledge. King suggested that the level of critical analysis work being carried out by the Bank actually declined. He further contended that despite the Bank's well supported system, many employees did not participate in the communities of practice.

Bansler and Haven (2003) conducted a case study of a failed web-based knowledge sharing system among geographically dispersed middle managers in a multinational corporation. They cited five reasons for the failure of this community of practice: (a) Managers did not have time to participate, (b) there were no incentives for contributing to the system, (c) managers felt that sharing accomplishments might be viewed as boasting, (d) managers preferred to share best practices in their own personal networks, and (e) managers felt that most contributions had local rather than a global relevancy.

Ardichvili et al. (2003) studied knowledge-sharing communities of practice in a multinational heavy equipment manufacturer with operations in 100 locations in over 20 countries. The focus of the study was three established communities with more than 1000 members. They concluded that the success of virtual communities depends upon members' willingness to share knowledge in an on-line environment and to use the community as a source of knowledge. They found that the most significant barrier to using virtual communities of practice as a source of knowledge is that people have their own personal networks, based on relationships developed over time.

*Knowledge transfer and social context.* Organizational knowledge is socially produced (Abou-Zeid, 2002, p. 33), and contextually bound to an organization's culture. Shared understanding develops in the context of shared space (Gill, 2004; Nonaka & Konno, 1998). The more contextually similar are two organizations, the more likely are knowledge transfers between them to be successful (Dinur, 2002). Gill (2004) argued that the concept of shared knowledge is a human-centered approach to technology, which is in contrast to the dominant techno-centric rational approach. According to Gill, "the very concept of shared knowledge space assumes the existence of diversity and therefore associated notions of human dimensions such as those of ambiguity, uncertainty, creativity, judgment, ingenuity that form part of the tacit dimension of shared space" (p. 2). In the Japanese language, the word *ba* describes "a shared space for emerging relationships" (Nonaka & Konno, 1998, p. 40). This shared space may be physical, virtual, or mental. In Japanese philosophy, *ba* provides the context from which shared meaning and collective knowledge develop.

Nidumolu, Subramani, and Aldrich (2001) pointed to firms' failure to consider the "situated knowledge web" (p. 115) as a factor in the limited success of their knowledge management programs. In a 13 month ethnographic case study of a market research organization, they pointed to the need to understand the "patterned interactions" (p. 116) of individuals within an activity system. The situated knowledge web described by Nidumolu et al. is the formal and informal network of knowledge sharing in an organization. They contended that because much of the most valuable knowledge to the firm is context specific, the informal web is more effective than the formal structure.

Also, the dispersed nature of knowledge resources necessarily makes administrative and political control of the situated knowledge web difficult.

*Managing knowledge transfer.* Practices for managing intellectual capital in the industrial age are no longer appropriate for the tacit knowledge of the knowledge economy (Johnson, 2002). According to Starbuck (1992), coordination and control in knowledge intensive firms is generally accomplished through norms and values rather than the formal hierarchy. Seely Brown and Duguid (2001) noted how developments in the early semiconductor industry came from small groups of individuals working unfettered by organizational structure. They argued that creative developments were possible because of "shared knowledge, inherent coordination, and collective understanding" (p. 93). Seely Brown and Duguid suggested that a company needs the discipline of formal structure and processes without constraining creativity. They contended that the best companies learn how to manage both. This may require a certain amount of intentional management and a certain amount of "intentional unmanagement" (Rowland, 2004, p. 45).

Managers in MNCs are responsible for creating the organizational environment where social interaction among individuals supports the creation, utilization, and accumulation of globally dispersed knowledge (Ensign, 1999). Learning may remain individual or it may become collective, depending upon the willingness and motivation (Kalling, 2003) of individuals to share knowledge and experiences (Lehesvirta, 2004). Lehesvirta argued that managers who understand the process of organizational learning will create the environment and opportunities that motivate people to share knowledge. Similarly, Daghfous (2004) referred to a firm's "absorptive capacity" (p. 21), which

depends upon the different absorptive capacities of its individual employees, and the firm's ability to combine these through policies, procedures, and coordination that support social interaction.

*Measuring knowledge transfer*. Capital and labor are easily measured, but knowledge is an elusive asset that is difficult to measure (Starbuck, 1992). Knowledge may not even reside with individuals, but rather it may be embedded in the equipment, routines, and culture of the organization. Because knowledge assets are embedded in the organizational context and the complex value creation process, knowledge transfer is difficult to measure (Marr & Spender, 2004). Martz and Shepherd (2003) suggested that companies may not be capturing the benefits of explicit and tacit knowledge sharing if they rely on traditional economic accounting measures for organizational learning. The only measure of an organization's ability to share tacit knowledge may be whether or not the organization is generally moving in the right direction (Marr & Spender, 2004).

*Knowledge Transfer in MNCs*

*Exploiting superior capabilities.* Firms typically invest abroad for one of two reasons: (a) to exploit their existing capabilities or (b) to acquire new capabilities (Chung (2001). From the traditional perspective, "the multinational corporation is an economic organization that evolves from its origins to spanning across borders" (Kogut & Zander, 1993, p. 426). Multinational corporations are attracted to invest in developing markets where they can exploit their unique capabilities (Chung, 2001). The headquarters serves as the source of innovation and knowledge for the rest of the organization (Gupta & Govindarajan, 1991). According to Zander and Solvell (2000), in the recent past MNCs followed a projectionist strategy of investing in foreign subsidiaries and transferring or

replicating their technological capabilities to those subsidiaries. This strategy increased in use among MNCs in the postwar period. Despite the postwar prevalence of the projection strategy, firms are finding that it is difficult to exploit superior knowledge through the use of foreign direct investment unless they are able to overcome the difficulties inherent in transferring tacit knowledge (Martin & Salomon, 2003a, 2003b). Zander (2002) suggested that the view of multinational advantage is shifting from firm-specific capabilities, expanding markets, and financial factors to the innovative capacity that comes from combining geographically dispersed knowledge.

*Acquiring capabilities.* Firms also choose foreign direct investment as a means to acquire new knowledge and capabilities (Chung & Alcacer, 2002). Kogut and Zander (1993) suggested that MNCs may use subsidiaries as a means to acquire new knowledge from foreign markets and to combine it with the global knowledge of the firm. From the resource-based view, firms are more efficient at this than markets, which is the basis for the advantage held by MNCs. Multinationals who have pursued diversification of technological capabilities often establish "centers of excellence within the multinational network" (Zander & Solvell, 2000, p. 53), allowing them to benefit from integrating and recombining these diverse capabilities. Multinational corporations may not realize a sustained competitive advantage from subsidiaries if they do not share their knowledge effectively across the global organization (Buckley & Carter, 1999).

*The role of subsidiaries*. Ghoshal and Bartlett (1988) proposed that subsidiaries of MNCs have a three fold role that includes the creation, adoption, and diffusion of innovation. In this role, subsidiaries of MNCs are a strategic source of knowledge creation in the expanding global economy (Gupta & Govindarajan, 1991). There was a

time when "globalization meant 'teaching the world' from headquarters, or from subsidiaries in advantaged locations or dominant clusters" (Doz et al., 2001, p. 10). As globalization has increased, the knowledge necessary to compete in the global economy no longer resides in one location. Rather, it is globally dispersed and sometimes found in small pockets on the edge of or outside of the organization's sphere. Doz et al. (2001) suggested that when superior knowledge existed in the corporate home, multinational corporations capitalized on it by co-location of experts. The co-location of individuals with technical, marketing, and competitive knowledge enabled the sharing of tacit knowledge, and facilitated the creation of new knowledge and innovations from the corporate home. Doz et al. suggested that in a world of dispersed knowledge, companies need a strategy that achieves the same melding of tacit knowledge, in the absence of co-location.

*Global collaboration and knowledge transfer*. Global markets and knowledge management are the two most significant challenges facing international business management in the next century (Garcia & Vano, 2002). In the area of knowledge management, one of the major challenges is maintaining global collaborative networks that support knowledge transfer. Cantwell and Santangelo (2000) suggested that the opportunity for innovative profits by MNCs comes from the combining of technological knowledge that occurs as a result of cross-border interaction within the MNCs corporate network. Tacitness increases the difficulty and consequently the cost of combining and transferring this knowledge (Martin & Salomon, 2003b). If MNCs are not successful in creating an environment for knowledge sharing to occur, transferring tacit knowledge by codification strategies may be uneconomical. Consequently, the ability to transfer and

deploy tacit knowledge has become a strategic concern for MNCs (Subramaniam & Venkatraman, 2001). Tacit knowledge must be "disseminated quickly and seamlessly across functional levels, borders, and cultures" (Marquardt & Reynolds, 1994, p. 32), to support the creation of new knowledge that is essential to organizational growth and survival. Several studies have pointed to the importance of social interaction between individuals in MNCs to build the social capital (Hitt, Lee, & Yucel, 2002; Hoegl, Parboteeah, & Munson, 2003; Lesser & Storck, 2001) that supports knowledge transfer (Ghoshal & Bartlett, 1988; Persaud et al., 2001; Subramaniam & Venkatraman, 2001). Despite a growing awareness of the importance of knowledge sharing, Gupta and Govindarajan (2000) suggested that knowledge sharing among subsidiaries in MNCs occurs to a much lesser extent than perceived by executive management.

In a study of 38 cases of innovation in nine multinational companies, Ghoshal and Bartlett (1988) found that nearly all of the highly innovative MNCs had dense patterns of formal and informal intra- and inter-unit communication. They facilitated cross-functional teams, committees, and taskforces. Regular communications between individuals in subsidiaries and headquarters, in some cases on a daily basis, were common among the innovative MNCs. Managers in the highly innovative MNCs had regular travel schedules that allowed face-to-face meetings and the development of personal relationships.

Persaud et al. (2001) studied the knowledge creation and transfer process among globally dispersed research and development labs in an MNC. They posited that "in order to tap into the knowledge base of their globally distributed R&D [*sic*] network, an MNC must foster among its R&D [sic] staff synergistic innovative relationships" (p. 12). They

argued that research and development professionals must "feel comfortable sharing knowledge with their counter parts in other parts of the organization" (p. 12). They suggested that knowledge sharing is more challenging in MNCs because of language and cultural differences among globally dispersed professionals, and because of the tacit nature of some knowledge. According to Persaud et al., cultural differences between individuals affect the creation, sharing, and dissemination of knowledge in MNCs. They suggested that tacit knowledge is particularly influenced by differences in cultural context that can lead to different interpretation between knowledge partners in the knowledge transfer process.

Based on a study of 90 transnational product introductions by MNCs, Subramaniam and Venkatraman (2001) suggested that a key component of success was the organization's ability to transfer and deploy tacit knowledge. They suggested that cultural differences between countries are a key obstacle to the transfer of tacit knowledge. They found that the ability to transfer tacit knowledge is increased by the use of cross-national teams whose members have previous international experience, regular communication, and rich communication channels.

Schulz (2003) argued that little of the existing research on organizational knowledge has examined the processes by which knowledge evolves in organizations. He pointed to the need for a coherent theory of knowledge transfer to understand how MNCs can efficiently combine and utilize globally dispersed knowledge. Schulz suggested that "knowledge flows are of particular importance for multinational corporations because they tend to span large geographical, cultural, and organizational distances" (p. 441).

*Obstacles to Knowledge Transfer in MNCs*

*Knowledge ambiguity*. Simonin (1999) discussed the ambiguous nature of knowledge and the role of "knowledge ambiguity" (p. 463) in multinational knowledge transfer. Simonin identified seven antecedents of knowledge ambiguity: (a) tacitness, (b) asset specificity, (c) complexity, (d) experience, (e) partner protectiveness, (f) cultural distance (Kogut & Singh, 1988), and (g) organizational distance. In a study of 151 MNCs, Simonin (1999) assessed the simultaneous influence of these variables on knowledge transfer. *Tacitness* was revealed in this study to have the greatest influence on knowledge ambiguity. *Cultural distance* (Kogut & Singh, 1988) was also found to significantly affect knowledge ambiguity. Knowledge ambiguity was moderated over time by the experience of cross-cultural collaboration.

*Tacitness*. The tacit nature of knowledge is a *cognitive* barrier to knowledge sharing and organizational performance (Hoopes & Postrel, 1999; Huber, 2001). In a case study of a software development firm, Hoopes and Postrel demonstrated how gaps in shared knowledge can lead to costly errors for a MNC. They suggested that superior capabilities come from superior organizational integration of knowledge. They further suggested that integrating mechanisms that support "unique patterns of *shared* knowledge" (p. 838) can contribute to a firm's sustained competitive advantage because they cannot be competed away. Integration of knowledge is complicated, however, by the often tacit nature of the knowledge that people use to solve problems. Huber (2001) suggested that cognitive barriers to knowledge sharing may be linked to the tacit nature of knowledge and the recipient's difficulty absorbing knowledge without sufficient contextual background. According to Hoopes and Postrel (1999), creating the

environment for social interaction that potentially can overcome the cognitive barriers of tacit knowledge sharing may require a substantial time commitment of individuals across the organization.

In a study of 133 divisions of U.S.-based MNCs in China, India, and Russia, Lord and Ranft (2000) found that the more tacit knowledge is, the more difficult it is to codify, and the less likely it is to be shared among divisions in the organization. They examined the relationship between 11 independent variables and the transfer of local market knowledge. Of all the factors studied, *tacitness* was the most negatively correlated with knowledge transfer.

*Organizational culture*. The organization's culture can be an obstacle to knowledge transfer. Bartlett and Ghoshal (1998) argued that the major obstacle to organizational learning and knowledge sharing in organizations is the vertical structure and financial focus that inhibits personal relationships and the horizontal flow of knowledge. They suggested that organizations must create informal horizontal communication channels to diffuse the knowledge that gets stuck and protected within the formal organizational structure. According to Bartlett and Ghoshal, this requires an environment of trust and an integrated network of collaboration that supports knowledge flows.

In a study of more than 50 organizations that have knowledge management strategies, De Long and Fahey (2000) found that organizational culture is a major obstacle to realizing the benefits from organizational knowledge. According to De Long and Fahey, organizational culture creates the context that can either support or discourage social interaction. The characteristics of a culture that leverages knowledge creation are

frequent interaction, collaborative problem solving, seeking out existing knowledge and expertise, and knowledge sharing instead of knowledge storage.

*National culture.* Differences in national culture may affect organizational performance and organizational learning. Palich and Gomez-Mejia (1999) suggested that national culture is an element of the relatedness between business units, and that MNCs will operate more efficiently when units are more culturally related. They argued that when units of an MNC are more culturally related, the MNC will also be more efficient at sharing knowledge. According to O'Keeffe (2003), the fit between country cultures is a key consideration for MNCs attempting to employ advanced technologies in globally dispersed operations. He argued that organizational learning in a MNC is increasingly dependent upon learning networks and the ability to create knowledge and transfer it across borders. Palich and Gomez-Mejia (1999) pointed to the need for further research concerning the relationship between cultural diversity in MNCs and the firm's performance. They suggested that Hofstede's (1980) dimensions of national culture and Kogut and Singh's (1988) measure of cultural distance may be useful measures to test propositions concerning the effects of national culture.

## National Culture and Cultural Distance

### *Difference in National Culture*

Hofstede (1980, 2001) defined culture as collective programming of the human mind that distinguishes one group of humans from another. According to Hofstede (2001), each person possesses *mental programs* that guide behavior. Human mental programming exists at three levels: *individual, universal,* and *collective*. The *individual* mental program of each person is unique, and at least partly inherited. *Universal*

programming includes human instincts and the biological systems shared by humankind. *Collective* mental programming is shared by people who belong to the same group or category. According to Hofstede, *national culture* resides at the collective level of mental programming.

All societies must cope with similar problems, but they do so in varying ways (Hofstede, 2001). In two studies involving 116,000 IBM employees in 40 countries, Hofstede (1980) identified four common dimensions that empirically defined these differences in national cultures: (a) *power distance*, (b) *uncertainty avoidance*, (c) *individualism*, and (d) *masculinity*. Through his continuing research, Hofstede (2001) expanded the data to include more than 50 countries, and also added a fifth dimension, *long-term orientation*, based on the Chinese Values Survey developed by Michael Harris Bond (Hofstede & Bond, 1984). Hofstede (2001) found that these five dimensions were present to varying degrees in all of the national cultures that he studied.

*Power distance*. Human inequality is one of the basic issues faced by all societies (Hofstede, 2001). Societies vary in the ways in which they cope with the issues of inequality and dominance in human relationships. In organizations, this inequality is manifest in the boss-subordinate relationship. Hofstede argued that the level of power and control that bosses and their subordinates accept in the hierarchy is related to national culture.

Hofstede (1980, 2001) derived a Power Distance Index (PDI) for each country from the mean score for three questions: (a) subordinates' fear of disagreeing with their boss, (b) subordinates' perception of their bosses as autocratic or persuasive / paternalistic decision makers, and (c) subordinates' preference for their bosses style to be autocratic

versus democratic. The PDI is represented on a scale from zero to 100, with 100 equating to large power distance. Malaysia ranked highest with a PDI of 104, and Austria ranked lowest with a PDI of 11.

*Uncertainty avoidance*. Another basic fact of human existence is uncertainty (Hofstede, 2001). Societies differ in the ways in which they cope with the inherent uncertainty of the future. Hofstede proposed that societal tendencies toward "prejudice, rigidity and dogmatism, intolerance of different opinions, traditionalism, superstition, racism, and ethnocentrism" (p. 146) are related to an intolerance of ambiguity, that he defined as Uncertainty Avoidance. Triandis (2004) described Hofstede's (1980, 2001) dimension of Uncertainty Avoidance in terms of tightness or looseness of cultural rules and norms. He suggested that a preference for structure and predictability is associated with tightness or high uncertainty avoidance.

Hofstede (1980, 2001) derived an Uncertainty Avoidance Index (UAI) for each country based on the mean score of three questions: (a) employees' perception that company rules should never be broken, (b) employees' preference for stability of employment with their employer, and (c) employees' perception of stress levels in their work. The UAI country index is based on a scale of zero to 100, with 100 equating to a high level of uncertainty avoidance. Greece was ranked the highest with a UAI of 112, and Singapore was ranked lowest with a UAI of 8.

*Individualism versus collectivism*. Hofstede (2001) identified the relationship between the individual and collective society as a third societal issue that is common to all cultures. At the heart of differences in individualism versus collectivism are societal norms and values that affect the concept of the self related to others and the person

related to the organization. Hofstede suggested that in collectivist cultures there is greater emotional dependence by people upon institutions and organizations, while in individualist cultures there is emotional independence. Collectivist cultures emphasize belonging and membership, while individualist cultures emphasize individual initiative and achievement. Collectivist cultures value expertise, order, duty, and the security of the organization, while individualists value autonomy, variety, pleasure and individual financial security. In collective cultures group decision making is preferred, as opposed to individual decisions. In collectivist cultures much that is communicated is implicit and context specific, while individualist cultures rely more on explicit communication.

Triandis (2000) suggested that patterns of social interaction are different among collectivist and individualist cultures. According to Triandis, people in individualist cultures tend to sample the content of communications, while people from collectivist cultures tend to sample the context of communications. The sampling of context versus content often leads to miscommunication. According to Triandis, miscommunication between members of different cultures often goes undetected, because people mistakenly believe that others are similar to themselves. For example, individualist often attributed behavior to internal factors such as attitudes and personalities, while collectivists tend to attribute behaviors to external factors (Triandis, 2004). Differences between linear and non-linear thought patterns, and abstract versus associative reasoning are other sources of misunderstanding (Triandis, 2000). Some authors (Bhagat et al., 2002; Triandis, 2004) have suggested that individualism-collectivism is the most important of Hofstede's (1980, 2001) dimensions of national culture.

Hofstede (2001) derived the Individualism Index (IDV) from the mean country scores for a set of work-goal related questions. Individualism was positively related to three specific work-goals: personal time, freedom, and challenge. Hofstede suggested that these three work goals emphasize the individual's independence from the organization. Individualism was negatively related to three other work goals: use of skills, physical conditions, and training. He suggested that these work goals emphasize the individual's dependence on the organization. Like Hofstede's other indices, the IDV index is scaled from zero to 100, with high individualism associated with increasing score. The United States ranked number one in individualism with an IDV score of 91. Guatemala ranked lowest with an IDV of 6.

*Masculinity versus femininity*. Hofstede (2001) contended that biological differences between the sexes and the related gender roles in society are one of the first issues with which any society must cope. Hofstede suggested that male dominance in most societies is the result of common gender roles of male assertiveness and female nurturance. According to Hofstede, "men are concerned with economic and other achievements and women must be more concerned with taking care of people and children in particular" (p. 280). Although these general roles are common, Hofstede contended that there are variations between national cultures. These gender role variations are thought to begin in the family unit, but their influence extends into other areas of society. Hofstede proposed that variations in gender role patterns across cultures influence the perceived importance of work goals between men and women. Hofstede measured the importance of 22 work goals to men and women across nine occupations. Within the data from all countries sampled, he identified two bipolar factors:

intrinsic/extrinsic and social/ego. Work goals with intrinsic/extrinsic polarities were not found to be gender related. Conversely, work goals with social/ego polarities were related to gender differences. The social factor correlated with female preferences, including cooperation and interpersonal relationship with their manager. The ego factor correlated with male preferences, including earnings and advancement.

Hofstede (2001) derived a Masculinity Index (MAS) for each country based on the mean score across eight social/ego work goals: manager, cooperation, desirable area, employment security, challenge, advancement, recognition, and earnings. The MAS index ranged from zero to 100, with 100 equating to high masculinity. A country with high masculinity demonstrated a preference for ego related work goals while a country with low masculinity indicated a preference for social related work goals. Japan ranked highest in masculinity, with an MAS score of 95, and Sweden ranked lowest with an MAS score of 5.

*Long- versus short-term orientation*. The final dimension of national culture identified by Hofstede (2001) grew out of a concern that the original research represented a Western bias. Long-Term Orientation (LTO) emerged as an additional dimension in data from the Chinese Values Survey (CVS) developed by Michael Harris Bond (Hofstede & Bond, 1984). The CVS was based on an inventory of Eastern values surveyed among 100 students (50 male and 50 female) in each of 23 different countries. The CVS included a dimension that was not addressed in Hofstede's (1980) original research questions: Long- versus Short-term Orientation. Long-term orientation was associated with a preference for three values: persistence (perseverance), ordering of relationships by status, and having a sense of shame. A short-term orientation was

associated with four values: personal stability, protecting one's own face, respect for tradition, and reciprocation of favors.

Hofstede (2001) developed the LTO index on a scale from zero to 100, based on the CVS factor scores for the eight values revealed by the CVS. China ranked highest with an LTO score of 118. Pakistan ranked lowest with a score of zero.

*Seven Cultural Dilemmas*

Hampden-Turner and Trompenaars (1993) suggested that people from different national cultures base decisions concerning common dilemmas upon different values. In a study of 15,000 managers from Europe, the U.S., and Asia who attended management training at the Center for International Business in the Netherlands, Hampden-Turner and Trompenaars asked managers to respond to several decision-making dilemmas. From these responses they concluded that people from different national cultures base their response on different underlying assumptions. They grouped these assumptions into seven dichotomous value dimensions: (a) universalism – particularism, (b) analysis – integration, (c) individualism – communitarianism, (d) inner direction – outer direction, (e) sequential time – synchronized time, (f) achieved status – ascribed status, and (g) equality – hierarchy. Trompenaars (1996) argued that international managers must understand these differences between cultures in order to minimize conflict in the relationships among international colleagues. Hampden-Turner and Trompenaars (2000) suggested that these dichotomous dimensions represent value choices that all people must make. They contended that international managers must develop cross-cultural competence in integrating culturally different values for reconciling these dilemmas.

*Cultural Distance*

The concept of cultural distance (Kogut & Singh, 1988) has it origins in studies of acquisitions, mergers, and foreign direct investment decisions by MNCs. In a search of the literature on cultural distance, most of the existing studies were found to have examined the relationship between cultural distance and a MNC's choice of entry mode in foreign markets (Brouthers & Brouthers, 2001; Kogut & Singh, 1988) or a MNC's performance (Kessapidou & Varsakelis, 2002; Luo, 2001, 2004; Morosini et al., 1998; Ross, 1999). In one study closely related to this research, Manev and Stevenson (2001) examined the relationship between cultural distance and the development of social ties among managers in MNCs.

Kogut and Singh (1988) theorized that "the more culturally distant are two countries, the more distant are their organizational characteristics on average" (p. 414). Consequently, the costs and uncertainty of entry into foreign markets are increased. They studied 228 cases of entry into the U.S. market through acquisitions, new greenfield investments, and joint ventures. Their findings supported the proposition that differences in national culture affect the choice of entry mode by MNCs. They also suggested that cultural distance may be a factor in other types of managerial decision-making in MNCs.

Kogut and Singh (1988) developed a composite index for the average *cultural distance* between The United States and other countries, based on Hofstede's (1980) original four dimensions of national culture: power distance, uncertainty avoidance, masculinity/femininity, and individualism. Their composite index was computed as "the deviation along each of the four cultural dimensions...corrected for differences in the

variances of each dimension and then arithmetically averaged" (Kogut & Singh, 1988, p. 422), as shown in Figure 6.

$$CD_j = \sum_{I=1}^{4} \{(I_{ij} - I_{iu})^2 / V_i\} / 4$$

*Figure 6*. Equation for average cultural distance. *Note.* Proposed by Kogut and Singh (1988). $CD_j$ is the cultural distance of the *j*th country from the U.S. $I_{ij}$ is Hofstede's (1980) index for the *i*th cultural dimension and *j*th country. $I_{iu}$ is Hofstede's index for the *i*th cultural dimension and the U.S. $V_i$ is the statistical variance of the index data for the *i*th cultural dimension.

Morosini et al. (1998) contended that previous research concerning cultural distance and foreign expansion by MNCs had paid little attention to the effects of cultural distance on firm performance in cross-border acquisitions. In a study of 52 cross-border acquisitions by Italian firms between 1987 and 1992, they tested the relationship between cultural distance and acquisition performance. Morosini et al. suggested that cultural distance actually increases acquisition performance. While this seems at first to be a contradiction, they theorized that firms may be attracted to acquisitions in culturally distant countries because routines and repertoires related to innovation may be more difficult for a firm to replicate without a merger or acquisition.

In a variation of the formula by Kogut and Singh (1988), Morosini et al. (1998) computed cultural distance as the total Euclidian distance between two countries based on Hofstede's (1980) original four indices, as shown in Figure 7.

$$CD_{ju} = \sqrt{\sum_{I=1}^{4} (I_{ij} - I_{iu})^2}$$

*Figure 7.* Equation for total or Euclidean cultural distance. *Note*. Proposed by Morosini et al (1998). $CD_{ju}$ is the cultural distance for the *j*th country from the *u*th country. $I_{ij}$ is Hofstede's (1980) index for the *i*th cultural dimension and *j*th country. $I_{iu}$ is Hofstede's (1980) index for the *i*th cultural dimension and from the *u*th country.

Ross (1999) examined the fit between a MNC's business strategy and Hofstede's (1980) dimensions of national culture. In a study of U.S. firms operating in China, Ross attempted to show how each dimension of national culture may affect business strategy. He emphasized the importance of building trust to overcome cultural distance with cultures such as China, where relationships are highly valued. In a study of international cooperative ventures in China, Lou (2001) suggested that the personal attachment of boundary spanners was negatively affected by cultural distance. Lou (2004) found that cultural distance was a more significant factor than time-based experience in the success of foreign investments in China.

Brouthers and Brouthers (2001) studied cases of multinational entry in central and eastern European countries by 231 firms from the Netherlands, Germany, Britain, and the United States. They found that investment risk has a moderating effect on the relationship between cultural distance and choice of entry mode by MNCs.

In a study of 487 foreign firms operating in Greece, Kessapidou and Varsakelis (2002) studied the relationship between cultural distance and firm performance. They used the measure of cultural distance defined by Kogut and Singh (1988). Their findings suggested that better performance by Greek affiliates was

associated with higher cultural distance between the culture of the parent company and the Greek culture.

Shenkar (2001) suggested that inconsistent results obtained by researchers studying the relationship between cultural distance and market entry mode by MNCs may be the result of conceptual and methodological problems with the cultural distance construct. He argued that while the measure of cultural distance provides a simple and standardized way to quantify the differences between national cultures, the construct may over simplify the complex, intangible, and subtle nature of culture. Shenkar provided several recommendations for improving the measure of cultural distance. He argued that the aggregating of Hofstede's (2001) indices in the cultural distance measure must be theoretically justified or else be replaced by the selected use of one or more of the indices. Shenkar recommended that researchers should control for cultural attraction, acculturation, and the previous foreign experience of individuals in studies involving cultural distance. He also recommended that cultural distance be considered as both an independent variable and a dependent variable.

Manev and Stevenson (2001) conducted a unique study involving cultural distance and social ties. In a social network study of 457 managers in a MNC, Manev and Stevenson (2001) studied the relationship between nationality, cultural distance, expatriate status, and the formation of strong ties. They used the formula for cultural distance developed by Morosini et al. (1998). Manev and Stevenson (2001) concluded that more culturally distant managers were likely to have strong instrumental ties, while less culturally distant managers were more likely to have strong expressive ties. According to Manev and Stevenson, the transfer of work related information depends

upon instrumental ties, rather than expressive ties, and work related information is transferred regardless of cultural distance. They suggested that managers in MNCs should promote social interaction and cross-border teams to increase both instrumental and expressive tie strength.

Holden (2001) offered that in the global economy "all activities of knowledge management involve acts of cross-cultural exchange: from one language to another, through arrays of networks, as forms of inter- and intra-organizational relationship management" (p. 155). He suggested that the existing literature has not addressed the relationship of all factors that make up diversity in the relationship between knowledge partners, including language, national culture, ethnic origin, and others. Vast amounts of knowledge exist in languages other than English. Tacit knowledge, which can be a source of competitive advantage, is globally dispersed among people who are embedded in the context of local and national culture. Holden suggested that cultural distance and a lack of trust between individuals inhibit cross-border knowledge transfer. Tacit knowledge looses its cultural context and risks being poorly understood when it is transferred to another culture. According to Holden, the challenge for managers in MNCs is to establish the organizational environment that encourages "mutual learning, interactive networking, and knowledge sharing" (p. 161).

## The Strength of Social Ties

### *Social Networks*

Krackhardt and Hanson (1993) suggested that the informal organization structure is more important than the formal structure. They identified three types of informal social networks that are thought to be present to some extent in all organizations: (a) the advice

network, (b) the trust network, and (3) the communication network. Social networks facilitate employee "interaction, collaboration, and access to non-redundant tacit knowledge" (Droege & Hoobler, 2003, p. 56). In MNCs, intra-organizational networks facilitate intra-unit knowledge transfer and learning, and are a considered to be source of competitive advantage (Tsai, 2001). Cross, Parker, Prusak, and Borgatti (2001) suggested that "as we move further into an economy where collaboration and innovation are increasingly central to organizational effectiveness, we must pay more attention to the sets of relationships that people rely on to accommodate their work" (p. 101).

A social network is comprised of a set of social actors and the relations or ties among them (Fienberg et al., 1985; Wasserman & Faust, 1999). A social network exists when at least one path of social relationships can be traced among a set of individuals (Moody & White, 2003). Social network analysis has its roots in social anthropology and sociometry (Marsden, 1990). Moreno (1934) is credited as being the first social scientist to study social networks of individuals and to have used mathematics to analyze sociometric data (Fienberg et al., 1985). Following the work of Moreno (1934), cultural anthropologists began to employ the concept of social networks to explain roles and position within a social structure. Mathematics and graph theory were employed as analytical tools, solidifying social network analysis as a rational tool for scholarly research in the field of sociology (Cross, Borgatti, & Parker, 2002).

Sociometric data are typically represented as directed graphs or "digraphs" (Fienberg et al., 1985, p. 52), where nodes and arcs represent the connections between actors. The connections for a single type of relation among a set of N actors can also be represented as an N x N sociomartix. Multivariate relations are represented by multiple

matrices. Sociometric variables may be binary or valued. Binary data are used to represent choice, or the presence of dyadic relationships. Valued data are used to represent the strength of dyadic relationships. A dyad is any pair of actors and the tie(s) between them. When network analysis is concerned with the ties among pairs of actors, the unit of analysis is said to be the dyad (Wasserman & Faust, 1999).

*Tie Strength*

Marsden (1990) identified five common measures of social networks: network size, network density, centrality, network range, and tie strength. *Tie strength* is a measure of multiple properties in dyadic relationships including *closeness*, *frequency*, and *duration* of the relationship. Marsden suggested that "closeness, duration, and frequency are all positively related to an 'intimacy' focus which appears to be the most consequential property of social ties" (p. 455). Marsden and Campbell (1984) identified *closeness* as the best overall indicator of tie strength.

Marsden and Campbell (1984) credited Granovetter (1973) as the original source for the concept of tie strength. Granovetter proposed that the analysis of interpersonal relations at the dyadic level could, through network analysis, be used to explain larger macro phenomena. He suggested, for example, that the strength of interpersonal ties between individuals was related to the diffusion of knowledge. Granovetter defined tie strength as "a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie" (p. 1361).

*Strong vs. Weak Ties*

Researchers are unable to agree on the role of strong vs. weak ties in knowledge sharing. Granovetter (1973) theorized that if an individual *A* has strong ties to two other individuals *B* and *C*, the probability is increased that *B* and *C* will eventually interact and form at least a weak tie between them. He argued that weak ties are instrumental in the diffusion of knowledge. Granovetter suggested that weak ties are capable of acting as a "bridge" (p. 1364) between otherwise disconnected network clusters of stronger ties. Following this logic, he argued that weak ties, rather than strong ties, enable knowledge to travel over greater social distance. He theorized that in a network supported by both strong and weak ties, the knowledge shared between individuals with strong ties is likely to be redundant, while the knowledge shared between those with weak ties is likely to be unique.

Augier and Vendelo (1999) contended that weak social ties between individuals support the transfer of codified knowledge, and are also useful for locating sources of expertise. Strong social ties are necessary, however, to support the exchange of tacit knowledge. Networks with weak social ties may be able to locate important sources of knowledge; but if that knowledge is non-codified, weak ties may not support its transfer. Conversely, they argued that networks with strong social ties may fail to discover existing sources of knowledge.

Hansen (1999) conducted a network study of new-product development in 41 divisions of a multinational electronics company. The study examined 120 development projects to determine the relationship between inter-unit tie strength and knowledge transfer. The results of the study suggested that weak ties are useful for locating widely

distributed knowledge, and strong ties are useful for transferring complex knowledge. Hansen described knowledge sharing among organizational units as a "search-transfer problem" (p. 83): the need to both search for and transfer complex knowledge. Expanding on Granovetter's (1973) theory of weak ties, Hansen (1999) argued that weak ties are advantageous in the search for new information or project-specific knowledge, because non-redundant knowledge is more likely to come from those with whom one has infrequent or distant relationships.

Hansen (2002) conducted a follow-on analysis of the data from previous research by Hansen (1999). The results suggested that direct relationships are more effective than indirect relationships for locating needed knowledge and for transferring tacit knowledge. Hansen (2002) suggested that the answer to the search-transfer problem (Hansen, 1999) is to create "task-specific *knowledge networks*" (Hansen, 2002, p. 232). This approach partitions inter-unit networks according to related knowledge.

Levin et al. (2002) argued that strong ties are associated with more effective knowledge transfer. They contended that strong ties are more effective because they are also based on trusting relationships. Weak ties can also be effective for tacit knowledge transfer when the knowledge seeker trusts in the benevolence and competence of the knowledge source.

Droege and Hoobler (2003) proposed that an optimal mix of weak and strong ties promotes the greatest level of tacit knowledge diffusion. They suggested that weak ties between individuals are more likely to promote the initial sharing of tacit knowledge that is non-redundant. Once this knowledge makes its way into the social network, strong social ties promote its diffusion, helping it to become embedded in the organization.

Some researchers have extended the discussion of strong vs. weak ties to include external relationships and alliances. Rindfleisch and Moorman (2001) suggested that in the inter-organizational context it is strong ties, rather than weak ties, that are likely to enhance knowledge transfer between competitors. Cavusgil, Calantone, and Zhao (2003) found that inter-firm tie strength was positively related to tacit knowledge transfer. Mitsuhashi (2003) obtained survey data from 46 alliances by biopharmaceutical firms concerning the relationship between alliance performance and social ties among research and development executives. The results of his survey indicated a positive relationship between the length of relationships and alliance performance. Frequency of interaction prior to alliance formation was negatively related to performance. He theorized that strong ties indicated by frequent interaction prior to an alliance may mean that firms are unable to benefit from an alliance because they have redundant knowledge. This is consistent with Granovetter's (1973) theory concerning weak ties.

*Network Density and Heterogeneity*

While tie strength has been associated with knowledge *sharing* at the dyadic level, researchers have also suggested that knowledge *diffusion* in a social network is related to network density. In a dense social network there are multiple paths for knowledge diffusion. Fisher and White (2000) argued that the relationships in social networks are heterogeneous rather than uniformly dense. In a case study of innovation at a Swedish telecommunications company, Hellstrom and Malmquist (2000) discussed how heterogeneous teams are more effective than homogeneous teams. Reagans & Zuckerman (2001) argued that both density and heterogeneity are important in social networks. Moody and White (2003) argued that independent paths increase the probability of

reliable diffusion throughout the network. In a study of 210 MBA students arranged in 39 teams, Rulke and Galaskiewicz (2000) found that social network ties facilitate knowledge sharing, and that dense informal networks increase the performance of groups that have distributed specialized knowledge.

*Social Networks and Knowledge Sharing*

The literature has suggested that knowledge sharing is facilitated by the interaction of individuals. These interactions are best characterized by social network theory (Harris, 2001). According to Argote et al. (2003), a key factor in successful knowledge transfer is the dyadic social relationship between individuals. Dyadic relationships can vary along several dimensions including the frequency and intensity of contact between individuals and their social similarity. Patterns of multiple dyadic connections may be influenced by the network in which they are embedded. Knowledge properties also affect the ease of transfer between individuals and organizations. Knowledge that is tacit, ambiguous, or not codified is more difficult to transfer. Argote et al. suggested that the transfer of knowledge in dyadic relationships is improved by the presence of strong social ties. They contended that "relationships are critical when one moves beyond studying individuals to studying social units such as organizations" (p. 580). They suggested that future research on knowledge transfer should include the relationship between tie strength and other contextual variables.

Reagans and McEvily (2003) studied knowledge transfer among 113 engineers and scientists in a contract research and development firm. They tested the hypotheses that common knowledge or expertise, tie strength, social cohesion, and network range are all positively related to the ease of knowledge transfer, and that the positive relationship

between tie strength and ease of knowledge transfer is greater for tacit knowledge. The results of the study by Reagans and McEvily (2003) suggested that tie strength has a strong positive effect on the ease of knowledge transfer. This effect was greater when knowledge was non-codified. Network cohesion and network density were also positively related to ease of knowledge transfer. There was a strong correlation between tie strength and social cohesion. Reagans and McEvily suggested that this supports the theory that strong individual ties are accompanied by strong third party connections. Strong ties accompanied by a dense cohesive structure facilitated the rapid diffusion of knowledge in a network cluster. The results suggested that strong ties facilitate the transfer of all types of knowledge, and that tacit knowledge is more difficult to transfer than codified knowledge. The results also indicated that individuals who were surrounded by a diversity of network contacts were better able to span structural holes, even when tie strength was weak. A strong tie was necessary, however, for transferring tacit knowledge across a structural hole.

Levin et al. (2002) studied the relationship between tie strength, trust, and knowledge sharing in the social networks of three firms: a U.S. pharmaceutical company, a British bank, and a Canadian oil and gas company. The results suggested that tie strength had a significant positive effect on the receipt of useful knowledge in terms of project outcomes. Tie strength was also positively related to benevolence- and competence-based trust. When the trust dimensions were controlled for, the positive effect of strong ties was insignificant. This suggested that weak ties are sufficient for transferring useful knowledge when trust is present in the relationship.

Borgatti and Cross (2003) proposed that information seeking in social networks is a function of being aware of what others know, valuing what they know, having access to that person, and on the perceived cost of obtaining that information. In a multinational study of two social networks in the pharmaceutical industry, involving 72 scientists and researchers, they concluded that knowing, valuing, and access were all strongly correlated with information seeking. In discussing the possibilities for future research, Borgatti and Cross noted that their model may have been incomplete because it did not account for cultural differences.

*Social Networks and Cultural Distance*

According to Manev and Stevenson (2001), socialization and strong ties between individuals increase cooperation and facilitate knowledge sharing between subsidiaries in MNCs. In a network study of 457 managers in a MNC, Manev and Stevenson examined the relationship between nationality, cultural distance, expatriate status, and the formation of strong ties. In their study, cultural distance was based on the Euclidean formula proposed by Morosini et al. (1998). Manev and Stevenson (2001) identified two types of ties: instrumental ties and expressive ties. Instrumental ties were related to the performance of work tasks, and expressive ties were related to friendship and personal support. They found that instrumental ties were stronger for more culturally distant managers and expressive ties were more likely for managers who were less culturally distant. Important work related information, which depends upon instrumental tie strength, was transferred regardless of cultural distance.

In a network study of a German-Japanese international joint venture, Salk and Brannen (2003) attempted to determine how differences in national culture affect the

performance of a multinational management team. The results of the study suggested the presence of in-group bias among both cultural groups and distinct differences in advice seeking patterns. They suggested that these differences were reflective of Japanese reliance on socioemotional bonds and the German "reliance on expertise and formal, individual responsibility" (p. 193).

*Social Network Analysis*

Social network analysis uses the measurement of structural or relational ties among actors to test propositions concerning group relational properties. Special analytical techniques are required for social network data. According to Wasserman and Faust (1999), it is not appropriate to use standard "multiple regression, t-test, canonical correlations, structural equation models, and so forth to study social network data or to test network theories" (p. 21), because interdependence in network observations can create an autocorrelation problem (Krackhardt, 1988). Krackhardt proposed a non-parametric solution to the autocorrelation problem; one that employs the quadratic assignment procedure (QAP) proposed by Hubert and others (Hubert, 1987; Hubert & Schultz, 1976) for correlation between two N x N matrix variables. Krackhardt (1988) adapted this technique to regression in multivariate network studies through a variation called multiple regression quadratic assignment procedure (MRQAP). During the literature search several network studies were found to have employed these techniques (Borgatti & Cross, 2003; Burris, in press; Dekker, Krackhardt, & Snijders, 2003; Hinds, Carley, Krackhardt, & Wholey, 2000; Krackhardt, 1988; Krackhardt, 1993; Manev & Stevenson, 2001; Tsai, 2002). Based on the wide acceptance of QAP and MRQAP for

analysis of network data, and the commercial availability of analytical software (Borgatti et al, 2002) these techniques have been selected for use in this study

## Study Context

A multinational manufacturing company in the semiconductor industry was selected for this study. Knowledge concerning semiconductor manufacturing processes includes a tacit component (Almeida et al., 2002; Martin & Salomon, 2003b), which makes it difficult to share among globally dispersed manufacturing sites (Appleyard et al., 2000). Differences in national culture among manufacturing sites may be an obstacle to tacit knowledge sharing (Almeida & Grant, 1998, West, 2002). The semiconductor industry has emphasized codification strategies and the use of information and computer technologies to manage knowledge (Almeida et al., 2002; Appleyard et al., 2000). In contrast to this approach, some authors have pointed to the need for interpersonal relationships and richer modes of communications (Almeida & Grant, 1998; Almeida et al., 2002).

Appleyard et al. (2000) noted that despite the efforts by most semiconductor companies to develop manufacturing processes and to codify and replicate them at other manufacturing sites, significant differences in yield performance normally exist between sites. Yield performance is measured in terms of the percentage of good chips on a wafer, and the percentage of defect free wafers produced. There are two primary sources of yield losses in semiconductor manufacturing: particle contamination and out of control process parameters (Hatch, 1997; Hatch & Mowery, 1998). The difficulty in achieving high yields is in part attributed to the relatively "imperfect scientific understanding of semiconductor manufacturing" (Appleyard et al., 2000, ¶ 6). Process knowledge is

typically increased over time through problem solving and experimentation (Khurana, 1999; Last & Kandel, 2002). This knowledge often remains tacit among individual teams of engineers, supervisors, and workers. Consequently, much of the knowledge related to successful high-yielding semiconductor manufacturing is difficult to transfer between sites (Appleyard et al., 2000).

Almeida et al. (2002) suggested that the semiconductor industry is an example of a knowledge-based global industry. Semiconductor manufacturing involves complex, yield sensitive production processes that have been described as an "intertwining of codified and tacit knowledge" (p. 147). Because semiconductor process knowledge is highly tacit, experience is a key factor in the early adoption of new processes (Cabral & Leiblein, 2001). According to Hatch and Mowery (1998), the rate of learning is inhibited by "the complexity and 'tacitness' of much of the knowledge and know-how" (p. 1464) associated with semiconductor processes. At the same time, globalization has forced semiconductor companies to disperse their design and manufacturing activities across world wide locations (Almeida et al., 2002). Consequently, multinational semiconductor companies are faced with the challenge of knowledge-building across national borders.

Almeida and Grant (1998) suggested that little is understood about the knowledge transfer mechanisms used by MNCs. In a study of multinational semiconductor manufactures, they attempted to determine which mechanisms were considered most effective for cross-border knowledge transfer. Almeida and Grant interviewed executives from IBM, National Semiconductor, Philips, Siemens, and Texas Instruments in hopes of determining what mechanisms were most effective for cross-border knowledge transfer in the semiconductor industry. They concluded that richness of communication is an

important criterion for transferring context-specific tacit knowledge or explicit knowledge that may be complex. The interviewees considered face-to-face meetings as the richest communication media, and the most effective mechanism for collaborative problem solving and the transfer of tacit knowledge. Communities of practice were considered to be unproductive until the individuals involved had established a personal relationship. Different languages and national cultures were identified as obstacles to knowledge transfer and a source of added cost for multinational operations.

Almeida et al. (2002) interviewed engineers and technology managers in eight large multinational semiconductor companies. The interviewees were asked unstructured questions concerning their company's knowledge management processes, knowledge transfer mechanisms, types of knowledge transferred, and their assessment of the most effective organizational methods for knowledge management. The integrating of globally dispersed knowledge was identified by interviewees as the key to knowledge-building. All of the companies in their study cited the use of computer-based information technology, but noted its limitations for integrating explicit and tacit knowledge. Some of the interviewees stated that information technology solutions are only effective when accompanied by richer media such as telephone, video conference, and face-to-face communications. They also cited the importance of building trust in the relationship between individuals. Interpersonal networks, established over time, played an important role in establishing and maintaining these relationships. Almeida et al. argued that multinational semiconductor companies must "standardize procedures and formats, to administer coordination between national units, develop interpersonal relationships

between employees, and create a common culture to facilitate communication and cooperation" (p. 159).

West (2002) studied the differences between process development in Japanese and U.S. semiconductor manufacturers. He noted that there is greater socialization in Japanese firms, resulting in enhanced communication and knowledge transfer with less formalized structure. U.S. engineers favored professional socialization over organizational socialization, while the reverse was true in Japan. These differences, according to West, suggest that within a MNC, knowledge creation will differ according to the local context and *national culture* of each subsidiary. West argued that as the sources of knowledge have become globally dispersed, rather than centered on the corporate home, MNCs must develop mechanisms for meshing the knowledge from culturally different contexts.

In a study of the semiconductor manufacturing industry, Martin and Salomon (2003b) selected 346 memory device manufactures with international facilities built since 1970. They suggested that semiconductor manufacturers rely on the accumulation of tacit knowledge to continuously reduce feature size and increase circuit density. Martin and Salomon further suggested that the codifiability and teachability of semiconductor manufacturing process knowledge are reduced with each successive stage of miniaturization. Consequently, manufacturing process knowledge and know-how are becoming increasingly difficult to transfer between sites.

## Conclusions

Based on the literature review, a model of knowledge sharing in MNCs is proposed that includes both explicit and tacit knowledge, as depicted in Figure 8. The

model assumes that codification is effective for transferring explicit knowledge between culturally distant knowledge partners in MNCs. Codification is not effective, however, for transferring tacit knowledge. Tacit knowledge transfer between culturally distant knowledge partners in MNCs is assumed to require the sharing of context specific, personal knowledge supported by strong social ties between individuals. This latter assumption is the basis for this study concerning the relationship among cultural distance, the strength of social ties, and tacit knowledge sharing in a multinational corporation.

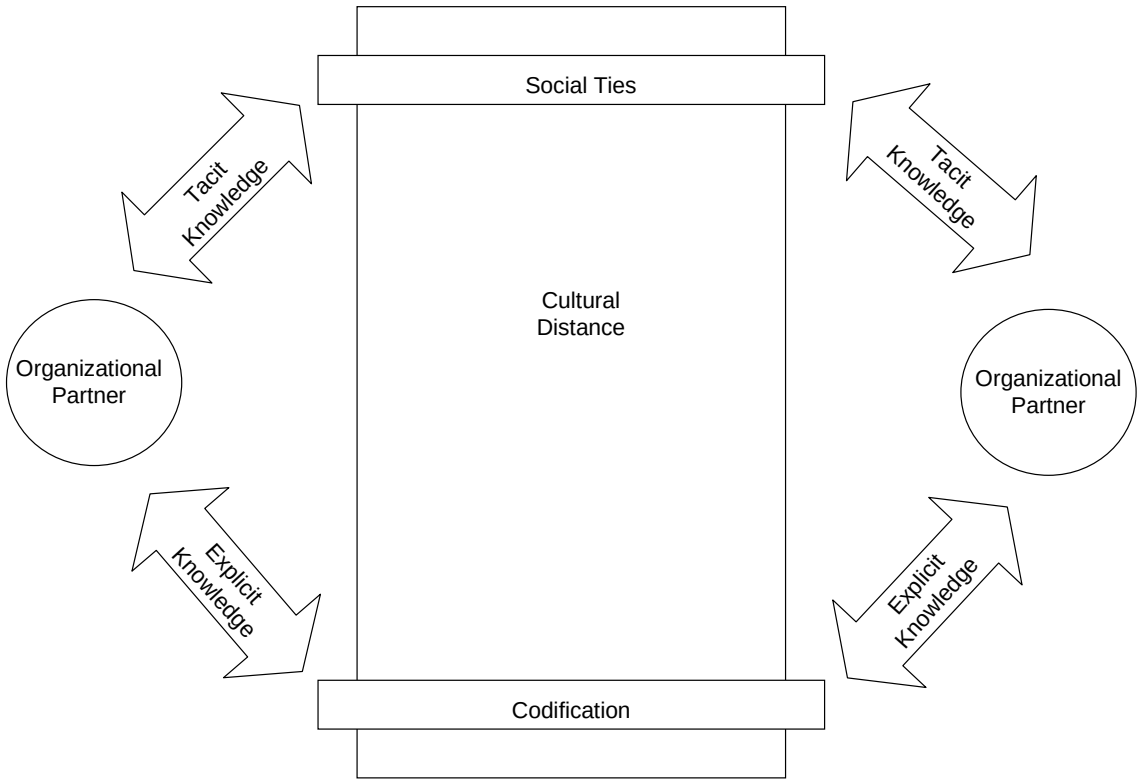


*Figure 8.* Model of knowledge transfer in MNCs

## Summary

Three gaps were identified in the literature. First, although cultural distance has been identified as an obstacle to knowledge transfer in MNCs (Almeida & Grant, 1998;

Bhagat et al., 2002; Garcia & Vano, 2002; Holden, 2001; McDonough et al., 1999; O'Keeffe, 2003; Palich & Gomez-Mejia, 1999; Persaud et al., 2001; Salk & Brannen, 2003; Simonin, 1999; Subramaniam & Venkatraman, 2001; Triandis, 2000, 2004; West, 2002; Zander & Solvell, 2000) the literature review found no studies that have directly examined the relationship between cultural distance and tacit knowledge sharing. Second, no studies involving cultural distance (Kogut & Singh, 1998; Morosini et al., 1998) have included Hofstede's (2001) dimension of long-term orientation as a component of cultural distance. Finally, the literature includes several studies concerning the relationship between tie strength (Granovetter, 1973; Marsden & Campbell, 1984) and tacit knowledge sharing (Argote et al., 2003; Borgatti & Cross, 2003; Levin et al., 2002; Reagans & McEvily, 2003). No studies were found to have examined the relationship among cultural distance, the strength of social ties, and tacit knowledge sharing in MNCs.

A multinational manufacturing company in the semiconductor industry provided an excellent opportunity to study tacit knowledge sharing in MNCs. Knowledge concerning semiconductor manufacturing processes includes a tacit component (Almeida et al., 2002; Martin & Salomon, 2003b), which makes it difficult to share among globally dispersed manufacturing sites (Appleyard et al., 2000). Differences in national culture among these sites may be an obstacle to tacit knowledge sharing (Almeida & Grant, 1998, West, 2002). This study has attempted to fill these gaps in the existing literature.

The literature review also identified some alternative views concerning the key variables used in this study. The study has attempted to add knowledge in those areas. One alternative view was expressed by Manev and Stevenson (2001) who suggested that work related knowledge is transferred regardless of cultural distance. The study has

addressed this alternative view by attempting to determine the extent to which a relationship may exist between cultural distance and tacit knowledge sharing. Another alternative view was proposed by Shenkar (2001). He argued that there are methodological problems with the cultural distance construct. This study not only examined cultural distance, but also examined the individual effects from each of Hofstede's (1980, 2001) indices that make up the cultural distance construct. Finally, several researchers have argued that weak, rather than strong, social ties are more effective in knowledge sharing (Granovetter, 1973, Mitsuhashi, 2003). Hansen (1999) argued that weak ties are more effective for locating new knowledge and that strong ties facilitate the transfer of complex knowledge. Reagans and McEvily (2003) argued that strong social ties are not more effective for knowledge transfer, but rather they are more efficient. In this study, strong social ties are theorized to be more effective than weak ties for tacit knowledge sharing. The study has specifically attempted to add new knowledge in the debate over strong vs. weak social ties in knowledge sharing. In chapter 3, the research design and methodology that was selected for the study will be discussed. Chapter 3 explains the methodology that was used to test the hypothesized relationship among the study variables, and how the study attempted to answer the research question.

# CHAPTER 3: METHODOLOGY

Chapter 1 introduced the problem and explained the purpose of the study. Chapter 2 discussed the theoretical framework that led to the research question. In chapter 3, the methodology that was used to answer the research question is described. The purpose of this quantitative correlational study, using social network data, was to determine the extent to which strong social ties are effective for overcoming cultural distance between individuals and increasing the sharing of tacit manufacturing process knowledge among a target population of 252 process engineers in a multinational semiconductor manufacturing company with operations in Germany, the United States, Singapore, and Japan. The independent variable is *cultural distance* (Hofstede, 1980, 2001; Kogut & Singh, 1988; Morosini et al., 1998), the intervening variable is the *strength of social ties* (Marsden & Campbell, 1984), and the dependent variable is the extent to which *tacit manufacturing process knowledge* is shared (Appleyard et al., 2000; Hatch & Mowery, 1998). The control variables are differences in gender, country of origin outside of the study, experience in the multinational environment, and experience as an expatriate. Four dummy variables are also included for modes of communication used by the study participants.

Participants completed a web-based survey comprised of Likert-scale questions concerning their relational ties with other process engineers at the participating company's manufacturing sites in Germany, the United States, Singapore, and Japan. Data for each of the relational variables are represented as a N x N sociomatrix, where $X_{ij}$ describes the relational tie among all possible pairs of participants *i* and *j*. Network correlation and regression using quadratic assignment procedure (QAP) (Hubert, 1987;

Hubert & Schultz, 1976; Krackhardt, 1988) and multiple regression quadratic assignment procedure (MRQAP) (Borgatti, et al., 2002; Krackhardt, 1993) were employed for nonparametric analysis of social network data.

## Research Question

The study attempted to answer the following question: What is the relationship among cultural distance, the strength of social ties among process engineers, and the sharing of tacit manufacturing process knowledge in a multinational manufacturing company in the semiconductor industry? The hypothesized relationship among the independent, intervening, and dependent variables is shown in Figure 9.

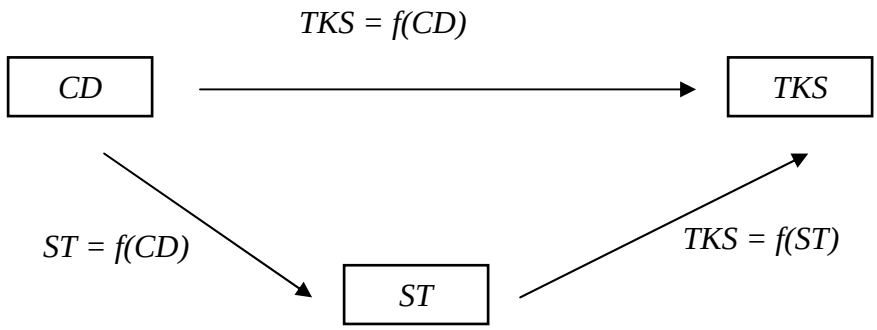


*Figure 9.* Hypothesized relationship among the study variables. *Note.* Cultural Distance = *CD*; Social Ties = *ST*; Tacit Knowledge Sharing = *TKS*

## Hypotheses

The theoretical framework developed in chapter 2 provided the basis for the hypothesized relationship among cultural distance, the strength of social ties, and the sharing of tacit manufacturing process knowledge in a multinational manufacturing company in the semiconductor industry. Chapter 3 describes the design and methodology that have been selected for research to support or reject the following hypotheses:

*Null Hypothesis 1$H_0$*

There is no statistically significant relationship between cultural distance and the sharing of tacit manufacturing process knowledge in a multinational company in the semiconductor industry.

*Alternative Hypothesis 1$H_1$*

There is a statistically significant relationship between cultural distance and the sharing of tacit manufacturing process knowledge in a multinational company in the semiconductor industry.

*Null Hypothesis 2$H_0$*

There is no statistically significant relationship between cultural distance and the strength of social ties among process engineers in a multinational company in the semiconductor industry.

*Alternative Hypothesis 2$H_1$*

There is a statistically significant relationship between cultural distance and the strength of social ties among process engineers in a multinational company in the semiconductor industry.

*Null Hypothesis 3$H_0$*

There is no statistically significant relationship between the strength of social ties among process engineers and the sharing of tacit manufacturing process knowledge in a multinational company in the semiconductor industry.

*Alternative Hypothesis 3$H_1$*

There is a statistically significant relationship between the strength of social ties among process engineers and the sharing of tacit manufacturing process knowledge in a multinational company in the semiconductor industry.

## Research Design

This quantitative correlational study, using social network data, attempted to determine the extent to which there is a relationship among cultural distance, strong social ties, and the sharing of tacit manufacturing process knowledge among a target population of 252 process engineers from four culturally distant manufacturing sites in Germany, the United States, Singapore, and Japan. Cultural distance, social ties, and tacit knowledge sharing are treated as relational ties among the 252 process engineers who, by virtue of the organizational structure, comprise a complete social network. Participants completed a web-based survey questionnaire (Appendix B) using Likert-scale questions concerning their relational ties with other process engineers at the participating company's manufacturing sites in Germany, the United States, Singapore, and Japan. Survey questionnaires were selected as part of the research design for the proposed study because they are the most common method for collecting social network data (Wasserman & Faust, 1999). Likert-scale questions are appropriate for social network studies that measure the perceptions of social actors concerning their relational ties with others (Marsden, 1990). Each survey question was assigned to a network variable in an N x N matrix, with a potential of N(N-1) dyadic observations for each relational variable. Network correlation and regression based on non-parametric randomization were used to test the hypotheses.

A quantitative approach was selected over a qualitative one for the study. According to Creswell (2003), a quantitative approach is appropriate when measurements can be collected to statistically analyze testable theories. Linear correlation is appropriate for inference testing of hypotheses when sample data are paired, normally distributed, and hypotheses concern the statistical significance of the relationship between pairs of variables (Triola, 2001). According to Triola, multiple regression analysis is appropriate when analyzing the relationship among multiple variables and the statistical significance of that relationship as a predictor of results from similar studies. In this study, a set of null hypotheses are offered concerning the relational ties among the network of study participants. The null hypotheses concern pairs of relational variables, and the model concerns the multivariate relationship among those variables. Correlation and regression techniques especially suited for network data and matrix variables were applied to inference test the hypothesized relationships.

Standard statistical methods for inference testing of hypotheses are not appropriate for network data, because the observations of dyadic relations within a network are not independent (Borgatti & Cross, 2003; Dekker et al., 2003; Krackhardt, 1988). To address this concern, correlations among the independent, intervening, control, and dependent variables were analyzed using the non-parametric quadratic assignment procedure (QAP) (Hubert, 1987; Hubert & Schultz, 1976; Krackhardt, 1988). The predictive ability of the model was tested using multiple regression quadratic assignment procedure (MRQAP) (Borgatti et al., 2002; Krackhardt, 1993).

*Social Network Approach*

A Social network approach was selected for the study because it differs from other empirical approaches in two important ways. First, social network studies focus on the *relations* among actors, rather than the attributes of individual actors (Wasserman & Faust, 1999). Second, because the focus is on relations, actors cannot be sampled independently concerning their relational ties; therefore observations are not independent (Hanneman, 2001). Social network analysis provides a methodology for modeling and testing theories about such relationships and structures (Wasserman & Faust, 1999).

The epistemological basis for this study is a positivist claim (Creswell, 2003) concerning the relationship among independent, intervening, and dependent variables, such as in the proposed relationship among cultural distance, the strength of social ties, and tacit knowledge sharing. Objective knowledge concerning this relationship is considered to be available through the perceptions of the social actors involved in knowledge sharing. Marsden (1990) supported an objectivist position for the use of social network analysis, arguing that social relations can be measured by the perceptions of the social actors involved.

A social network is comprised of a set of social actors and the relations or ties among them (Fienberg et al., 1985; Wasserman & Faust, 1999). Moreno (1934) is credited as being the first social scientist to study social networks of individuals, and to have used mathematics to analyze sociometric data (Fienberg et al., 1985). The basic unit of analysis in social network studies is the dyad, or pairs of actors, and the tie(s) between them (Wasserman & Faust, 1999). Dyadic data for a single relational variable among a set of actors N, can be represented as an N x N sociomatrix. For any relationship X,

directed from person *i* to person *j*, a matrix variable $X_{ij}$ describes the relational ties among N = *i* = *j* actors in the network. A sociomatrix is constructed by listing the names of all actors on both the vertical and horizontal axis. The normal convention for relational ties is from person *i*, represented on the vertical axis, to and person *j*, represented on the horizontal axis. Sociometric variables may be binary or valued. Where no relationship exists between a pair of actors, a zero is entered in the matrix. Multivariate relations are represented by multiple matrices (Fienberg et al., 1985; Wasserman & Faust, 1999).

Patterns of interaction within social networks form the basis for theories of social network structure and or relational processes (Wasserman & Faust, 1999). According to Wasserman and Faust, social network theory differs from "Standard" (p. 7) social science in its focus on relational data rather than the attributes of individuals. Social ties include any type of relationship that can be measured and analyzed among all the actors in a network.

*Subject Population*

This quantitative correlational study surveyed participants representing four national cultures at four international manufacturing sites of a multinational manufacturing company in the semiconductor industry. The manufacturing sites were located in Germany, the United States, Singapore, and Japan. Participants in the study were process engineers who engage in cross-national knowledge sharing among manufacturing sites. Subjects were identified from a list of job titles provided by the participating organization. This closed population consisted of group of N = 252 individuals with the title of process engineer or process engineering team leader. For the purposes of this study, this group was considered to be a whole social network (Marsden,

2003). Within this group there were six technology sub-groups consisting of engineers who supported same or similar manufacturing process steps that were common among the sites. The global distribution of this study population is shown in Table 1.

TABLE 1

*Distribution of process engineers by site*

| Site | Number of Process Engineers |
|---|---|
| Germany | 139 |
| United States | 37 |
| Singapore | 37 |
| Japan | 39 |
| TOTAL | 252 |

The organization selected for this study represents a purposive inquiry into tacit knowledge sharing in the semiconductor industry. The specific organization studied is a population of convenience. While this study offers data that may be generalized to all MNCs, claims of such knowledge are not possible without data from several other organizations in diverse industries.

*Population Boundaries*

Quantitative studies using social network data typically follow one of two design strategies: "'whole-network' or 'egocentric'" (Marsden, 2003, p. 3). These terms refer to the method of defining network boundaries for the study. Whole-network studies focus on the complete set of dyadic relationships in a social collective. The focus of egocentric studies, according to Marsden, is the "focal actor" (p. 3), also termed "ego" (p. 5), and the

dyadic relationships with “alters” (p. 5) to whom ego is linked. Whole networks are also comprised of egos and alters. What distinguishes whole-network from egocentric studies is the way in which the set(s) of objects (egos and alters) within the network boundary are defined.

The boundaries of a whole-network are based on actors’ characteristics, group membership, participation in events or activities, or specific relational tie(s) (Marsden, 2003). Whole-network studies seek data about the relational ties among *all* the actors in a defined group, while egocentric studies have open boundaries. In this whole-network study, the whole network is the group of 252 individuals with the title of process engineer or process engineering team leader at four of the organization’s international manufacturing sites. One approach to designing this study would have been to ask each participant to select, from the entire list of 252 possible alters, those individuals with whom they share knowledge. Wasserman and Faust (1999) called this a “roster” (p. 46) approach. A roster can be employed when the complete set of actors is known. It may, however, be unreasonable to ask participants to choose from a complete roster that is very large (Reagans & McEvily, 2003).

An alternative approach is to ask participants to name those people with whom they have a specific type of relational tie. Wasserman and Faust (1999) described this approach as “free recall” (p. 46). Egocentric studies must rely on participants’ free recall to identify alters with whom they have a relational tie (Marsden, 2003), because egocentric studies typically involve large *open* populations where the complete set of actors is *not* known. Marsden noted that whole networks also contain egocentric networks

comprised of the ties surrounding each actor. This leads to the possibility of employing a combination of fixed roster and free recall for designing large whole-network studies.

According to Marsden (2003), participants are likely to forget the names of all those with whom they have a specific type of relationship. He suggested that the problem of forgetting can be addressed by using a mixture of roster recognition and free recall for name generation. In a whole-network study by Reagans and McEvily (2003), a combination of roster and recall techniques was employed to define network boundaries. Reagans and McEvily suggested that combining whole-network and egocentric techniques can avoid potential problems that are inherent with both methodologies. They suggested that the fixed roster for a complete network may be very large. Providing a smaller roster, with a sub-set of individuals who are known to be in the respondent's frame of reference, can reduce the burden on the respondent and provide more accurate data. The selection of a sub-set from a fixed roster is critical, because the researcher may unknowingly exclude important contacts. To address these concerns, Reagans and McEvily suggested combining the fixed roster technique with a free recall name generator technique.

In this study, a combination of sub-group roster and egocentric recall techniques were used to define the contact list for each participant. Each process engineer was provided with a list of those process engineers who were in the participant's technology sub-group. These were engineers who had same or similar process support responsibilities. There were six technology sub-groups; each was related to a step in the manufacturing process. Participants were asked to select, from the roster provided, those process engineers "*with whom they have ever discussed process or yield related problems*

*or improvements.*" Next, each participant was asked to recall the names of other process engineers, who were not in their sub-group, "*with whom they have ever discussed process or yield related problems or improvements.*" The result of this sub-group roster and recall process is a contact list of alters with whom each participant claims to have shared knowledge related to yield problems or improvements in the manufacturing process. The survey instrument asked participants to describe the strength of their ties and the extent to which they shared knowledge with each of these contacts.

The selection of alters among all actors in the network is described by a binary variable of the form $X_{ij}$ that is represented as an "adjacency matrix" (Wasserman & Faust, 1999, p. 150), so named because it indicates which nodes are adjacent to one another. If person *i* identified person *j* as someone "*with whom they have ever discussed process or yield related problems or improvements*," then $X_{ij}$ was set to 1 in the adjacency matrix, otherwise $X_{ij}$ was set to 0. All variables in the study were arranged in matrices similar to the adjacency matrix, with relational data only where a tie was indicated. As noted by Wasserman and Faust (1999), the adjacency matrix for directional relationships is not necessarily symmetric. If person *i* identified person *j* as a contact, person *j* may not necessarily reciprocate. For computational reasons, symmetry of all matrices was necessary in the study. To accommodate this requirement, identification of a tie by either person *i* or person *j* was treated as a reciprocal tie during the data analysis.

*Sampling Strategy*

Sampling strategies are generally employed in open-network studies, and do not apply when the subject of the study is an entire closed population (Marsden, 1990). An exception is the study of subsets within a closed population for the purpose of estimating

overall network density. Random sampling procedures are most appropriate, according to Marsden, when data from open egocentric studies are being generalized to a large population. Consistent with Marsden's assertions, a sampling strategy was not considered appropriate for this whole-network study of a closed population of process engineers.

*Survey Methodology Selection*

Survey research methods were used to measure participants' perceptions concerning tie strength and tacit knowledge sharing. Survey questionnaires are the most commonly used technique for gathering social network data about respondents' relational ties (Wasserman & Faust, 1999). Survey questionnaires often ask respondents to make selections or choices concerning their relational ties with others. These responses are best represented as binary data. Questionnaires may also be used to gather valued data from participants by asking them to describe their relational ties on a Likert scale. Survey questionnaires employing the Likert scale have been used extensively to measure relational ties in social networks (Granovetter, 1973; Marsden, 1990; Marsden & Campbell, 1984). Survey questionnaires rely on the respondent's perception concerning relational ties. This methodology assumes that social ties "have an objective existence, beyond respondent recognitions" (Marsden, 1990, p. 445).

In this study, selection or choice type questions were used to construct an adjacency matrix of egos and alters, and to gather data concerning the control variables for gender differences, national origin outside the study, and expatriate experience, as well as the dummy variables for modes of communication. Likert-scale survey questions were used to measure the intervening variable (strength of social ties), and the dependent variable (the extent to which tacit knowledge is shared). Participants were asked to rank

the closeness of their social relationships with other process engineers and to rank the extent to which they shared knowledge related to yield problems or yield improvements in semiconductor manufacturing processes. A single Likert-scale question was used to measure each network variable. Borgatti and Cross (2003) argued that this practice is appropriate for network studies, provided that certain measures are taken during the study. These include pre-testing the reliability of the questions and structuring the questions so as to elicit recollection of long-term rather than specific interactions of individuals (Marsden, 1990). Both of these measures were taken during this study.

*Limitations of the Research Design*

There are two potential limitations posed by the selected research design: (a) the accuracy of self-reporting, and (b) the difficulty of measuring tacit knowledge. Marsden (1990) acknowledged the "central question…of whether one seeks to measure actually existing social relations, or social relations as perceived by actors involved in them" (p. 437). Despite these limitations, Marsden contended that self-reporting is the "predominant research method used" (p. 440) in social network studies. To address concerns about the accuracy of self reported ties in this study, the average scores reported by person *i* and person *j* for closeness and knowledge sharing were used.

Direct measurement of tacit knowledge sharing may not be practical. Tacit knowledge is subjective, experiential, personal, and context-specific (Nonaka & Takeuchi, 1995). In this study, tacit knowledge was *assumed* to be shared when undocumented yield improvements were discussed between process engineers. The assumption that *uncodified* knowledge is also *tacit knowledge* is consistent with the work of Kogut and Zander (1993), and also with the nature of semiconductor yield

improvements, as cited by several authors (Almeida et al., 2002; Appleyard et al., 2000; Hatch & Mowery, 1998).

## Variables

### *The Independent Variable – Cultural Distance*

Cultural distance (Kogut & Singh, 1988; Morosini et al., 1998) is a composite index for the aggregate difference between the cultural norms of one country and another. It is based upon Hofstede's (1980, 2001) five dimensions for the differences in national culture: *power distance* (PDI), *uncertainty avoidance* (UAI), *individualism* (IDV), *masculinity* (MAS), and *long- versus short-term orientation* (LTO). Cultural distance can be computed as either the arithmetic average, corrected for the statistical variance of each dimension (Kogut & Singh, 1988), or as the total Euclidean distance (Morosini et al., 1998) between two countries along Hofstede's (1980, 2001) cultural dimensions.

Several authors have suggested that Hofstede's (1980, 2001) dimension of *individualism-collectivism* may have the most influence on knowledge transfer between different cultures (Bhagat et al., 2002; Shenkar, 2001; Triandis, 2004). Shenkar (2001) also expressed concern over the aggregating of Hofstede's (1980, 2001) dimensions. In this study, each of Hofstede's dimensions of national culture was treated as an independent variable in order to address this concern. The five cultural dimensions in each dyadic relationship between person *i* and person *j* are represented as valued matrix variables of the form $X_{ij}$, as follows: *power distance* ($PDI_{ij}$); *uncertainty avoidance* ($UAI_{ij}$), *individualism* ($IDV_{ij}$), *masculinity* ($MAS_{ij}$), and *long- versus short-term orientation* ($LTO_{ij}$). Additionally, both the average and the Euclidean computations for cultural distance are treated as independent variables.

*Average cultural distance.* In this study, the average cultural distance in each dyadic relationship is a valued matrix variable of the form $X_{ij}$, based on an adaptation of the formula by Kogut and Singh (1988), as shown in Figure 10.

$$CD_{ij\_avg} = \sum_{n=1}^{5} \{(I_{ni} - I_{nj})^2 / V_n\} / 5$$

*Figure 10.* Modified equation for average cultural distance. *Note.* Includes all five of Hofstede's (1980, 2001) indices. $CD_{ij\_avg}$ is the average cultural distance of *person i* from person *j*. $I_{ni}$ is Hofstede's index for the *n*th cultural dimension and person *i*. $I_{nj}$ is Hofstede's index for the *n*th cultural dimension and person *j*. $V_n$ is the statistical variance of the index data for the *n*th cultural dimension.

*Euclidean distance*. In this study, the Euclidean cultural distance in each dyadic relationship is a valued matrix variable of the form $X_{ij}$, based on an adaptation of the formula by Morosini et al. (1998), as shown in Figure 11.

$$CD_{ij\_t} = \sqrt{\sum_{n=1}^{5} (I_{ni} - I_{nj})^2}$$

*Figure 11.* Modified equation for Euclidean cultural distance. *Note.* Includes all five of Hofstede's (1980, 2001) indices. $CD_{ij\_t}$ is the total Euclidean cultural distance for person *i* from person *j*. $I_{ni}$ is Hofstede's index for the *n*th cultural dimension and person *i*. $I_{nj}$ is Hofstede's (1980, 2001) index for the *n*th cultural dimension and person *j*.

Hofstede's (1980, 2001) indices for the dimensions of national culture between each of the study sites are shown in Table 2. The computed values for the average cultural distance between persons at each of the sites, adjusted for the variance in each index, are shown in Table 3. The computed values for Euclidean cultural distance are shown in Table 4.

TABLE 2

*Hofstede's index values for dimensions of national culture*

| Site | PDI | UAI | IDV | MAS | LTO |
|---|---|---|---|---|---|
| Germany | 35 | 65 | 67 | 66 | 31 |
| United States | 40 | 46 | 91 | 62 | 29 |
| Singapore | 74 | 8 | 20 | 48 | 48 |
| Japan | 54 | 92 | 46 | 95 | 80 |
| Variance | 484 | 576 | 625 | 324 | 841 |

TABLE 3

*Average cultural distance between national sites*

| | Germany | United States | Singapore | Japan |
|---|---|---|---|---|
| Germany | 0.00 | 0.33 | 2.73 | 1.63 |
| United States | | 0.00 | 2.80 | 2.75 |
| Singapore | | | 0.00 | 4.44 |
| Japan | | | | 0.00 |

TABLE 4

*Euclidean cultural distance between national sites*

| | Germany | United States | Singapore | Japan |
|---|---|---|---|---|
| Germany | 0.0 | 31.3 | 87.1 | 69.1 |
| United States | | 0.0 | 90.5 | 89.6 |
| Singapore | | | 0.0 | 106.6 |
| Japan | | | | 0.0 |

*The Intervening Variable – Strength of Social Ties*

The strength of social ties between individuals within a social network is a measure of emotional intensity or closeness (Marsden & Campbell, 1984). The concept of tie strength was first proposed by Granovetter (1973). Building on sociometry techniques from social psychology, Granovetter proposed that social networks could be analyzed on a macro scale by measuring the strength of interpersonal ties in dyadic relationships. He suggested that tie strength was related to macro phenomena such as diffusion of knowledge, social mobility, political organization, and social cohesion. Granovetter defined the strength of a social tie as "a (probably linear) combination of the amount of time, the emotional intensity, the intimacy (mutual confiding), and the reciprocal services which characterize the tie" (p. 361). Granovetter's strength of ties remained an intuitive concept without a defined measure until the work of Marsden and Campbell (1984).

Analyzing data from three cross-sectional studies of best friends conducted in two American and one German city, Marsden and Campbell (1984) concluded that there were two primary indicators of tie strength: (a) time spent in the relationship, and (b) closeness,

with closeness being the best indicator of tie strength. Time spent in the relationship is a combination of frequency and duration of contact. Closeness is defined as a measure of the intensity of a relationship, ranging from an acquaintance to a very close friend. Marsden and Campbell suggested that the importance of duration to tie strength may decline over the length of the relationship. They also cautioned that frequency of interaction may tend to overestimate tie strength between individuals who are neighbors or co-workers, and that duration may over estimate tie strength between relatives. Marsden and Campbell concluded that closeness may be the best indicator of tie strength in all types of relationships. In this study, tie strength was measured as a function of closeness in dyadic relationships. Duration and frequency of contact were not included in the measure of tie strength because of the concerns identified by Marsden and Campbell, and also to avoid possible interaction with the measure of tacit knowledge sharing, which is based on frequency of contact.

*Closeness or emotional intensity*. Closeness in each dyadic relationship is treated as a valued matrix variable of the form $X_{ij}$. The closeness that person *i* reported having with person *j* was measured on a 5-point Likert scale ranging from distant to a close personal friend. Closeness in each dyadic relationship ($CL_{ij}$) is the average closeness reported by person *i* and person *j*.

*Tie strength.* Following the work of others (Reagans & McEvily, 2003; Uzzi, 1999), tie strength was calculated by transforming closeness or emotional intensity into network proportions. According to Reagans and McEvily (2003), network proportions put tie strength into the context of the respondent's network of alters. Tie strength using

network proportions was determined using an adaptation of the formula proposed by Reagans and McEvily, as shown in Figure 12.

$$ST_{ij} = CL_{ij} / \sum_{q=1}^{N} CL_{iq,\ q=j}$$

*Figure 12.* Equation for tie strength. *Note.* $ST_{ij}$ is the strength of the tie between person *i* and person *j*, in network proportions. $CL_{ij}$ is the average closeness or intensity of the tie between person *i* and person *j*. N is the total number of contacts named by person *j*

q is another person in person *j's* network. For the analysis, the effects of tie strength in network proportions and closeness were both examined.

*The Dependent Variable – Tacit Knowledge Sharing*

Semiconductor manufacturing involves complex, yield sensitive production processes (Hatch & Mowery, 1998) that have been described as an "intertwining of codified and tacit knowledge" (Almeida et al., 2002, p. 147). Hatch and Mowery (1998) noted that yield losses are a significant obstacle to cost-effective manufacturing in the semiconductor industry. Hatch and Mowery cited two major causes for yield losses: unwanted random particle contamination and parametric processing problems. They suggested that process parameter problems result from "an incomplete understanding of the parameters of the process technology as well as insufficient process control" (p. 1463). Hatch and Mowery described much of the knowledge associated with achieving yield improvement as *tacit* rather than explicit, and based in *know-how* rather than science. Despite the efforts by most semiconductor companies to codify and replicate processes among manufacturing sites, significant differences in yield performance normally exist between sites, because much of the knowledge required to improve yields is tacit and not easily shared (Appleyard et al., 2000).

In this study, tacit knowledge sharing in each dyadic relationship is treated as a valued matrix variable of the form $X_{ij}$. The extent to which person *i* shared *undocumented* process or yield related problems or improvements with person *j* was measured on a 5-point Likert scale ranging from less than yearly to almost daily. Tacit knowledge sharing in each dyadic relationship ($TKS_{ij}$) is the average score reported by person *i* and person *j*.

*Control Variables*

The effects of gender, country of origin outside of the study, experience in the multinational environment, and experience as an expatriate were controlled in the study. These factors were treated as dummy variables in the analysis, in order to compensate for their possible influence on the relationship among the independent, intervening, and the dependent variables.

*Gender*. Gender homophily has been established as a factor that affects frequency of communication (Borgatti & Cross, 2003). People are more likely to interact with others who are like themselves. This applies to gender, and suggests that people of the same gender are more likely to have ties and to seek information from one another. In this study, gender differences in each dyadic relationship are treated as a binary variable of the form $X_{ij}$. Following the method used by Borgatti and Cross, if person *i* and *j* were of different gender, then $G_{ij}$ was set to 1. If they were of the same gender, then $G_{ij}$ was set to 0. The model was tested by controlling for the effects of gender different dyads where $G_{ij}$ had a value of 1.

*Country of origin.* In the global economy, labor is becoming a mobile resource. This factor must be controlled for in the study. Singapore, the United States, and much of Europe have a high percentage of foreign workers, while Japan is a more homogeneous

culture (Samiee & Mayo, 1990). If the national origin of either person in the dyadic relationship is other than those being studied, Hofstede's indices for differences in national culture may not apply. In this study, the national origins in each dyadic relationship are treated as a binary variable of the form $X_{ij}$. If either person *i* or person *j* had a national origin other than those included in the study, then $O_{ij}$ was set to 1, otherwise $O_{ij}$ was set to 0. The model was tested by controlling for the effects of national origin outside of study by dyads where $O_{ij}$ had a value of 1.

*Multinational experience.* Personal experience working in a multinational environment may increase the effectiveness of cross-cultural collaboration (Simonin, 1999). In this study, the average duration of employment with the company by individuals in each dyadic relationship is treated as a valued matrix variable of the form $X_{ij}$. The average time that person *i* and person *j* had worked for the company ($ExpC_{ij}$) was determined to the nearest tenths of years, as follows: $ExpC_{ij} = (ExpC_i + ExpC_j)/2$. In the analysis of results, $ExpC_{ij}$ was dichotomized to create a dummy variable for average experience greater than 3 years. Three years was selected because the mean experience level of dyads in the study was approximately three years. The model was tested by controlling for any possible effect from dyads having multinational work experience greater than 3 years.

*Expatriate experience.* Manev and Stevenson (2001) found that tie strength in dyadic relationships may be influenced by previous expatriate experience. They also found that there may be a relationship among expatriate experience, cultural distance, and tie strength. Subramaniam and Venkatraman (2001) suggested that a key component of success in the transfer of tacit knowledge is individuals' previous international

experience. Shenkar (2001) recommended that researchers control for previous foreign experience in studies involving cultural distance. In this study, previous and current expatriate experience in each dyadic relationship is treated as binary variables of the form $X_{ij}$. If person *i* or *j* was previously an expatriate or delegate at the site where the other person was located, then $XpatP_{ij}$ was set to 1, otherwise $XpatP_{ij}$ was set to 0. Also, if person *i* or *j* was an expatriate or delegate at the time of the study, and had been in that status for less than one year, then $XpatC_{ij}$ was set to 1, otherwise $XpatC_{ij}$ was set to 0. The model was tested by controlling for the effects of dyads where either person *i or j* had current or previous expatriate experience.

*Dummy Variables for Modes of Communication*

Few social network studies seem to have differentiated between possible modes of contact. In one study of knowledge management practices in MNCs, Almeida and Grant (1998) suggested that telephone, video conference, and face-to-face communications are effective media that support interpersonal networks and knowledge transfer. McDonough et al. (1999) examined the effectiveness of electronic databases, electronic mail, face-to-face communication, and faxes in MNCs. In a social network study of cooperation and competition among global business units of an MNC, Tsai (2002) asked participants to describe the extent to which they used face-to-face, telephone, electronic, and conventional paper memos.

In this study, four possible modes of communication were measured: face-to-face ($FF_{ij}$), telecommunication ($T_{ij}$) (telephone or video conference), electronic mail ($EM_{ij}$), and communities of practice ($COP_{ij}$). Interaction via each of these modes is treated as binary matrix variable of the form $X_{ij}$. If person *i* or *j* report having contact via any mode,

the appropriate variable for that mode was set to 1, otherwise the value was set to 0. These data were used as dummy variables to assess any possible relationship among closeness, tacit knowledge sharing, and each mode of communication.

The study variables are summarized in Table 5. A discussion of the measurement instruments associated with these variables is included in the next section, followed by a discussion concerning the validity and reliability of these measures and constructs.

TABLE 5

*Summary of study variables*

| Variables | Name | Type |
|---|---|---|
| | Independent Variables | |
| Average Cultural Distance | $CD_{ij\_avg}$ | $CD_{ij\_avg} = \sum_{n=1}^{5}\{(I_{ni} - I_{nj})^2/V_n\}/5$ |
| Total Euclidean Distance | $CD_{ij\_t}$ | $CD_{ij\_t} = \sqrt{\sum_{n=1}^{5}(I_{ni} - I_{nj})^2}$ |
| Power Distance | $PDI_{ij}$ | Absolute difference in index values |
| Uncertainty Avoidance | $UAI_{ij}$ | Absolute difference in index values |
| Individualism | $IDV_{ij}$ | Absolute difference in index values |
| Masculinity | $MAS_{ij}$ | Absolute difference in index values |
| Long-Term Orientation | $LTO_{ij}$ | Absolute difference in index values |
| | Intervening Variable | |
| Strength of Social Ties | $ST_{ij}$ | $ST_{ij} = CL_{ij}/\sum_{q=1}^{N} CL_{iq,\, q=j}$ |
| Closeness | $CL_{ij}$ | 5-pt Likert (distant to a close personal friend) Average score of person *i* and *j* |

| | | |
|---|---|---|
| | Dependent Variable | |
| Tacit Knowledge Sharing | $TKS_{ij}$ | Frequency that undocumented knowledge related to improving yields is shared.<br>5-pt Likert (< yearly to almost daily)<br>Average score of person *i* and *j* |
| | Control Variables | |
| Gender differences | $G_{ij}$ | Binary (same as $i = 0$; different = 1) |
| Origin outside the study | $O_{ij}$ | Binary (same as = 0; different = 1) |
| Multinational experience | $ExpC_{ij}$ | $ExpC_{ij} = 1$ if $(ExpC_i + ExpC_j)/2 > 3$ |
| Current expat/delegate < 1year | $XpatC_{ij}$ | Binary (yes = 1; no = 0) |
| Previous expatriate/delegate | $XpatP_{ij}$ | Binary (yes = 1; no = 0) |
| | Modes of Communication | |
| Face-to-Face | $FF_{ij}$ | Binary (1 if used, 0 if not used) |
| Telecommunication | $T_{ij}$ | Binary (1 if used, 0 if not used) |
| Electronic mail | $EM_{ij}$ | Binary (1 if used, 0 if not used) |
| Communities-of-Practice | $COP_{ij}$ | Binary (1 if used, 0 if not used) |

## Research Instruments

### *Strength of Social Ties*

The best overall measure of tie strength in social relationships is closeness or emotional intensity (Marsden & Campbell, 1984). In this study, the survey instrument

used to measure closeness was adapted from the General Social Survey (GSS) (National Opinion Research Center, 2004) and a social network study of knowledge transfer among research and development engineers conducted by Reagans and McEvily (2003). Reagans and McEvily's instrument was adapted for this study to include a fifth level, defined as *a close personal friend*. The closeness that person *i* had with person *j* ($CL_{ij}$) was measured on a 5-point Likert scale using the following categories: (0) distant, (1) less than distant, (2) close, (3) especially close, or (4) a close personal friend.

*Tacit Knowledge Sharing*

Metrics for tacit knowledge sharing pose a particular challenge. This challenge was well expressed by the philosopher Michael Polanyi. According to Polanyi (1966), tacit knowing is beyond intentional explicit thought, for "no one speaks of a knowledge he himself has and cannot tell" (p. 8). Organizational knowledge is a mixture of explicit and tacit knowledge (Nonaka & Takeuchi, 1995). Semiconductor process knowledge is similarly described as an "intertwining of codified and tacit knowledge" (Almeida et al., 2002, p. 147). According to Nonaka and Takeuchi (1995), explicit knowledge can be codified or expressed in symbols, making it transmittable to other people through systematic language. Tacit knowledge, on the other hand, is difficult to transfer to other people because it is experiential, personal, and context-specific. In this study, the level of tacitness is assumed to be related to the codifiability of knowledge (Kogut & Zander, 1993). Tacit knowledge is "difficult to understand and codify" (p. 636); consequently, it is likely to remain un-codified. Knowledge that is not likely to be codified lies in the realm of tacit know-how (Crossan et al., 1999).

In a search of the literature, no existing instruments were found for measuring the transfer of tacit knowledge related to process yield improvement activities. In this study, tacit semiconductor process knowledge is defined as *un-codified* knowledge related to manufacturing yield problems or improvements. The subject company had a well established procedure for classifying process testing activities according to five levels of importance. Only Class 3, 4, or 5 process testing activities were required to be shared with other sites. In the study, tacit knowledge sharing ($TKS_{ij}$) was measured by the frequency with which person *i* discussed with person j, process or yield related problems or improvements that were *not* explicitly documented in the company's Class 3, 4, or 5 process testing and implementation documents. This was measured on a 5-point Likert scale using the following categories: (1) less than once a year, (2) at least once a year, (3) at least once a month, (4) at least once a week, or (5) almost every day.

## Validity and Reliability

In network studies there are particular concerns related to accuracy, validity, reliability, and measurement error. Beyond the normal concerns of whether a measure actually measures what is intended and repeatedly provides the same result, there is also a concern of whether an observed network structure is the *true* network structure (Wasserman & Faust, 1999).

### *Accuracy*

Social network studies typically rely upon self-reported data from respondents, rather than the researcher's direct observations of peoples' relationships. In a summary of previous works on the accuracy of self-reported social interactions, Wasserman and Faust (1999) stated that "about half of what people report about their own interactions is

incorrect in one way or another" (p. 57). They argued that this does not decrease the accuracy of social network data, because the focus of network studies is not the particular interactions of individuals, but rather the accuracy of long-term patterns of interactions within the network structure. In this regard, Marsden (1990) suggested that although people cannot accurately recall the nature of their social ties when asked about very specific time frames, they are able to accurately report about their relationships in more general terms. In this study, temporal concerns about self-reported data were addressed by the selection of ranges for Likert-scale questions that ask respondents to recall general rather than specific time frames about their relationships. These range selections are consistent with already validated measures found in the GSS (National Opinion Research Center, 2004).

*Validity*

Wasserman and Faust (1999) noted that in social network studies the face validity of relational measures are often the only means that a researcher has for validating that a measure actually measures what is intended. Construct validity is a more formal test of the extent to which a measure validates theoretical propositions. According to Wasserman and Faust (1999), construct validity has been demonstrated for very few measures of social network concepts.

Construct validity has been evaluated for two of the variables measured in this study. Marsden and Campbell (1984) discussed the construct validity of the GSS measures for tie strength. Hofstede (2001) provided extensive data from comparative studies that validate the differences in national culture. The validation data for these measures are discussed in the paragraphs that follow. A search of the literature revealed

no appropriate tool for measuring the sharing of tacit semiconductor process knowledge between individuals. Consequently, a measure of tacit knowledge sharing has been developed for this study. This measure is based on literature from the fields of organizational knowledge and the semiconductor process industry. Face validity for the measure of tacit knowledge sharing was evaluated by a panel of four experts: Dr. Jay Klagge, Dr. Marie Abram, Dr. Anthony Kortens, and Dr. Val Burris. This panel reviewed the content and design of the survey questionnaire to accomplish the objectives of the measurements.

*Reliability*

Marsden (1993) identified two source of unreliability in network studies: (a) variations in the selection of alters by the respondent and (b) variations in response scores to a question by a given dyad. Both sources are likely to affect the reliability of relational network data. Concerning the first source of unreliability, Marsden argued that recognition is more reliable than recall for selecting network alters. He noted that network studies "rarely ask respondents to explicitly select a subset of alters from some larger set that constitutes the 'population'" (p. 402). Also, *measurement error* can be introduced into network studies if respondents' selection of alters is limited to a fixed quantity (Wasserman & Faust, 1999). In this study, concerns about the reliability of alter selection were addressed by asking respondents to recognize alters from a fixed roster, and then to recall an unlimited number of other alters from within the fixed population of the company's process engineers.

Marsden (1993) suggested that the second concern, reliability of response scores, can be verified by comparing the consistency of responses between alters. This method

was used initially in the pilot study to test the reliability of the research instrument, and again following the final survey to confirm reliability based on the actual study results. The reliability of survey questions designed to measure closeness and tacit knowledge sharing were verified by measuring the percentage of reciprocal ties and also by measuring the correlation coefficient for all responses between alters.

*Strength of social Ties*.

*Construct validity*. The strength of social ties is a theoretical construct that seeks "to describe social structures in terms of networks and to interpret the behavior of actors in light of their varying positions within the social structure" (Marsden, 1990, p. 436). The construct validity of any instrument for measuring the strength of social ties rests upon the extent to which that instrument is able measure the social interaction of individuals within a group.

In a meta-analysis of three cross-sectional studies of friendship in two U.S. and one German community, Marsden and Campbell (1984) evaluated the validity of tie strength as a multivariate construct comprised of *closeness*, *duration*, and *frequency* of contact between individuals. They developed a model for the indicators and predictors of tie strength. Their model served to construct-validate the indicators of tie strength in terms of their predictors. Marsden and Campbell concluded that *closeness* in a relationship is the best indicator of tie strength. They suggested that duration and frequency of contact were "contaminated" (p. 499) in the friendship studies by relationships between family, neighbors, and coworkers. Marsden and Campbell argued that "frequency as a measure of strength will tend systematically to overestimate the strength of ties between persons who are neighbors or co-workers, while the use of

duration as a measure of strength will overestimate the strength of ties between relatives" (p. 499). Also, the importance of duration to tie strength may decline over the length of the relationship. Because of these concerns, in this study tie strength was based only upon the measurement of closeness or emotional intensity in relationships.

*Reliability*. Marsden (1993) evaluated the reliability of the GSS measures for tie strength. He suggested that the reliability of tie strength measures can be increased above threshold levels if the number of alters are at least 7 or 8 per respondent. Marsden also suggested that a fixed roster approach eliminates the problem of unreliability in the selection of alters. As previously stated, a fixed roster was used in this study. The mean numbers of alters per respondents in this study was 19.5, with a standard deviation of 10.4, which was well above the threshold level defined by Marsden.

*Construct Validity of Cultural Distance*

Hofstede's (1980, 2001) indices for the five dimensions of national culture are the basis for the cultural distance construct. Hofstede's original data was generated from a worldwide study of more than 116,000 IBM employees. Hofstede (2001) validated his indices by correlating the scores from his study with those derived from numerous other studies that examined the same concepts within different populations. The large sample size in Hofstede's research, combined with comparative results from other studies, seem to confirm what Triandis (2004) said concerning Hofstede's (1980, 2001) work: "Hofstede's work has become the standard against which new work on cultural differences is validated" (p. 89).

Hofstede's (2001) comparative results for validating Power Distance, Uncertainty Avoidance, Individualism, and Masculinity included four notable sources. The first was a

1974 study of 362 international managers who attended an executive development seminar at IMEDE (Institut pour l'enseignement des Methodes de Direction de l'Enterprise) in Lausanne, Switzerland. The second was a 1983-84 survey of 1,590 elite academic, government, and industry professionals from 19 countries, who attended management seminars in Salzburg during the period between 1964 and 1983. The third was a survey of more than 15,000 commercial airline pilots from 36 countries, conducted between 1993 and 1997. Finally, Hofstede also correlated these indices with results from the 1997 European Media and Marketing Survey (EMS 97), which surveyed more than 6,000 higher income households across Europe.

*Power distance.* According to Hofstede (2001), the IMEDE results compared well with the PDI, with a Spearman's rank correlation coefficient of rho = 0.71. The Salzburg alumni compared favorably, with a product-moment correlation coefficient of $r = 0.68$. Commercial airline pilots were strongly correlated at $r = 0.76$ and rho = 0.81.

*Uncertainty avoidance*. Uncertain avoidance correlated strongly between the Salzburg alumni and Hofstede's (1980, 2001) IBM data, with $r = 0.94$. Commercial airline pilots were marginally correlated, at $r = 0.49$ and rho = 0.47. The EMS 97 consumers correlated strongly, with $r = 0.86$.

*Individualism*. Managers attending IMEDE correlated positively with Hofstede's (1980, 2001) results for Individualism, at rho = 0.64. Results from the Salzburg alumni were strongly correlated, with $r = 0.72$. Commercial airline pilots demonstrated a similar result with $r = 0.70$. EMS 97 consumers were also positively correlated, $r = 0.60$.

*Masculinity*. Hofstede's (1980, 2001) masculinity index was moderately correlated for managers attending IMEDE, with rho = 0.59. Salzburg alumni were

strongly correlated, at $r = 0.83$. EMS 97 consumers also correlated strongly to the masculinity index, with $r = 0.72$ and rho = 0.78. The airline pilots correlated positively, with an r-value of 0.72.

*Long-term orientation*. Hofstede (2001) added Long-term Orientation (LTO) to his original 1980 work. He correlated the LTO index against different studies from those used to validate the other indices. His research on Long-term Orientation was replicated in a study of 300 mid-level managers from China, Hong Kong, and the United States. This study confirmed Hofstede's ranking of China as the highest, the U.S. as the lowest, and Hong Kong in the middle for LTO. Hofstede also correlated his results with the World Values Survey (Inglehart, Basañez, & Moreno, 1998). The World Values Survey overlapped with 13 of the countries in Hofstede's (2001) work, and correlated strongly, with $r = 0.70$.

*External Validity*

There are several factors outside of the study that could affect the dependent variable. These include local variations in organizational culture or practices, the psychological or emotional state of study participants, economic trends, and the economic health of the MNC to be studied. Local variations in the organizational culture or practices of this MNC may have an influence on social interaction among individuals from different sites. The psychological or emotional condition of process engineers may influence their willingness to establish and maintain strong social ties. The semiconductor industry is currently recovering from one of its deepest downturns. Economic pressures to control costs may influence the frequency and modes of cross-site interaction among individuals. To limit the effects of these external factors upon the research outcomes, the

validation process in this study included existing validation data, a panel of experts, and a pilot study that was conducted prior to the actual study.

## Pilot Study

A small pilot study was conducted involving 22 equipment engineers from the four manufacturing sites, who have knowledge sharing needs similar to those of process engineers. The first objective of the pilot study was to test the instructions and procedures for deployment of the study, and to test the clarity of the survey instruments. Second, the pilot study assessed the reliability of the test instrument to provide consistent results. The threshold for reliability was a percentage of reciprocated ties greater than 50% and a Pearson's correlation greater than 0.7 for responses between alters to the closeness and tacit knowledge survey questions. Nineteen participants completed the pilot study, for a response rate of 86.4%. The results of the pilot study verified the reliability of the survey instrument. The percentage of reciprocated ties was 71.2%. The correlation between alters for the measure of closeness was significant, at $r = 0.771$. Likewise, the correlation between alters for the tacit knowledge sharing question was significant, at $r = 0.734$.

## Procedures

The MNC participating in this study agreed to the use of the company's intranet for a web-based survey. A link to the survey was sent by electronic mail to each participant. Participants had the choice of taking the survey in English, or a certified translation in German, or Japanese. Alternative local languages were not deemed necessary for participants in Singapore, because Singaporean professionals are fluent in written and spoken English. Participants were informed concerning the nature and intent of the study. To proceed with the survey, participants first read a release form (Appendix

A) informing them that their participation was optional and that all information would be kept in strict confidence.

As respondents completed the questionnaire, their responses were automatically entered in an electronic database for later analysis. Responses to the survey were monitored by daily observation of the database. Follow-up messages were sent after 14 days and 21 days to those who had not completed the survey. Prior to analysis, survey data was screened for incomplete or ambiguous answers. Partially completed or non-conforming surveys were eliminated from the data.

## Analysis

Network correlation and regression techniques based on non-parametric randomization were used to test the hypothesized relationships. Standard statistical methods for inference testing of hypotheses are not appropriate for network data, because the observations of dyadic relations within a network are not independent (Borgatti & Cross, 2003; Dekker et al., 2003; Krackhardt, 1988). Varying amounts of interdependence in network observations create an autocorrelation problem (Krackhardt, 1988). For example, in this study the extent to which person *i* shared knowledge with person *j* was influenced to some unknown degree by every other person that *i* shared knowledge with. This problem may be significant when testing a null hypothesis that two network variables are uncorrelated. Krackhardt (1988) proposed a non-parametric solution to the autocorrelation problem; one that employs the quadratic assignment procedure (QAP) proposed by Hubert and others (Hubert, 1987; Hubert & Schultz, 1976) for correlation between two N x N matrix variables. Krackhardt (1988) adapted this

technique to regression in multivariate network studies through a variation called multiple regression quadratic assignment procedure (MRQAP).

Ordinary-least-squares (OLS) techniques for testing hypothesized relationships assume that data in dyadic relationship are independent, and that error terms are equally distributed across person *i*'s network (Krackhardt, 1988). Krackhardt argued that dyads cannot reasonably be assumed to be independent. Consequently, OLS tests applied to network data may be biased by row or column interdependence. Krackhardt demonstrated that when autocorrelation is 0.2 or less, OLS and QAP are equally effective, with only a 10% chance that data will appear significantly correlated. When the degree of autocorrelation increases to 0.5, there is a 40% chance that data will appear significantly correlated using OLS. When autocorrelation increases to 0.8, there is a 60% chance that data will appear correlated with OLS. Krackhardt demonstrated that using QAP the chance that data will appear correlated remains constant at 10%, regardless of the degree of autocorrelation.

*Quadratic Assignment Procedure (QAP)*

QAP compensates for autocorrelation errors in the data by comparing the correlation coefficients for the actual data with those of a reference distribution. Testing a null hypothesis between two variables requires creation of a reference distribution by random permutations of actors in the matrix rows and columns of one variable, while holding the actual observed data in the matrix cells constant (Wasserman & Faust, 1999). For each permutation, an index is computed for how close the permutated data are to the hypothesis. Stated another way, each permutation is "a random estimate of the relation between the two variables" (Dekker et al., 2003, p. 2). Multiple randomizing (up to *n*!

times) results in a reference distribution of coefficients called the "permutation distribution" (Wasserman & Faust, 1999, p. 676). This random reference distribution represents one that "could have been derived from a dataset with the same structure as the data set under evaluation" (Dekker et al., 2003, p. 2). A permutation test of the hypothesis determines the fraction of the permutations that have coefficients that fit worse than those actually observed (Wasserman & Faust, 1999).

*Multiple Regression Quadratic Assignment Procedure (MRQAP)*

MRQAP extends the bivariate QAP analysis to the more common multivariate situation (Krackhardt, 1988; Krackhardt, 1993). In MRQAP analysis, regression coefficients are first created using OLS estimates for the relationship between the dependent matrix variable and each independent, intervening, or control matrix variable (Hinds et al., 2000). Then the rows and columns of the dependent variable matrix are randomly permutated (up to $n!$ times), calculating a new set of regression coefficients for each permutation. The result is a reference, permutation distribution of beta coefficients. The significance of the beta coefficients are stated in terms of the percentage of permutated betas that are larger than the observed betas.

*Hypothesis Testing Using QAP*

To test the hypothesized relationships in this study, inference tests were designed based on the QAP using UCINET 6 software (Borgatti et al., 2002). For each hypothesis, the inference test of the hypothesis compared the correlation coefficient for the two variables with the value obtained for a reference population distribution created by 2,500 permutations. The null hypothesis assumes that $r = 0$. The alternative hypothesis assumes that $r \neq 0$. A positive relationship is indicated by an $r$-value between 0 and 1. A negative

relationship is indicated by an *r*-value between 0 and -1. The significance of the *r* values was assessed at $\rho < 0.001$, $\rho < 0.01$, and $\rho < 0.05$, one-tailed test. The ρ-value is a fraction representing the permutations that fit worse than those actually observed.

*Predictive Model Testing Using MRQAP*

To test the predictive ability of the model, multiple regression analysis was performed based on permutation distributions generated with MRQAP (Krackhardt, 1993) using UCINET 6 software (Borgatti et al., 2002). Regression coefficients were calculated using OLS for the relationship between the dependent variable, tacit knowledge sharing ($TKS_{ij}$), the control variables, the independent variables, and the intervening variable. Then the rows and columns of the dependent variable matrix were randomly permutated 2,500 times, calculating a new set of regression coefficients for each permutation. The resulting reference, permutation distribution of beta coefficients for each variable was compared to the actually observed betas. The significance of the beta coefficients is stated in terms of the percentage of permutated betas that are larger than the observed beta for that variable. The significance was assessed at $\rho < 0.001$, $\rho < 0.01$, and $\rho < 0.05$, one-tailed test.

*Data Presentation*

The data are presented in chapter 4. Table 7 summarizes the network statistics and demographics. Table 8 presents the descriptive statistics, including the mean, standard deviation, minimum values, and maximum values for the independent, intervening, and dependent variables. The results of 171 bivariate correlations among all of the study variables are presented in Table 10. The results from five hierarchical regression models that examine the predictive ability of the hypothesized relationships are examined in

Table 14. Model 1 tested the influence of the control variables as predictors of tacit knowledge sharing. Model 2 examined the effectiveness of various modes of communication. The control variables are combined with cultural distance in model 3 to test the hypothesized relationship between cultural distance and tacit knowledge sharing. In model 4 the control variables were combined with social ties to test the hypothesized relationship between social ties and tacit knowledge sharing. A fifth model combined the control variables with cultural distance and social ties to test the predictive ability of the complete model and to evaluate the hypothesized role of social ties as an intervening mediator in the relationship between cultural distance and tacit knowledge sharing.

## Summary

This quantitative correlational study, using social network data, attempted understand the relationship among cultural distance, the strength of social ties, and the sharing of tacit manufacturing process knowledge in a multinational company in the semiconductor industry. The relationship among these variables was examined in a social network study involving a target population of 252 process engineers in a multinational company with four manufacturing sites located in Germany, the United States, Singapore, and Japan.

The research design is a quantitative correlational study using social network data and a web-based survey for data collection. The unit of analysis is the dyad, or pairs of respondents and alters. Variables in the study are arranged in N x N matrices with N(N-1) potential dyadic observations for each relational variable. The research instruments were adapted from the GSS Codebook Variables (National Opinion Research Center, 2004) and a previous social network study of knowledge transfer among research and

development engineers (Reagans & McEvily, 2003). Validity and reliability were addressed to the extent possible in the study. Network correlation analysis based on QAP was used to test the hypothesized relationships among the independent, intervening, and dependent variables. Multiple regression analysis using MRQAP was used to test the predictive ability of the model for tacit knowledge sharing. In chapter 4 the results of the study will be presented and analyzed. Finally, conclusions from the research will be presented in chapter 5, along with implications and recommendations concerning the utility and generalizability of the research.

# CHAPTER 4: PRESENTATION AND ANALYSIS OF DATA

Chapter 3 described the methodology that was used to test the hypothesized relationship among the study variables and to answer the research question. This chapter examines the results of the survey and reports on the statistical analysis of the study data that was performed to test the hypotheses. The chapter begins with a discussion of the survey results followed by an analysis of the reliability of the measurement instrument. The next section discusses descriptive statistics, including network statistics, demographics, and univariate statistics for the study variables. This is followed by a presentation of the results of a bivariate correlation analysis among all of the study variables. Finally, the statistical fit of the research model is assessed and the results of hypothesis testing are discussed.

The purpose of this quantitative correlational study, using social network data, was to determine the extent to which strong social ties are effective for overcoming cultural distance between individuals and increasing the sharing of tacit manufacturing process knowledge among a target population of 252 process engineers in a multinational semiconductor manufacturing company with operations in Germany, the United States, Singapore, and Japan. The independent variable is *cultural distance*, the intervening variable is the *strength of social ties*, and the dependent variable is the extent to which *tacit manufacturing process knowledge* is shared. In the study, cultural distance, social ties, and tacit knowledge sharing are treated as relational ties among the study participants who, by virtue of the organizational structure, comprise a complete social network. Control variables in the study are differences in gender, country of origin outside of the study, experience working in the multinational environment, and

experience as an expatriate. Four dummy variables are also included for modes of communication used by the study participants.

Participants completed a web-based survey (Appendix B) comprised of Likert-scale questions concerning their relational ties with other process engineers at the participating company's manufacturing sites in Germany, the United States, Singapore, and Japan. Each relational variable was structured as a separate NxN matrix describing the actor-by-actor relational ties. Network correlation and regression techniques using quadratic assignment procedure (QAP) and multiple regression quadratic assignment procedure (MRQAP), described in chapter 3, were used to inference test the hypotheses.

## Survey Results

A link to the survey website was sent by electronic mail to each of the 252 process engineers. Four of these messages were returned as undeliverable because these engineers had recently left the organization. Seventy-seven responses were received during the first two weeks of the study. The first follow-up message was sent after 14 days. This follow-up was originally scheduled to be sent after 7 days, but was delayed for 1 week due to Easter holidays in Germany and spring break in the United States. During the week following the first follow-up message the number of responses increased to 111. A second follow-up message was sent after 21 days, and the study was closed 1 week later. In total, the survey website was active for 28 days. The total number of responses received was 152, for a response rate of 60.3%.

Fourteen participants started but did not complete the survey. These partially completed surveys were not included in the data. The final number of accepted surveys used in the data analysis was 138. Table 6 shows the target number of participants,

number of responses, response rate, and number of accepted surveys from each site. The lower response rate from Germany may have been due to a reorganization that was announced just prior to the survey. An unknown number of participants were informed about pending changes in their work assignments and possible termination of employment around the same time that the survey commenced. Despite this unfortunate factor, the number of completed surveys was more than acceptable for statistical purposes (Triola, 2001).

TABLE 6

*Summary of Responses by Site*

| Site | Target Number of Participants | Number of Responses | Response Rate | Accepted Surveys |
|---|---|---|---|---|
| Germany | 139 | 63 | 45.3% | 58 |
| United States | 37 | 35 | 94.5% | 34 |
| Singapore | 37 | 27 | 72.9% | 23 |
| Japan | 39 | 27 | 69.2% | 23 |
| TOTAL | 252 | 152 | 60.3% | 138 |

## Reliability of Survey Instrument

Following the methodology proposed by Marsden (1993), the reliability of the survey instrument was verified by comparing the consistency of responses between alters. The reliability of survey questions designed to measure closeness and tacit knowledge sharing were verified by measuring the percentage of reciprocated ties and also by QAP correlation of the responses between alters. Both measures confirmed the reliability of the

survey instrument. The percentage of reciprocated ties in the study was 53.7%. The consistency of responses between alters for the closeness measure was strongly correlated, with a Pearson's coefficient of 0.678 ($\rho < .001$). Likewise, the consistency of alters' responses for the tacit knowledge question was strongly correlated, with a Pearson's coefficient of 0.736 ($\rho < .001$).

## Descriptive Statistics

Table 7 contains a summary of network statistics and demographics. The total number of accepted study participants was N = 138, for a network size of 138 x 138. The number of observations or potential ties among the participants are N(N-1) = 18,906. The mean number of alters named by each ego was 19.5, with a standard deviation of 10.4, a minimum of 2, and a maximum of 57. The total number of network ties or dyads was 3,496. Network density, the number of actual ties divided by the number of possible ties (observations), was 3,496/18,906 = 0.1849.

The average multinational experience among all dyads was 2.3 years, with a standard deviation of 5.6 years, a minimum of 0.1 years, and a maximum of 30.9 years. Based on the mean level of multinational experience, the experience variable $Exp_{ij}$ was dichotomized at $Exp_{ij}$ > 3yrs to create a control or dummy variable. Ten female and 128 male participants completed the survey, resulting in 562 dyads with gender differences. There were 1,424 dyads where either person *i* or person *j* was of a national origin other than those being studied (German, U.S, Singaporean, or Japanese). The number of cross-site ties or dyads was 908. There were 58 dyads involving a current expatriate with less than 1 year of experience in that assignment, and 230 dyads involving a previous expatriate who had worked for more than 1 year in the other person's culture.

TABLE 7

*Network statistics and demographics*

| Statistic | Total | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Participants N | 138 | ---- | ---- | ---- | ---- |
| Observations N(N-1) | 18,906 | ---- | ---- | ---- | ---- |
| Alters Named per Ego | ---- | 19.5 | 10.4 | 2 | 57 |
| Network Ties (dyads) | 3,496 | ---- | ---- | ---- | ---- |
| Network Density | 0.1849 | ---- | ---- | ---- | ---- |
| Cross-site Ties (dyads) | 908 | ---- | ---- | ---- | ---- |
| Multinational Experience | ---- | 2.3 yrs | 5.6 | 0.1 | 30.9 |
| Dyads where $ExpC_{ij} > 3$ | 3,432 | ---- | ---- | ---- | ---- |
| Female Participants | 10 | ---- | ---- | ---- | ---- |
| Male Participants | 128 | ---- | ---- | ---- | ---- |
| Gender-Different Dyads | 562 | ---- | ---- | ---- | ---- |
| Origin-Different Dyad | 1,424 | ---- | ---- | ---- | ---- |
| Current Expatriate Dyads | 58 | ---- | ---- | ---- | ---- |
| Previous Expatriate Dyads | 230 | ---- | ---- | ---- | ---- |

Social networks can be represented as a directed graph or "digraph" (Wasserman & Faust, 1999, p. 94). A digraph is constructed of nodes that represent actors, and lines between those nodes that represent ties. An arrow on each line represents the direction of the tie from its origin to its destination. A digraph of the 3,496 ties among the 138 study participants is depicted in Figure 13.

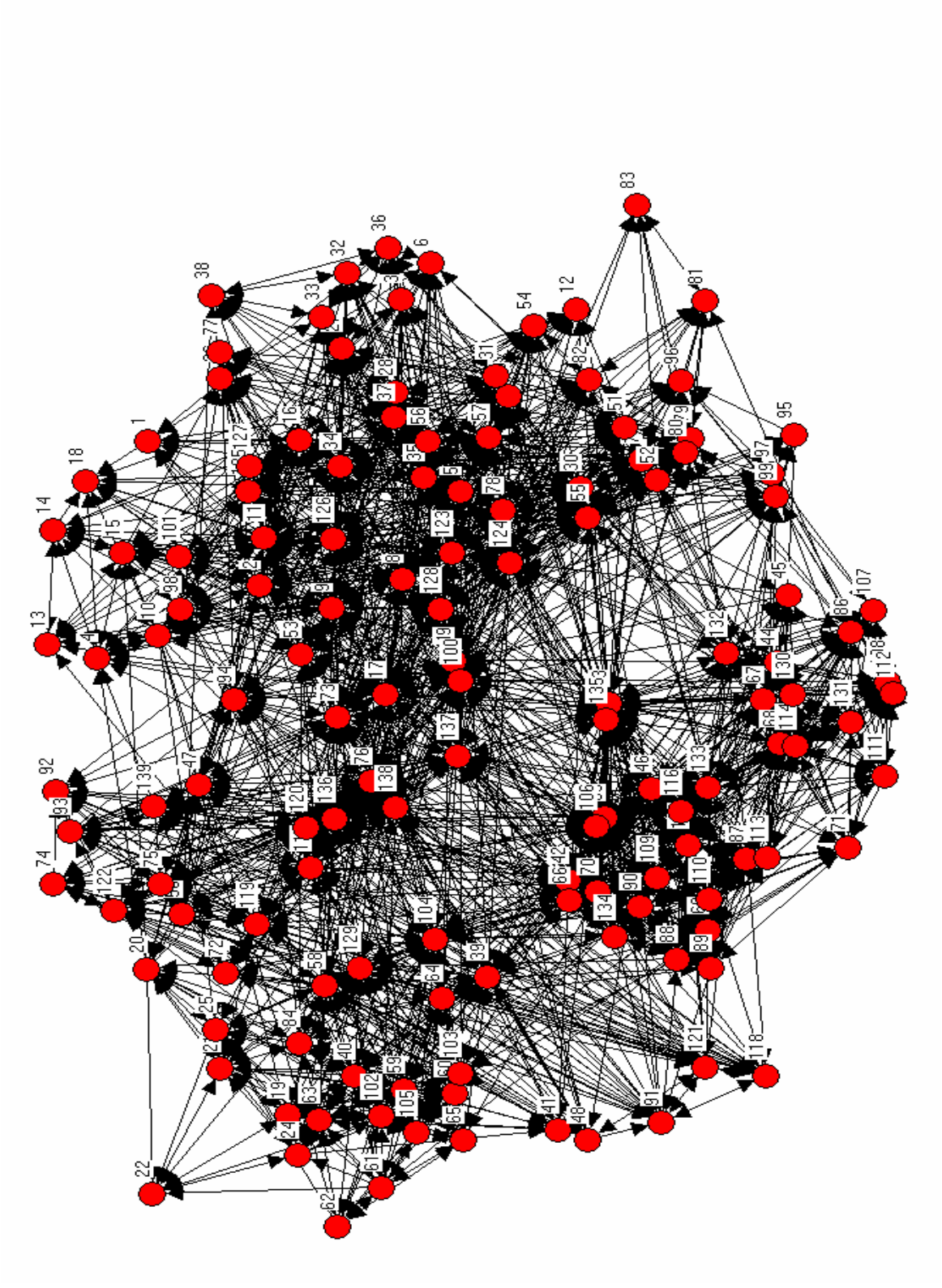

*Figure 13.* Network digraph

Univariate statistics for the independent, intervening, and dependent variables are presented in Table 8. These include the mean and standard deviation for each matrix variable as well as the minimum and maximum values.

TABLE 8

*Descriptive Statistics*

| Variable | Mean | SD | Min | Max |
|---|---|---|---|---|
| $PDI_{ij}$ | -1.103 | 5.761 | -39.000 | -0.000 |
| $UAI_{ij}$ | -2.026 | 9.981 | -84.000 | -0.000 |
| $IDV_{ij}$ | -1.908 | 9.250 | -71.000 | -0.000 |
| $MAS_{ij}$ | -0.911 | 4.912 | -47.000 | -0.000 |
| $LTO_{ij}$ | -1.041 | 5.948 | -51.000 | -0.000 |
| $CD_{ij\_avg}$ | -0.103 | 0.532 | -4.439 | -0.000 |
| $CD_{ij\_t}$ | -3.506 | 16.627 | -106.607 | -0.000 |
| $CL_{ij}$ | 0.238 | 0.641 | 0.000 | 4.000 |
| $ST_{ij}$ | 0.007 | 0.021 | 0.000 | 0.333 |
| $TKS_{ij}$ | 0.359 | 0.934 | 0.000 | 5.000 |

*Note*. Based on 18,960 observation within the network

*Cultural Distance*

Cultural distance and each of Hofstede's (1980, 2001) indices that comprise the cultural distance construct were reverse coded to facilitate the analysis. Cultural distance between alters, calculated as the average ($CD_{ij\_avg}$) of the differences in Hofstede's indices adjusted for statistical variance in those measures (Kogut & Singh, 1988), had a

mean value of -0.103, with a standard deviation of 0.532 and a maximum negative value of -4.439. The Euclidean measure (Morosini et al., 1998) of differences in Hofstede's indices ($CD_{ij\_t}$) had a mean value of -3.506, with a standard deviation of 16.627 and a maximum negative value of -106.607.

The mean value for power distance between alters ($PDI_{ij}$) was -1.103, with a standard deviation of 5.761. Uncertainty avoidance ($UAI_{ij}$) had a mean value of -2.026 and a standard deviation of 9.981. The largest cultural difference between alters was the individualism measure ($IDV_{ij}$), with a mean value of -1.908 and a standard deviation of 9.250. The mean of differences for the masculinity measure ($MAS_{ij}$) was -0.911, with a standard deviation of 4.912. Long-term orientation ($LTO_{ij}$) had a mean value of -1.041 and a standard deviation of 5.948.

*Tie Strength*

The closeness that person *i* had with person *j* was measured on a 5-point Likert scale using the following categories: (0) distant, (1) less than distant, (2) close, (3) especially close, or (4) a close personal friend. Closeness in each dyadic relationship ($CL_{ij}$) was treated as the average closeness reported by person *i* and person *j*. The mean score for the closeness measure was 0.238, which is slightly more than a distant relationship. The standard deviation was 0.641, indicating that approximately 68% of relationships were somewhat less than distant, and 95% ($2\sigma$) were less than close. Tie strength ($ST_{ij}$), which was computed as closeness in proportion to an ego's network of alters, had a mean value of 0.007, a standard deviation of 0.021, a minimum value of 0, and a maximum of 0.333.

*Tacit Knowledge Sharing*

Tacit knowledge sharing was measured by the frequency with which person *i* discussed with person *j*, process or yield related problems or improvements that were *not* explicitly documented in the company's Class 3, 4, or 5 process testing and implementation documents. This was measured on a 5-point Likert scale using the following categories: (1) less than once a year, (2) at least once a year, (3) at least once a month, (4) at least once a week, or (5) almost every day. Tacit knowledge sharing in each dyadic relationship ($TKS_{ij}$) was treated as the average reported by person *i* and person *j*. Overall, the mean level of tacit knowledge sharing among participants was 0.359, which is considerably less than once a year. The standard deviation was 0.934; indicating that approximately 68% of the respondents shared tacit knowledge less than once a year and 95% shared tacit knowledge slightly more often than once a year.

*Modes of Communication*

The frequency distributions for the four modes of communication examined in the study are shown in Table 9. Participants were asked, for each of the individuals they had selected or named, to indicate the modes of communication they use to share information. Possible modes of communication were face-to-face ($FF_{ij}$), telecommunication ($T_{ij}$) (telephone or video conference), electronic mail ($EM_{ij}$), and communities of practice ($COP_{ij}$). The most common form of communication was electronic mail, which was cited by 2,116 dyads. Face-to-face communication was the second most cited mode, with 1,904 dyads reporting face-to-face communication as one of the modes they used for knowledge sharing. Telecommunications was reported by 1,348 dyads. Only 44 dyads reported using the company's communities of practice and interest website.

TABLE 9

*Modes of communication*

| Mode | Frequency Cited |
|---|---|
| Electronic mail | 2,116 |
| Face-to-Face (F-$F_{ij}$) | 1,904 |
| Telecommunications | 1,348 |
| Communities of Practice and Interest | 44 |

## Correlation Results

The results of QAP correlations among all of the study variables are shown in Table 10. As previously discussed in chapter 3, QAP is a non-parametric statistical methodology that compensates for autocorrelation errors that are likely to occur when OLS methods are applied to matrix data sets (Borgatti & Cross, 2003; Dekker et al., 2003; Krackhardt, 1988). QAP correlations were performed using UCINET 6 software (Borgatti et al., 2002). Table 10 contains the standardized r-values along with significance levels from 171 bivariate correlations. Significance levels were assessed at $\rho < .05$, $\rho < .01$, and $\rho < .001$. Pearson's correlation coefficients were considered as slightly correlated (0.1 to 0.4), moderately correlated (0.4 to 0.7), or highly correlated (> 0.7).

TABLE 10

*QAP Correlations among variables*

| Variable | $G_{ij}$ | $O_{ij}$ | $Exp_{ij}$>3 | $XpatC_{ij}$ | $XpatP_{ij}$ | $F\text{-}F_{ij}$ | $T_{ij}$ | $EM_{ij}$ | $COP_{ij}$ |
|---|---|---|---|---|---|---|---|---|---|
| $G_{ij}$ | 1.000 | | | | | | | | |
| $O_{ij}$ | $0.262^{3}$ | 1.000 | | | | | | | |
| $Exp_{ij}$ >3 | $0.349^{3}$ | $0.581^{3}$ | 1.000 | | | | | | |
| $XpatC_{ij}$ | $0.069^{1}$ | $0.042^{1}$ | $0.118^{3}$ | 1.000 | | | | | |
| $XpatP_{ij}$ | $0.089^{3}$ | $0.144^{3}$ | $0.236^{3}$ | $0.064^{1}$ | 1.000 | | | | |
| $F\text{-}F_{ij}$ | $0.276^{3}$ | $0.428^{3}$ | $0.688^{3}$ | $0.102^{3}$ | $0.147^{3}$ | 1.000 | | | |
| $T_{ij}$ | $0.243^{3}$ | $0.386^{3}$ | $0.569^{3}$ | $0.122^{3}$ | $0.176^{3}$ | $0.631^{3}$ | 1.000 | | |
| $EM_{ij}$ | $0.297^{3}$ | $0.456^{3}$ | $0.734^{3}$ | $0.099^{3}$ | $0.227^{3}$ | $0.666^{3}$ | $0.709^{3}$ | 1.000 | |
| $COP_{ij}$ | $0.030^{1}$ | $0.099^{3}$ | $0.100^{3}$ | -0.003 | $0.045^{1}$ | $0.108^{3}$ | $0.093^{3}$ | $0.115^{3}$ | 1.000 |
| $PDI_{ij}$ | $-0.241^{3}$ | $-0.212^{3}$ | $-0.404^{3}$ | $-0.167^{3}$ | $-0.127^{3}$ | $-0.070^{3}$ | $-0.169^{3}$ | $-0.330^{3}$ | $-0.032^{1}$ |
| $UAI_{ij}$ | $-0.238^{3}$ | $-0.239^{3}$ | $-0.427^{3}$ | $-0.134^{3}$ | $-0.173^{3}$ | $-0.062^{3}$ | $-0.155^{3}$ | $-0.347^{3}$ | $-0.029^{1}$ |
| $IDV_{ij}$ | $-0.214^{3}$ | $-0.263^{3}$ | $-0.434^{3}$ | $-0.135^{3}$ | $-0.172^{3}$ | $-0.073^{3}$ | $-0.162^{3}$ | $-0.357^{3}$ | $-0.032^{2}$ |
| $MAS_{ij}$ | $-0.203^{3}$ | $-0.221^{3}$ | $-0.390^{3}$ | $-0.085^{2}$ | $-0.104^{3}$ | $-0.050^{3}$ | $-0.115^{3}$ | $-0.312^{3}$ | $-0.019^{1}$ |
| $LTO_{ij}$ | $-0.162^{3}$ | $-0.207^{3}$ | $-0.369^{3}$ | $-0.068^{2}$ | $-0.057^{2}$ | $-0.048^{3}$ | $-0.093^{3}$ | $-0.292^{3}$ | $-0.018^{1}$ |
| $CD_{ij\_avg}$ | $-0.239^{3}$ | $-0.232^{3}$ | $-0.406^{3}$ | $-0.127^{3}$ | $-0.111^{3}$ | $-0.061^{3}$ | $-0.150^{3}$ | $-0.330^{3}$ | $-0.026^{1}$ |
| $CD_{ij\_t}$ | $-0.231^{3}$ | $-0.255^{3}$ | $-0.444^{3}$ | $-0.129^{3}$ | $-0.157^{3}$ | $-0.067^{3}$ | $-0.156^{3}$ | $-0.361^{3}$ | $-0.029^{2}$ |
| $CL_{ij}$ | $0.310^{3}$ | $0.440^{3}$ | $0.766^{3}$ | $0.105^{3}$ | $0.188^{3}$ | $0.787^{3}$ | $0.621^{3}$ | $0.681^{3}$ | $0.118^{3}$ |
| $ST_{ij}$ | $0.271^{3}$ | $0.418^{3}$ | $0.708^{3}$ | $0.079^{3}$ | $0.129^{3}$ | $0.705^{3}$ | $0.520^{3}$ | $0.573^{3}$ | $0.115^{3}$ |
| $TKS_{ij}$ | $0.316^{3}$ | $0.492^{3}$ | $0.789^{3}$ | $0.114^{3}$ | $0.195^{3}$ | $0.817^{3}$ | $0.623^{3}$ | $0.704^{3}$ | $0.129^{3}$ |

| Variable | $PDI_{ij}$ | $UAI_{ij}$ | $IDV_{ij}$ | $MAS_{ij}$ | $LTO_{ij}$ | $CD_{ij\_avg}$ | $CD_{ij\_t}$ | $CL_{ij}$ | $ST_{ij}$ |
|---|---|---|---|---|---|---|---|---|---|
| $PDI_{ij}$ | 1.000 | | | | | | | | |
| $UAI_{ij}$ | $0.908^{3}$ | 1.000 | | | | | | | |
| $IDV_{ij}$ | $0.931^{3}$ | $0.878^{3}$ | 1.000 | | | | | | |
| $MAS_{ij}$ | $0.760^{3}$ | $0.920^{3}$ | $0.751^{3}$ | 1.000 | | | | | |
| $LTO_{ij}$ | $0.697^{3}$ | $0.789^{3}$ | $0.724^{3}$ | $0.936^{3}$ | 1.000 | | | | |
| $CD_{ij\_avg}$ | $0.912^{3}$ | $0.979^{3}$ | $0.892^{3}$ | $0.935^{3}$ | $0.833^{3}$ | 1.000 | | | |
| $CD_{ij\_t}$ | $0.934^{3}$ | $0.974^{3}$ | $0.944^{3}$ | $0.920^{3}$ | $0.857^{3}$ | $0.979^{3}$ | 1.000 | | |
| $CL_{ij}$ | $-0.190^{3}$ | $-0.193^{3}$ | $-0.194^{3}$ | $-0.157^{3}$ | $-0.135^{3}$ | $-0.180^{3}$ | $-0.193^{3}$ | 1.000 | |
| $ST_{ij}$ | $-0.131^{3}$ | $-0.145^{3}$ | $-0.138^{3}$ | $-0.133^{3}$ | $-0.119^{3}$ | $-0.138^{3}$ | $-0.146^{3}$ | $0.897^{3}$ | 1.000 |
| $TKS_{ij}$ | $-0.169^{3}$ | $-0.175^{3}$ | $-0.183^{3}$ | $-0.158^{3}$ | $-0.147^{3}$ | $-0.171^{3}$ | $-0.183^{3}$ | $0.919^{3}$ | $0.847^{3}$ |

*Note.* All significance based on 2,500 permutations

$^{1}$ = $\rho < .05$, $^{2}$ = $\rho < .01$, $^{3}$ = $\rho < .001$

This study attempted to answer the following question: What is the relationship among cultural distance, the strength of social ties among process engineers, and the sharing of tacit manufacturing process knowledge in a multinational manufacturing company in the semiconductor industry? The hypothesized relationship among the independent, intervening, and dependent variables is shown in Figure 14, along with the correlation results.

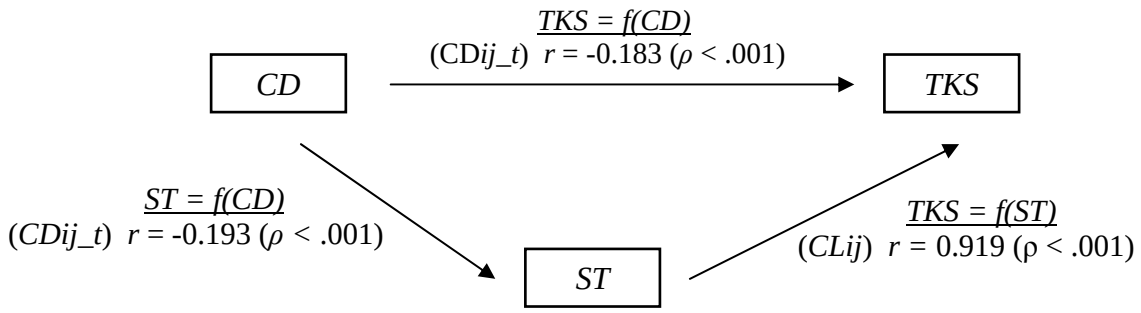


*Figure 14.* Correlations among hypothesized relationship. *Note.* Cultural Distance = *CD*; Social Ties = *ST*; Tacit Knowledge Sharing = *TKS*

Both measures of cultural distance were negatively correlated with tacit knowledge sharing ($TKS_{ij}$). Average cultural distance ($CD_{ij\_avg}$) was slightly correlated, at r = -0.171 (ρ < .001). The negative correlation between Euclidean cultural distance ($CD_{ij\_t}$) and tacit knowledge sharing was barely larger, at r = -0.183 (ρ < .001). Average cultural distance ($CD_{ij\_avg}$) and Euclidean cultural distance ($CD_{ij\_t}$) were highly and significantly correlated with each other, at r = 0.979 (ρ < .001), which suggests that both are measures of the same construct. Based on the stronger correlation with tacit knowledge sharing, the Euclidean measure for cultural distance ($CD_{ij\_t}$) was chosen for use in the regression models.

Both measures for the intervening variable social ties were highly and significantly correlated with the dependent variable tacit knowledge sharing ($TKS_{ij}$). Closeness ($CL_{ij}$) was highly correlated with tacit knowledge sharing, at r = 0.919 (ρ < .001). The related measure of tie strength ($ST_{ij}$), or closeness in network proportions, was also highly correlated with tacit knowledge sharing, at r = 0.847 (ρ < .001). The two measures were also highly correlated with each other, at r = 0.897 (ρ < .001). Base on the correlation results, closeness appears to be a better measure for the strength of social ties

than closeness in network proportions. Consequently, closeness ($CL_{ij}$) was chosen for use in the regression models.

Cultural distance was negatively correlated with both measures for social ties. Average cultural distance ($CD_{ij\_avg}$) was slightly correlated with closeness ($CL_{ij}$), at r = -0.180 ($\rho < .001$), and slightly correlated with tie strength ($ST_{ij}$), at an r-value of -0.138 ($\rho < .001$). The negative correlation between Euclidean cultural distance ($CD_{ij\_t}$) and closeness ($CL_{ij}$) was slightly greater, at r = -0.193 ($\rho < .001$). Likewise, the correlation with tie strength ($ST_{ij}$) was slightly greater, at r = -0.146 ($\rho < .001$). Based on these results, and consistent with the previous comparisons, the Euclidean measure for cultural distance ($CD_{ij\_t}$) and the closeness measure for social ties ($CL_{ij}$) were selected for the regression models.

All of Hofstede's (1980, 2000) indices for differences in national culture, power distance ($PDI_{ij}$), uncertainty avoidance ($UAI_{ij}$), individualism ($IDV_{ij}$), masculinity ($MAS_{ij}$), and long-term orientation ($LTO_{ij}$) were slightly correlated with tacit knowledge sharing. Pearson's correlations were similar to those for cultural distance, with r-values ranging from -0.147 to -0.183 ($\rho < .001$). Similarly, Hofstede's indices were slightly correlated with closeness ($CL_{ij}$) and tie strength ($ST_{ij}$). As one might expect, all of Hofstede's indices were highly and significantly correlated with both the average and Euclidean measures of cultural distance. Based on these results, the individual effects from Hofstede's indices were not modeled.

Experience working in the multinational environment appears to be a significant factor. The control variable for multinational experience ($Exp_{ij}$ >3) was moderately correlated with Euclidean cultural distance ($CD_{ij\_t}$), at r = -0.444 ($\rho < .001$). Multinational

experience ($Exp_{ij} > 3$) was also highly and significantly correlated with tacit knowledge sharing ($TKS_{ij}$), at r = 0.789 (ρ < .001), and highly and significantly correlated with closeness ($CL_{ij}$), at r = 0.766 (ρ < .001). The strong correlation between multinational experience and closeness, and the fact that both variables were highly correlated with tacit knowledge sharing, suggests the possible presence of collinearity, which can interfere with the ability to interpret regression results (Dallal, 2005).

Correlations among the control variables were for the most part only slight. The exception was multinational experience ($Exp_{ij} >3$), which was moderately correlated with origin outside of the study. Experienced dyads were also more likely to have had face-to-face contact and to stay in contact by electronic mail. Multinational experience ($Exp_{ij} >3$) was moderately correlated with face-to-face communication ($F\text{-}F_{ij}$), at r = 0.688 (ρ < .001), and highly correlated with electronic mail ($EM_{ij}$), at r = 0.734 (ρ < .001).

Face-to-Face communication and electronic mail proved to also be significant factors in the correlation results. Face-to-face communication ($F\text{-}F_{ij}$) was highly correlated with tacit knowledge sharing, at r = 0.817 (ρ < .001), and highly correlated with closeness ($CL_{ij}$), at r = 0.787 (ρ < .001). Electronic mail ($EM_{ij}$) was highly correlated with tacit knowledge sharing, at r = 0.704 (ρ < .001). Collinearity is not a concern in this case, since the modes of communication were not included in the theoretical model for tacit knowledge sharing.

## Collinearity Diagnostics

Collinearity arises when it becomes difficult or impossible to reliably determine the influence of individual regression coefficients in a multiple regression equation (Dallal, 2005). According to Dallal, independent variables need not have a perfectly

linear relationship for there to be a problem of collinearity. Indicators that correlation among independent variables may be problematic include the following: "regression coefficients will change dramatically according to whether other variables are included or excluded from the model…regression coefficients will be large in magnitude with signs that seem to be assigned at random" (p. 4). In MRQAP regression, correlation between independent variables can affect regression coefficients as well as estimates of their significance (Dekker et al., 2003).

Collinearity became a concern in this study because of the strong correlation between the control variable for multinational experience ($Exp_{ij}$ >3) and the independent variable for closeness ($CL_{ij}$); both were highly correlated, at r = 0.766 ($\rho < .001$). Both variables were also highly and significantly correlated with the dependent variable, tacit knowledge sharing ($TKS_{ij}$), at r = 0.789 ($\rho < .001$) and r = 0.919 ($\rho < .001$) respectively. Morrow-Howell (1994) suggested that there is no specific zero-order Pearson's correlation coefficient that indicates problematic correlation between predictor variables. She noted that r-values of 0.8 or greater are typically considered to be potential problems, but problems can occur with variables that are moderately correlated at 0.4. For this study, further analysis for collinearity was considered if variables from the hypothesize model were correlated at r > 0.7. Two variables meet this criteria, multinational experience ($Exp_{ij}$ >3) and closeness ($CL_{ij}$).

Table 10 includes other highly correlated variables, but collinearity is not a concern in these instances because these variables were excluded from the theoretical model. Several redundant measures were excluded, since they would naturally result in collinerarity (Morrow-Howell, 1994). Specifically, the alternative measure for cultural

distance ($CD_{ij\_avg}$) was excluded along with the measures for Hofstede's differences in national culture ($PDI_{ij}$, $UAI_{ij}$, $IDV_{ij}$, $MAS_{ij}$, and $LTO_{ij}$). The alternative measure for social ties ($ST_{ij}$) was also excluded because of redundancy. The communication mode variable for electronic mail ($EM_{ij}$) was highly correlated with $Exp_{ij}$ >3, at r = 0.734 ($\rho$ < .001), and also with Telecommunication ($T_{ij}$), at r = .709 ($\rho$ < .001). Collinearity was not a concern in this case, because the communication modes were modeled separately.

Further concerns arose when stepwise regression models produced large and unexpected changes in the coefficients of other variables. In Table 11, the significance and individual influence of the other control variables are changed in models 1 and 1a with the inclusion or exclusion of $Exp_{ij}$ >3. In models 3 and 3a the magnitude of the coefficient for cultural distance changed significantly and reversed in sign with the inclusion or exclusion of $Exp_{ij}$ >3. Models 4 and 4a show the effects of the interaction between multinational experience and closeness, with the influence from $Exp_{ij}$ >3 dominating and reducing the effects of closeness ($CL_{ij}$). A similar influence was observed in models 5 and 5a. Although the $R^2$ value is improved from 0.855 to 0.868 when $Exp_{ij}$ >3 is included in model 5, collinearity appears to be interfering to some degree with an accurate estimate of the influence from other predictors, namely closeness ($CL_{ij}$). Despite the interference from $Exp_{ij}$ >3, the predictive ability of closeness ($CL_{ij}$) in model 5 is statistically significant at the 0.001 level. It is difficult, however, to ascertain the true nature of the intervening effect that closeness ($CL_{ij}$) may have over cultural distance in the hypothesized relationship due to the interference from $Exp_{ij}$ >3. Although these variables are measures of two different phenomena, they appear to have significant overlapping influence in the model.

TABLE 11

*Effects of $Exp_{ij}$ >3 in regression models*

| Variable | Model | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 1a | 3 | 3a | 4 | 4a | 5 | 5a |
| $G_{ij}$ | 0.043[2] | 0.191[3] | 0.061[3] | 0.190[3] | 0.006 | 0.019 | 0.014 | 0.023[1] |
| $O_{ij}$ | 0.048[2] | 0.423[3] | 0.045[2] | 0.422[3] | 0.056[2] | 0.105[3] | 0.055[3] | 0.109[3] |
| $Exp_{ij}$ >3 | 0.742[3] | | 0.830[3] | | 0.170[3] | | 0.223[3] | |
| $XpatC_{ij}$ | 0.021 | 0.076[3] | 0.037[1] | 0.075[3] | 0.011 | 0.017 | 0.017 | 0.019 |
| $XpatP_{ij}$ | 0.008 | 0.113[3] | 0.020 | 0.112[3] | 0.003 | 0.015 | 0.007 | 0.018 |
| $CD_{ij\_t}$ | | | 0.219[3] | -0.004 | | | 0.078[3] | 0.022[1] |
| $CL_{ij}$ | | | | | 0.760[3] | 0.862[3] | 0.731[3] | 0.863[3] |
| Model Fit | | | | | | | | |
| $R^2$ | 0.627 | 0.299 | 0.665 | 0.299 | 0.864 | 0.854 | 0.868 | 0.855 |
| Adj. $R^2$ | 0.627 | 0.299 | 0.664 | 0.299 | 0.864 | 0.854 | 0.868 | 0.855 |

*Note.* All significance based 2,500 permutations

[1] = $\rho < .05$, [2] = $\rho < .01$, [3] = $\rho < .001$

A multicollinearity analysis is normally conducted when collinearity between variables is suspected. According to Dallal (2005), a typical multicollinearity analysis examines the $R^2$, tolerance, and Variance Inflation Factors (VIF) that result when each independent and control variable is regressed on a linear combination of the others. Another statistical method involves analyzing the statistical variance in linear combinations of correlation coefficients from the correlation matrix by assessing their

eigenvalues and condition numbers (Morrow-Howell, 1994). For this study, the former method was chosen.

Table 12 presents the results from regressing each of the study variables from the model as a dependent variable with a linear combination of the other independent and control variables. Variables that are perfectly collinear will have an $R^2$ value of 1 when they are regressed on the other variables (Dallal, 2005). The tolerance value is calculated as 1 - $R^2$. Small tolerance values, approaching 0.1, are considered to be an indication of potential collinearity. Large VIF values are also an indication of collinearity. The VIF is the inverse of tolerance (1 / tolerance). Values of VIF greater than 10 are generally considered to be problematic (Dallal, 2005; Morrow-Howell, 1994).

TABLE 12

*Multicollinearity analysis including $Exp_{ij}$ >3*

| Variable | r > 0.7 | $R^2$ | Tolerance | VIF |
|---|---|---|---|---|
| $G_{ij}$ | 0 | 0.143 | 0.857 | 1.16686 |
| $O_{ij}$ | 0 | 0.343 | 0.657 | 1.52207 |
| $Exp_{ij}$ >3 | 1 | 0.729 | 0.271 | 3.69004 |
| $XpatC_{ij}$ | 0 | 0.026 | 0.974 | 1.02669 |
| $XpatP_{ij}$ | 0 | 0.061 | 0.939 | 1.06496 |
| $CD_{ij\_t}$ | 0 | 0.268 | 0.732 | 1.36612 |
| $CL_{ij}$ | 1 | 0.619 | 0.381 | 2.62467 |

Although none of the variables had a tolerance value smaller than 0.1 or a VIF greater than 10, multinational experience ($Exp_{ij}$ >3) had a fairly small tolerance value of

0.271. To further asses the significance of these values within the model, the same analysis was performed without the $Exp_{ij}$ >3 variable. These results are shown in Table 13. When $Exp_{ij}$ >3 was excluded, none of the tolerance values were less than 0.74 and none of the VIF values were greater than 1.4.

TABLE 13

*Multicollinearity analysis excluding* $Exp_{ij}$ >3

| Variable | r > 0.7 | $R^2$ | Tolerance | VIF |
|---|---|---|---|---|
| $G_{ij}$ | 0 | 0.138 | 0.862 | 1.16009 |
| $O_{ij}$ | 0 | 0.236 | 0.764 | 1.3089 |
| $XpatC_{ij}$ | 0 | 0.026 | 0.974 | 1.02669 |
| $XpatP_{ij}$ | 0 | 0.054 | 0.946 | 1.05708 |
| $CD_{ij\_t}$ | 0 | 0.118 | 0.882 | 1.13379 |
| $CL_{ij}$ | 0 | 0.253 | 0.747 | 1.33869 |

Considering these results, along with the observed effects in Table 11 from including or excluding $Exp_{ij}$ >3 in the regression models, there is sufficient reason to exclude $Exp_{ij}$ >3 from the final model. Morrow-Howell (1994) suggested that sound models with fewer variables are conceptually better than those with marginal variables. She noted that "researchers can usually add a variable or two that reach significance and boost the model $R^2$ by a percentage or two, but their addition may be at the expense of introducing problems with multicollinearity and jeopardizing the calculations on the rest of the variables" (p. 250). In addition to these measures, the regression analysis was performed using the semi-partialling MRQAP option offered in UCINET 6 software

(Borgatti et al., 2002), which Dekker et al. (2003) suggested is more robust to conditions of multicollinearity.

## Regression Results

The results of MRQAP regressions are shown in Table 14. Tacit knowledge sharing was regressed on five models that tested the predictive ability of the hypothesized relationships. Model 1 tested the effect of the control variables. As a group, the control variables accounted for only 29.9% of variance in tacit knowledge sharing. Origin outside of the study had the largest influence, with a beta value of 0.423 ($\rho < .001$).

The second model examined the combined effects from the four dummy variables for modes of communication (face-to-face, telecommunications, electronic mail, and communities of practice). As a group, without the effects from control or independent variables, they were able to account for 71.6% of the variance in tacit knowledge sharing. All of the modes of communication were significant at the .001 level except communities of practice, which was significant at the .05 level. Face-to-face communication and electronic mail were the most influential, at beta values of 0.608 and 0.257 ($\rho < .001$) respectively. The partial effects from each mode of communication were of interest in the study, though they were not included in the hypothesized relationship among the other study variables.

Model 3 tested the hypothesized relationship between cultural distance and tacit knowledge sharing. When combined with the set of control variables, the effects of cultural distance ($CD_{ij\_t}$) were not significant, with a beta value of only -.004. The $R^2$ value for this model was only 0.299.

TABLE 14

*MRQAP regression models*

| Variable | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 |
|---|---|---|---|---|---|
| $G_{ij}$ | 0.191[3] | | 0.190[3] | 0.019 | 0.023[1] |
| $O_{ij}$ | 0.423[3] | | 0.422[3] | 0.105[3] | 0.109[3] |
| $XpatC_{ij}$ | 0.076[3] | | 0.075[3] | 0.017 | 0.019 |
| $XpatP_{ij}$ | 0.113[3] | | 0.112[3] | 0.015 | 0.018 |
| $F\text{-}F_{ij}$ | | 0.608[3] | | | |
| $T_{ij}$ | | 0.055[3] | | | |
| $EM_{ij}$ | | 0.257[3] | | | |
| $COP_{ij}$ | | 0.029[2] | | | |
| $CD_{ij\_t}$ | | | -0.004 | | 0.022[1] |
| $CL_{ij}$ | | | | 0.862[3] | 0.863[3] |
| | | | Model Fit | | |
| $R^2$ | 0.299 | 0.716 | 0.299 | 0.854 | 0.855 |
| Adj. $R^2$ | 0.299 | 0.715 | 0.299 | 0.854 | 0.855 |

*Note*. All significance based 2,500 permutations

[1] = $\rho < .05$, [2] = $\rho < .01$, [3] = $\rho < .001$

In the fourth model, the influence of closeness in dyadic relationships was tested. When combined with the set of control variables, the model accounted for 85.4% of the

variance in tacit knowledge sharing. Closeness ($CL_{ij}$) was a significant predictor, at $\beta = 0.862$ ($\rho < .001$).

In model 5, cultural distance and closeness were combined with the set of control variables to test the hypothesized relationships in the theoretical model. The variance in tacit knowledge sharing accounted for in this model improved slightly to 85.5%. The beta value for closeness ($CL_{ij}$) improved slightly to 0.863 ($\rho < .001$). Also, in this model the negative effects of cultural distance were reversed, with the beta value for cultural distance ($CD_{ij\_t}$) becoming positive at $\beta = 0.022$ ($\rho < .05$).

## Hypotheses Testing

The hypothesized relationship among the study variables was tested by QAP correlation and MRQAP regression analysis using UCINET 6 software (Borgatti et al., 2002). Hierarchical regression using MRQAP is an accepted alternative for inference testing of network data. MRQAP overcomes the autocorrelation problem in network data that makes t-tests inappropriate for inference testing (Dekker et al., 2003). In QAP correlation, the correlation coefficient from a standard OLS correlation between two matrix variables is compared with the values obtained for a reference population distribution created by 2,500 random permutations of the actors *i* and *j*, while holding the data in each matrix constant (Wasserman & Faust, 1999). The ρ-value is a fraction representing the 2500 permutations that fit worse than those actually observed. Applying the QAP methodology to hypothesis testing in this study, the null hypothesis assumes that $r = 0$. The alternative hypothesis assumes that $r \neq 0$. A positive relationship is indicated by an *r*-value between 0 and 1. A negative relationship is indicated by an *r*-value between

0 and -1. Significance of the *r*-values was assessed at $\rho < 0.001$, $\rho < 0.01$, and $\rho < 0.05$, one-tailed test.

MRQAP is a variation of QAP (Krackhardt, 1988; Krackhardt, 1993) that uses the same nonparametric statistical algorithm to regress a dependent matrix variable on one or more independent matrix variables (Tsai, 2002). Beta coefficients and $R^2$ values are calculated using OLS for the relationship between the dependent variable and linear combinations, or models, of the independent variables. Then the positions of actors *i* and *j* are randomly permutated 2,500 times while holding the data in each matrix constant and calculating a new set of regression coefficients for each permutation. The resulting reference, permutation distribution of beta coefficients for each variable is compared to the actually observed betas. The significance of the beta coefficients is stated in terms of the percentage of permutated betas that are larger than the observed beta for that variable. for that variable. Applying the methodology to this study, tacit knowledge sharing ($TKS_{ij}$) was regressed on 5 models with stepwise combinations of the study variables. The significance was assessed at $\rho < 0.001$, $\rho < 0.01$, and $\rho < 0.05$, one-tailed test.

*Hypothesis 1H - Cultural Distance and Tacit Knowledge Sharing*

The first null hypothesis, $1H_0$, assumed that differences in national culture, defined as cultural distance, will have no significant affect upon tacit knowledge sharing among process engineers in a multinational corporation in the semiconductor industry. The alternative hypothesis, $1H_1$, posited that differences in national culture do affect the sharing of tacit knowledge. Hypothesis *1H* draws upon Hofstede's (1980, 2001) dimensions of differences in national culture, constructs for these differences termed as cultural distance (Kogut & Singh, 1988; Morosini et al., 1998), and several authors who

have suggested that cultural distance is an obstacle to knowledge transfer in MNCs (Almeida & Grant, 1998; Bhagat et al., 2002; Garcia & Vano, 2002; Holden, 2001; McDonough et al., 1999; O'Keeffe, 2003; Palich & Gomez-Mejia, 1999; Persaud et al., 2001; Salk & Brannen, 2003; Simonin, 1999; Subramaniam & Venkatraman, 2001; Triandis, 2000, 2004; West, 2002; Zander & Solvell, 2000).

*Null hypothesis $1H_0$.* Specifically, the null hypothesis $1H_0$ stated that there is no statistically significant relationship between cultural distance and the sharing of tacit manufacturing process knowledge in a multinational company in the semiconductor industry. The null hypothesis initially was rejected on the basis of QAP correlation. The results of QAP correlation between the dependent variable tacit knowledge sharing ($TKS_{ij}$) and both variations of the independent variable for cultural distance ($CD_{ij\_t}$ and $CD_{ij\_avg}$) indicated that $r \neq 0$. Average cultural distance ($CD_{ij\_avg}$) was negatively correlated with tacit knowledge sharing ($TKS_{ij}$), at $r = -0.171$ ($\rho < .001$). Euclidean cultural distance ($CD_{ij\_t}$) was negatively correlated, at $r = -0.183$ ($\rho < .001$). Despite the correlation results, MRQAP regression analysis in model 3 did not support the alternative hypothesis $1H_1$, that a statistically significant relationship exists between cultural distance and tacit knowledge sharing. When tacit knowledge sharing was regressed on cultural distance, controlling for differences in gender, national origins outside of the study, and expatriate experience, cultural distance at $\beta = -0.004$ in model 4 was not statistically significant. Therefore, there is not sufficient evidence to reject the null hypothesis $1H_0$.

*Hypothesis 2H – Cultural Distance and Social Ties*

The second null hypothesis, $2H_0$, assumed that cultural distance is not significantly related to the formation of strong social ties among process engineers in a

multinational corporation in the semiconductor industry. The alternative hypothesis, $2H_1$, posited that cultural distance is related to the formation of strong social ties. The relationship between cultural distance and tie strength is theorized to be directional, whereby strong social ties are an intervening or mediating variable in the relationship between cultural distance and tacit knowledge sharing. This hypothesis draws upon two previous studies. In one study, Manev and Stevenson (2001) suggested that more culturally distant managers were likely to develop strong instrumental ties related to the transfer of work related information. In another study, Salk and Brannen (2003) suggested that the development of socioemotional bonds and advice seeking patterns are reflective of cultural differences.

*Null Hypothesis $2H_0$.* Specifically, the null hypothesis $2H_0$ stated that there is no statistically significant relationship between cultural distance and the strength of social ties among process engineers in a multinational company in the semiconductor industry. The null hypothesis was initially rejected based on the results of QAP correlation. The results of QAP correlations between both measures of cultural distance ($CD_{ij\_t}$ and $CD_{ij\_avg}$) and the intervening variables for social ties ($CL_{ij}$ and $ST_{ij}$) indicated that for all combinations $r \neq 0$. Cultural distance and social ties were negatively correlated, at r-values ranging from -0.138 to -0.193 ($\rho < .001$). For the selected measures used in the model ($CD_{ij\_t}$ and $CL_{ij}$) the coefficient was $r = -0.193$ ($\rho < .001$). The results of MRQAP analysis in model 5 support the alternative hypothesis $2H_1$, that there is a statistically significant relationship between cultural distance and the strength of social ties. Although the relationship was statistically significant it was not substantively significant. When tacit knowledge sharing was regressed on cultural distance and closeness, controlling for

differences in gender, national origins outside of the study, and expatriate experience, cultural distance was only significant, at $\beta = 0.022$ ($\rho < .05$), with an accompanying sign change. Never the less, there is sufficient evidence to reject the null hypothesis $2H_0$.

*Hypothesis 3H – Social Ties and Tacit Knowledge Sharing*

The third null hypothesis, $3H_0$, posited that strong social ties have no significant affect upon tacit knowledge sharing among process engineers in a multinational corporation in the semiconductor industry. The alternative hypothesis, $3H_1$, posited that strong social ties are related to tacit knowledge sharing. This hypothesis draws upon the work of several authors who have suggested that knowledge transfer is improved in the presence of strong social ties (Argote et al., 2003; Borgatti & Cross, 2003; Levin et al., 2002; Reagans & McEvily, 2003).

*Null hypothesis $3H_0$.* Specifically, the null hypothesis $3H_0$ stated that here is no statistically significant relationship between the strength of social ties among process engineers and the sharing of tacit manufacturing process knowledge in a multinational company in the semiconductor industry. The null hypothesis was initially rejected on the basis of QAP correlation. The results of QAP correlation between the dependent variable tacit knowledge sharing ($TKS_{ij}$) and both of the independent variables for social ties ($CL_{ij}$ and $ST_{ij}$) indicated that $r \neq 0$. Closeness ($CL_{ij}$) was highly and significantly correlated with tacit knowledge sharing ($TKS_{ij}$), at $r = 0.919$ ($\rho < .001$). The strength of social ties ($ST_{ij}$) (closeness in network proportions) was also highly and significantly correlated with tacit knowledge sharing, at $r = 0.847$ ($\rho < .001$). The results of MRQAP analysis in model 4 support the alternative hypothesis $3H_1$, that a statistically significant relationship exists between social ties and tacit knowledge sharing. When tacit knowledge sharing was

regressed on closeness ($CL_{ij}$), controlling for differences in gender, national origins outside of the study, and expatriate experience, closeness was a significant predictor, at $\beta = 0.862$ ($\rho < .001$). These results were further supported in model 5. Therefore, there is sufficient evidence to reject the null hypothesis $3H_0$.

## Summary

This chapter presented the results of the research study along with a statistical analysis of the study data. The chapter began with the results of the survey, which provided data from 138 accepted responses by participants in Germany, the United States, Singapore, and Japan. The reliability of the research instrument was confirmed by the rate of reciprocated ties between alters, and by significant correlation between alters' responses for the measures of closeness and tacit knowledge sharing. The 138 study participants were part of a social network that contained a reported 3,496 relational ties, or dyads, among the study participants. Each of the study variables was represented as a 138 x 138 matrix of the form $X_{ij}$ for describing the relational ties between pairs of actors. Descriptive statistics were used to quantify the network structure and demographics as well as the statistical distribution of each relational variable.

QAP correlations were performed using UCINET 6 software (Borgatti et al., 2002) to asses the standardized r-values and the significance levels for 171 bivariate combinations of the study variables. Both of the independent variables for social ties were highly correlated with the dependent variable, tacit knowledge sharing. One of the control variables, multinational experience, was highly correlated with the dependent variable and was also highly correlated with the independent variables for social ties. Two of the communication modes, face-to-face and electronic mail, were also highly correlated with

tacit knowledge sharing. High correlations between the redundant measures for cultural distance and social ties made it necessary to select the most highly correlated measures for further testing in the regression models and to eliminate the others to avoid problems caused by collinearity. A multicollinearity analysis of the remaining variables suggested that the control variable for multinational experience should also be removed from the regression models.

The results from the QAP correlations and MRQAP hierarchical regression models were used for inference testing of the hypotheses. The null hypothesis $1H_0$ was not rejected; multiple regression analysis results suggested that the relationship between cultural distance and tacit knowledge sharing was not statistically significant. The null hypothesis $2H_0$ was rejected; correlation and regression analysis indicated that the relationship between cultural distance and social ties, while not substantively significant, was statistically significant. The null hypothesis $3H_0$ was also rejected; there was a statistically significant relationship between social ties and tacit knowledge sharing. Conclusions, implications, and recommendations concerning these results are presented in chapter 5.

# CHAPTER 5: SUMMARY AND RECOMMENDATIONS

Chapter 1 emphasized the importance of tacit knowledge sharing as a source of sustained competitive advantage for MNCs (Barney, et al., 2001; Bhagat et al., 2002; Kogut & Zander, 1992, 1993), and in particular the importance it has for achieving high-yielding manufacturing processes in the semiconductor industry (Almeida et al., 2002; Appleyard et al., 2000; Hatch & Mowery, 1998; Khurana, 1999; West, 2002). Multinational corporations seem to have difficulty sharing tacit knowledge among their globally dispersed operations (Martin & Salomon, 2003b). This difficulty may be due not only to the tacit nature of some knowledge (Nonaka & Takeuchi, 1995; Polanyi, 1966), but also to cultural distance between knowledge partners (Holden, 2001; Simonin, 1999).

Chapter 2 identified a gap in the literature concerning the sharing of tacit knowledge in multinational corporations. Cultural distance (Kogut & Singh, 1988; Morosini et al., 1998) was identified as a potential obstacle to tacit knowledge sharing (Simonin, 1999). Several authors have suggested that social ties may improve tacit knowledge sharing (Argote et al., 2003; Hansen, 1999; Lave & Wenger, 1991; Marsden & Campbell, 1984; Reagans & McEvily, 2003), but researchers also differ on the importance of strong versus weak social ties (Granovetter, 1973; Hansen, 1999, 2002; Reagans & McEvily, 2003). During the literature review no studies were found, however, to have examined the relationship among cultural distance, the strength of social ties, and tacit knowledge sharing in MNCs. Based on the literature review, strong social ties between individuals were theorized to improve the sharing of tacit knowledge between culturally distant knowledge partners in MNCs.

Chapter 3 described the methodology used to study the hypothesized relationship among the study variables and to answer the research question. The validity and reliability of the research instrument that was used to collect the study data was established. Statistical analysis involved network correlation and regression techniques based on non-parametric randomization to test the hypothesized relationships. Inference tests were based on the QAP correlation and MRQAP regression results obtained using UCINET 6 software (Borgatti et al., 2002).

This quantitative correlational study, using social network data, attempted to determine the extent to which strong social ties are effective for overcoming cultural distance between individuals and increasing the sharing of tacit manufacturing process knowledge among a target population of 252 process engineers in a multinational semiconductor manufacturing company with operations in Germany, the United States, Singapore, and Japan. The independent variable is *cultural distance* (Hofstede, 1980, 2001; Kogut & Singh, 1988; Morosini et al., 1998), the intervening variable is the *strength of social ties* (Marsden & Campbell, 1984), and the dependent variable is the extent to which *tacit manufacturing process knowledge* was shared (Appleyard et al., 2000; Hatch & Mowery, 1998). The control variables are differences in gender, country of origin outside of the study, experience in the multinational environment, and experience as an expatriate. Four dummy variables are also included for modes of communication used by the study participants.

Chapter 4 reported the results of the research study and answered the research question: What is the relationship among cultural distance, the strength of social ties among process engineers, and the sharing of tacit manufacturing process knowledge in a

multinational manufacturing company in the semiconductor industry? The data analysis in chapter 4 demonstrated that although there was a negative relationship between cultural distance and tacit knowledge sharing among the study participants, that relationship was not statistically significant. There was a strong and statistically significant relationship between social ties and tacit knowledge sharing. Further, strong social ties acted as a mediating variable between cultural distance and tacit knowledge sharing, reversing the slightly negative influence of cultural distance. When combined with social ties, cultural distance was statistically, though not substantively, significant. Additionally, the study revealed that face-to-face communication and electronic mail were highly correlated with social ties and tacit knowledge sharing. Although the results suggested that strong social ties are important for tacit knowledge sharing, the descriptive statistics revealed that there were relatively few dyads that reported having strong social ties, and few that reported frequent tacit knowledge sharing.

Chapter 5 draws on the results of the study, the literature review, and the methodological approach taken to support the conclusions. The limitations of the study are discussed, along with recommendations, implications of the research, ethical issues, and suggestions for future research. Based on the study results, there are three conclusions that have implications for leaders in MNCs:

1. Although cultural distance may not be a significant obstacle to tacit knowledge sharing in a MNC, tacit knowledge sharing between globally dispersed knowledge partners in MNCs seems to be happening infrequently. As a result, MNCs may not be achieving the sustained competitive advantage that is possible from shared tacit knowledge.

2. Strong social ties seem to support tacit knowledge sharing. To improve tacit knowledge sharing, leaders in MNCs are encouraged to support activities that promote the development of close personal relationships that foster strong social ties.
3. The development of close personal relationships seems to depend upon having face-to-face contact supported by electronic mail. Leaders are encouraged to provide opportunities for face-to-face contact between international partners in order for close personal relationships to develop; and to encourage regular communication by electronic mail to increase tacit knowledge sharing.

## Conclusions

### *Cultural Distance*

Contrary to expectations prior to the study, cultural distance turned out not to be a significant obstacle to tacit knowledge sharing. Cultural distance was negatively correlated with tacit knowledge sharing, yet the correlation was only slight at $r = -0.183$ ($\rho < .001$). When cultural distance was combined with the set of control variables in regression model 3 it had a beta value near zero ($\beta = -.004$). As previously discussed in Chapter 3, control variables were included in the study to compensate for the affects of three factors: (a) gender homophily (Borgatti & Cross, 2003), (b) national origins outside of those expected at the four study sites, and (c) experience working in the other person's culture as a current or previous expatriate (Manev & Stevenson, 2001; Shenkar, 2001). These factors were identified as having the potential to interfere with an accurate evaluation of the influence from the independent variables.

Researchers studying differences in national culture (Hampden-Turner & Trompenaars, 2000; Hofstede, 1980, 2001) have quantified the unique ways in which people of different national cultures view the world and respond to life's problems. These differences have been arithmetically combined to create a cultural distance construct (Kogut & Singh, 1988; Morosini et al., 1998). Several authors have suggested that cultural distance is an obstacle to tacit knowledge sharing. Simonin (1999) identified cultural distance as an antecedent of knowledge ambiguity. Holden (2001) argued that cultural distance and a lack of trust between individuals inhibit cross-border knowledge transfer. Almeida and Grant (1998) suggested that differences in national culture might be an obstacle to tacit knowledge sharing among semiconductor manufacturing sites. Despite these arguments, the results of this study seem to support the findings of Manev and Stevenson (2001) who suggested that important work-related information is transferred regardless of cultural distance. They found that culturally distant managers seemed to compensate for cultural distance by developing strong instrumental ties to facilitate work-related tasks.

*Social Ties*

The results presented in chapter 4 support the hypothesis that strong social ties support tacit knowledge sharing. Closeness between individuals was strongly correlated with tacit knowledge sharing, at $r = 0.919$ ($\rho < .001$). When Closeness was combined with the set of control variables in regression model 4 closeness had a beta-value of 0.862 ($\rho < .001$). This model was able to account for 85.4% of the variance in tacit knowledge sharing.

Several authors have identified the importance of social ties for tacit knowledge transfer (Argote et al., 2003; Hansen, 1999; Lave & Wenger, 1991; Marsden & Campbell, 1984; Reagans & McEvily, 2003). Researchers differ, however, on the role of strong versus weak social ties. The findings in this study support and add to the body of existing literature by demonstrating the importance of strong versus weak social ties for tacit knowledge sharing. Granovetter (1973) theorized that in a network supported by both strong and weak ties, weak ties are instrumental in spreading unique or non-redundant information. Building on Granovetter's theory of weak ties, Augier and Vendelo (1999) suggested that weak ties are important for locating sources of unique information; but if information is non-codified or tacit knowledge, weak ties might not support its transfer. Hansen (1999) defined this as the "search-transfer problem" (p. 83). Droege and Hoobler (2003) argued that weak ties promote the sharing of tacit knowledge, and that once new knowledge makes it way into a network of individuals, strong ties promote its diffusion. Argote et al. (2003) suggested that tacit knowledge transfer in dyadic relationships is improved in the presence of strong social ties. Reagans and McEvily (2003) identified network density and a cohesive network structure as important factors in the rapid diffusion of knowledge. They suggested that strong social ties are necessary for transferring tacit knowledge across a structural hole in a social network.

While the results of this study support the theory that strong social ties are more effective for tacit knowledge transfer, they offer no new information concerning the diffusion of knowledge within a social network. The results of the study suggest that strong social ties are necessary both for locating and transferring tacit knowledge. It is

beyond the scope of the study to say whether strong or weak ties are more effective for knowledge *diffusion* once tacit knowledge has been shared.

*Tacit Knowledge Sharing*

The results of multiple regression analysis for the hypothesized relationship are shown in Figure 15. The results of the study support the hypothesized relationship among cultural distance, social ties, and tacit knowledge sharing.

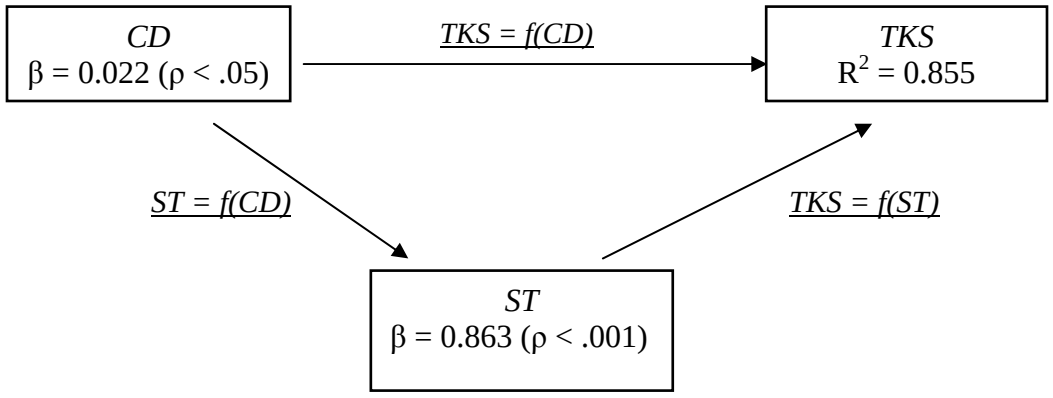


*Figure 15.* Regression results for hypothesized relationship. *Note.* Cultural Distance = *CD*; Social Ties = *ST*; Tacit Knowledge Sharing = *TKS.*

In regression model 5, tacit knowledge sharing was regressed on cultural distance and closeness, along with the set of control variables. The model accounted for 85.5% of the variance in tacit knowledge sharing, at $R^2 = 0.855$. Social ties were a strong predictor, with a beta-value of 0.863 ($\rho < .001$). Social ties also acted as a mediator, reversing the slightly negative influence of cultural distance. Cultural distance became a statistically, though not substantively, significant predictor at $\beta = 0.022$ ($\rho < .05$). The mediating effect of social ties on cultural distance seems to support Manev and Stevenson (2001), who found that culturally distant managers developed strong instrumental ties to facilitate work-related tasks.

An examination of the descriptive statistics in chapter 4 is useful for putting these results into context. Tacit knowledge sharing among all of the study participants had a mean value of only 0.359, with a standard deviation of 0.934. This indicates that, on average, the frequency of tacit knowledge sharing was less often than once a year. At the 2σ level, 95% of the participants shared tacit knowledge slightly more often than once a year. Similar results can be seen for social ties. Closeness among all of the study participants had a mean score of 0.238, with a standard deviation of 0.641. Interpreting these results at a 2σ level, 95% of the participants were less than close. While the results show that strong social ties support tacit knowledge sharing and have a mediating effect over cultural distance, few of the participants had close relationships and tacit knowledge sharing happened on a relatively infrequent basis. These results seem to support Appleyard et al. (2000), who contended that the knowledge related to yield improvements in semiconductor manufacturing tends to remain tacit among individual teams of engineers, supervisors, and workers. These results suggest that MNCs may not be realizing the potential for sustained competitive advantage that could come from shared tacit knowledge (Barney, 1991; Kogut & Zander, 1992, 1993, 1996).

*Modes of Communication*

In addition to studying the relationship among the independent variables, the study also evaluated the effectiveness of four modes of communication in relationship to the model of tacit knowledge sharing: (a) face-to-face communication, (b) electronic mail, (c) telecommunications, and (d) communities of practice. Face-to-face communication and electronic mail proved to be important factors in the study. Face-to-face communication was strongly and significantly correlated with closeness, at $r = 0.787$ ($\rho < .001$), and with

tacit knowledge sharing, at r = 0.817 (ρ < .001). Electronic mail was moderately correlated with closeness, at r = 0.681 (ρ < .001), and was highly correlated with tacit knowledge sharing, at r = 0.704 (ρ < .001). In regression model 2, tacit knowledge sharing was regressed on the set of communication variables; in this model, $R^2$ was 0.716. All modes of communication were significant for tacit knowledge sharing at the .001 level except for communities of practice, which was significant at the .05 level. Face-to-face communication had a beta-value of 0.608 (ρ < .001), and electronic mail had a beta-value of 0.257 (ρ < .001). The company's intranet-based communities of practice were the least influential factor in model 2, at a beta-value of only 0.029 (ρ < .01). Only 44 dyads reported using communities of practice to share tacit knowledge.

The study results support what several authors have noted concerning the importance of various modes of communication. Ghoshal and Bartlett (1988) found that highly innovative MNCs used face-to-face meetings to develop personal relationships, followed-up by dense patterns of regular communications, sometimes daily, between individuals in subsidiaries. Subramaniam and Venkatraman (2001) found that regular communication and rich communication channels increased tacit knowledge transfer. Persaud et al. (2001) found that once personal relationships have been established, technology-based solutions may become more effective for sharing knowledge. In a study of cross-border knowledge transfer in the semiconductor industry conducted by Almeida and Grant (1998), interviewees cited face-to-face meetings as the richest communication media and the most effective mechanism for collaborative problem solving and the transfer of tacit knowledge. The interviewees considered virtual communities of practice to be unproductive until the individuals involved had established a personal relationship.

While virtual communities seem to have the potential to support knowledge sharing, poor rates of participation in virtual communities have been found by researchers in other studies. Ardichvili et al. (2003) found that the most significant barrier to using virtual communities of practice was that people have their own personal networks based on relationships developed over time. In a case study of a failed web-based community, Bansler and Haven (2003) cited five reasons for the failure: (a) not enough time to participate, (b) no incentives to participate, (c) fear of seeming boastful, (d) a preference for one's own personal networks, and (e) a local rather than a global mindset. No efforts were made in this study to determine why so few individuals used the company's communities of practice. One participant did reply by electronic mail after completing the study and stated that he was not aware that an online community existed. It could be that the organization has not sufficiently promoted the use of its communities of practice.

## Scope and Limitations

A fifth manufacturing site, located in the former East Germany, was not included in the study. The decision to exclude this site was based upon not being able to quantify the cultural distance between individuals from this site and the other sites. Hofstede's (1980, 2000) indices for differences in national culture were based on data from the Federal Republic of Germany. Cultural indices were not available for the German Democratic Republic, and the two Germanies could not be assumed to be culturally identical. The response rate to the study may have been negatively influenced in cases where individuals had ties primarily with others at the site in the former East Germany.

Recommendations and implications for the research may be limited by the following factors. First, the study did not attempt to ascertain differences in

organizational culture among the sites. Second, only four national cultures were studied, so the conclusions may not be valid for relationships among other cultures. Third, the personal and professional motivations of the participants for establishing and maintaining relationships that might support tacit knowledge sharing were not assessed in the study. Finally, personal attributes of the participants, such as age and education, were not controlled for in the results.

## Recommendations

Multinational corporations are increasingly dependent upon globally dispersed knowledge to compete in the global economy (Bhagat et al., 2002). In the semiconductor industry, knowledge related to achieving a competitive advantage through process yield improvements is highly tacit and difficult to share (Almeida et al., 2002; Appleyard et al., 2000; Hatch & Mowery, 1998; Khurana, 1999; West, 2002). The results of this study suggest that semiconductor manufacturers with globally dispersed operations could improve the sharing of tacit knowledge related to improving yields by realizing stronger social ties among process engineers. The results of the study indicate that strong social ties are a function of closeness in personal relationships. Based on the study results, leaders in multinational semiconductor companies are encouraged to support activities that promote the development of close personal relationships among process engineers.

These findings are significant because there has been limited research concerning how MNCs can effectively harness globally dispersed tacit knowledge (Subramaniam & Venkatraman, 2001). In this study of tacit knowledge sharing, the degree of closeness among process engineers was strongly related to having face-to-face contact with one another and regular communication by electronic mail. Based on these findings, leaders

in semiconductor manufacturing companies are encouraged to provide opportunities for face-to-face meetings in settings that will support the development of close personal relationships among process engineers, and to encourage individuals to maintain these relationships by regular communication using electronic mail.

International relationship-building comes at a cost to MNCs. Hoopes and Postrel (1999) argued that creating an environment for social interaction that may eventually support tacit knowledge sharing requires a substantial time commitment of individuals across the organization. Also, international travel associated with face-to-face meetings is expensive. Travel costs associated with relationship-building are usually considered discretionary expenses, subject to cost cutting in difficult economic times. Consequently, maintaining established relationships by electronic mail and other electronic media, including communities of practice, may become increasingly important as organizations attempt to reduce costs.

## Implications

The study results suggest that multinational semiconductor companies may experience increased sharing of tacit knowledge related to improving yields as a result of stronger social ties among process engineers. Shared tacit knowledge related to reducing yield losses in manufacturing has been identified as a potential source of competitive advantage for semiconductor companies (West, 2002). These findings may be significant for MNCs in other industries. Kogut and Zander (1996) suggested that the knowledge that contributes to a firm's sustained competitive advantage is know-how- based tacit knowledge that is difficult to transfer. Multinational companies that learn how to share tacit knowledge successfully may create a sustained competitive advantage that will

challenge the threat from increasing global competition. Society as a whole may benefit from having companies that can remain competitive and prosperous in the face of global competition.

## Ethical Dimensions of Social Network Studies

Organizational network studies pose a special challenge for researchers in terms of the consent and anonymity of participants and the academic integrity of the study (Borgatti & Molina, 2003). A unique concern in network studies is the consent of non-participants. Consenting participants in a network study may identify relational ties with persons who have not responded to the survey. Borgatti and Molina noted that this raises a concern that non-respondents may become un-consenting participants in the study. Borgatti and Molina argued that in most cases participants are simply reporting about their own *perception* of a relational tie with another person, which is within their rights. Though it may be within an individual's rights, reporting on a relationship with another person without that person's consent still raises ethical concerns.

In this study, consenting participants provided data about their relational ties with co-workers who did not respond to the survey. This was not an ethical concern, since non-respondents were excluded from the study and the study results only included data from and about consenting respondents. Although non-respondents were not included, there remains an ethical duty to protect the confidentiality of un-consenting as well as consenting participants by maintaining the confidentiality of the study data.

Borgatti and Molina (2003) argued that eliminating data about non-respondents from a network study may jeopardize the integrity of the study. If the goal of the study is to understand structural characteristics such as centrality or cliques, then eliminating data

about non-respondents will distort the results. Missing data in network studies may result in failure to understand critical factors, such as the flow of information through a central actor. In this study the elimination of data about non-respondents was not deemed to be problematic. The focus of this study was the statistical distribution of the relational variables across the network of participants and a correlational analysis of the relationship among those variables. Including data about non-participants would actually distort the results. In this study, all ties were assumed to be reciprocal and the value of each relational variable is the average score reported by each respondent. Respondents had an equal chance to reciprocate a tie, but non-respondents had no chance to reciprocate. If non-respondents were included, it would be necessary to assume that non-respondents did not reciprocate, which would distort the results.

Anonymity of respondents is also a concern in organizational network studies. In network studies it is necessary to know the identity of each respondent in order to construct a network of relational ties among them. Borgatti and Molina (2003) noted that the researcher must be careful to disguise the identity of participants when displaying data, especially network diagrams. Employees of organizations could suffer adverse affects if employers are able to identify employees in network analyses, either by name or by inferring their identity from the network structure. In this study, the identity of all participants was blinded through the database. Additionally, no identifying features were included in the network data or diagrams that would make it possible to infer the identity of participants.

Borgatti and Molina (2003) suggested that with the growing popularity of network studies many researchers are only beginning to address the special ethical and integrity

issues. This research was conducted endeavoring to follow principles that fulfill the ethical duty to participants and non-participants, while maintaining academic integrity. Future network researchers are well advised to consider these factors and to appropriately apply them in their research.

## Suggestions for Future Research

Much of the knowledge that can lead to a competitive advantage for MNCs is tacit knowledge that is not easily shared (Kogut & Zander, 1992, 1993; Nonaka & Takeuchi, 1995). The results of this study indicate that strong social ties, characterized by close personal relationships, face-to-face contact, and communication by electronic mail are able to support tacit knowledge sharing. While these findings are significant, the study did not address the means by which MNCs might promote the development and maintenance of strong social ties. Future research might attempt to identify the policies and practices that are most effective, and the degree of influence that organizations might reasonably expect to have over the development of close personal relationships among employees. Future research might ask the following question: If MNCs invest in face-to-face communication and relationship-building, how can employees be encouraged to maintain those relationships? Researchers might also investigate the human resources considerations for employers who attempt to encourage relationship-building among employees.

The results of the study indicated that face-to-face communication was highly correlated with closeness in relationships and with tacit knowledge sharing. Communication by electronic mail was also strongly associated with tacit knowledge sharing. Virtual communities of practice had less influence. Unfortunately, Face-to-face

communication between international knowledge partners requires costly international travel. Future research might examine how MNCs can improve the effectiveness of electronic mail and how they can grow and support communities of practice, both of which are less costly but potentially effective forms of communication for tacit knowledge sharing.

Finally, the results of the study indicated that tacit knowledge sharing related to improving yields in semiconductor manufacturing was highly correlated with strong social ties among process engineers. The study did not, however, attempt to determine whether yield improvements or improved performance actually result from shared tacit knowledge. Future researchers might explore the extent to which MNCs have been able to realize yield improvements or a competitive advantage from shared tacit knowledge.

## Summary

To compete in the global economy, MNCs need to successfully share tacit knowledge among their globally dispersed operations (Almeida, Song, & Grant, 2002; Bhagat et al., 2002; Doz et al., 2001). The results of this study suggest that strong social ties improve tacit knowledge sharing among globally dispersed knowledge partners in a MNC. In the regression model of the relationship among cultural distance, social ties, and tacit knowledge sharing, social ties were a strong predictor of tacit knowledge sharing.

Several authors have suggested that cultural distance is an obstacle to sharing globally dispersed tacit knowledge in MNCs (Kogut & Singh, 1988; Manev & Stevenson, 2001; Morosini et al., 1998; Simonin, 1999). The results of this study indicate that while cultural distance is a statistically significant factor, it is not a substantively significant factor in tacit knowledge sharing. The results also indicate that strong social ties are able

to mediate the slightly negative effect that cultural distance seems to have on tacit knowledge sharing.

The results of the study suggest that leaders in MNCs can promote the development of strong social ties and tacit knowledge sharing by providing opportunities for face-to-face contact and by encouraging regular electronic mail and other forms of electronic communication between global knowledge partners. In the study, strong social ties were highly correlated with face-to-face communication, and were moderately correlated with the use of electronic mail. Face-to-face communication and the use of electronic mail were both highly correlated with tacit knowledge sharing.

The results of this study not only answer the question about the relationship among cultural distance, social ties, and tacit knowledge sharing, they also add to the body of knowledge concerning strong versus weak social ties. Researchers differ on the question of whether weak or strong social ties are more effective for knowledge transfer (Granovetter, 1973; Hansen, 1999; Mitsuhashi, 2003; Reagans & McEvily, 2003). The study results suggest that strong social ties are more effective for tacit knowledge sharing.

A MNC's ability to create and transfer knowledge can be a source of sustained competitive advantage (Barney, 1991; Barney et al., 2001; Kogut & Zander, 1992). The significance of the findings in this study is their potential for helping MNCs to realize a sustained competitive advantage from shared tacit knowledge. Globalization has increased the importance of cross-border knowledge transfer for the success of MNCs (Bhagat et al., 2002). These study findings are substantial because they have the potential to influence global strategies for competitiveness and greater success for MNCs and their stakeholders.

# REFERENCES

Abou-Zeid, E. (2002). An ontology-based approach to inter-organizational knowledge transfer. *Journal of Global Information Technology Management, 5*(3), 32-47.

Almeida, P. & Grant, R. (1998). *International corporations and cross-border knowledge transfer in the semiconductor industry*. Retrieved July 12, 2004 from http://cbi.gsia.cmu.edu/papers/cbi_workingpaper-1998_13.html.

Almeida, P., Song, J., & Grant, R. M. (2002). Are firms superior to alliances and markets? An empirical test of cross-border knowledge building. *Organization Science, 13*(2), 147-161.

Appleyard, M. M., Hatch, N. W., & Mowery, D. C. (2000). Managing the development and transfer of process technologies in the semiconductor manufacturing industry. *Nature & Dynamics of Organizational Capabilities*, 183-207.

Appleyard, M. M. & Kalsow, G. A. (1999). Knowledge diffusion in the semiconductor industry. *Journal of Knowledge Management, 3*(4), 288-295.

Ardichvili, A., Page, V., & Wentling, T. (2003). Motivation and barriers to participation in virtual knowledge-sharing communities of practice. *Journal of Knowledge Management, 7*(1), 64-77.

Argote, L., McEvily, B., & Reagans, R. (2003). Managing knowledge in organizations: An integrative framework and review of emerging themes. *Management Science, 49*(4), 571-582.

Augier, M. & Vendelo, M. T. (1999). Networks, cognition, and management of tacit knowledge. *Journal of Knowledge Management, 3*(4), 252-261.

Bansler, J. P. & Havn, E. C. (2003). Building community knowledge systems: an empirical study of IT-support for sharing best practices among managers. *Knowledge and Process Management, 10*(3), 156-163.

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99-120.

Barney, J. (2001). Resource-based theories of competitive advantage: A ten-year retrospective on the resource-based view. *Journal of Management, 27*, 643-650.

Barney, J., Wright, M., & Ketchen, D. J., Jr. (2001). The resource-based view of the firm: Ten years after 1991. *Journal of Management, 27*, 625-641.

Bartlett, C. A. & Ghoshal, S. (1998). Beyond strategic planning to organizational learning: Lifeblood of the individual corporation. *Strategy & Leadership, 26*(1), 34-39.

Bhagat, R. S., Kedia, B. L., Harveston, P. D., & Triandis, H. C. (2002). Cultural variations in the cross-border transfer of organizational knowledge: An integrative framework. *Academy of Management Review, 27*(2), 204-221.

Blackler, F. (1993). Knowledge and the theory of organizations: Organizations as activity systems and the reframing of management. *Journal of Management Studies, 30*(6), 863-884.

Borgatti, S. P. & Cross, R. (2003). A relational view of information seeking and learning in social networks. *Management Science, 49*(4), 432-445.

Borgatti, S. P., Everett, M. G., & Freeman, L. C. (2002). *UCINET 6 Version 6.59*. Harvard: Analytic Technologies.

Borgatti, S. P. & Molina, J. L. (2003). Ethical and strategic issues in organizational social network analysis. *The Journal of Applied Behavioral Science, 39*(3), 337-349.

Brouthers, K. D. & Brouthers, L. E. (2001). Explaining the national cultural distance paradox. *Journal of International Business Studies, 32*(1), 177-189.

Buckley, P. J. & Carter, M. J. (1999). Managing cross-border complementary knowledge: Conceptual developments in the business process approach to knowledge management in multinational firms. *International Studies of Management, 29*(1), 80-104.

Butler, T. (2003). From data to knowledge and back again: Understanding the limitations of KMS. *Knowledge and Process Management, 10*(3), 144-155.

Burris, V. (in press). Interlocking directorates and political cohesion among corporate elites. *American Journal of Sociology*. Retrieved December 4, 2004 from http://darkwing.uoregon.edu/~vburris/interlks.pdf

Cabral, R. & Leiblein, M. (2001). Adoption of a process innovation with learning-by-doing: Evidence from the semiconductor industry. *The Journal of Industrial Economics, XLIX* (3), 269-280.

Cantwell, J. & Narula, R. (2001). The eclectic paradigm in the global economy. *International Journal of the Economics of Business, 8*(2), 155-172.

Cantwell, J. & Santangelo, G. D. (2000). Capitalism, profits, and innovation in the new techno-economic paradigm. *Journal of Evolutionary Economics, 10*, 131-157.

Castillo, J. (2002). A note on the concept of tacit knowledge. *Journal of Management Inquiry, 11*(1), 46-57.

Cavusgil, S. T., Calantone, R. J., & Zhao, Y. (2003). Tacit knowledge transfer and firm innovative capability. *Journal of Business & Industrial Marketing, 18*(1), 6-21.

Chung, W. (2001). Identifying technology transfer in foreign direct investment: Influence of industry conditions and investing firm motives. *Journal of International Business Studies, 32*(2), 211-229.

Chung, W. & Alcacer, J. (2002). Knowledge seeking and location choice of foreign direct investment in the United States. *Management Science, 48*(12), 1534-1554.

Coase, R. H. (1937). The nature of the firm. *Economica, 4*, 386-405.

Coff, R. W. & Laverty, K. J. (2000). Roadblocks to competitive advantage: How organizational constraints and individual decision biases hinder investments in strategic assets. *Journal of High Technology Management Research, 12*, 1-24.

Conner, K. R. (1991). A historical comparison of resource-based theory and five schools of thought within organizational economics: Do we have a new theory of the firm? *Journal of Management, 17*, 121-154.

Cook, S. D. N. & Seely Brown, J. (1999). Bridging epistemologies: The generative dance between organizational knowledge and organizational knowing. *Organization Science, 10*(4), 381-400.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Cross, R., Borgatti, S. P., & Parker, A. (2002). Making invisible work visible: Using social network analysis to support strategic collaboration. *California Management Review, 44*(2), 25-46.

Cross, R., Parker, A., Prusak, L., & Borgatti, S. P. (2001). Knowing what we know: Supporting knowledge creation and sharing in social networks. O*rganizational Dynamics, 30*(2), 100-120.

Crossan, M. M., Lane, H. W., & White, R. E. (1999). An organizational learning framework: From intuition to institution. *The Academy of Management Review, 24*(3), 522-537.

Cowan, R., David, P. A., & Foray, D. (2000). The explicit economics of knowledge codification and tacitness. *Industrial and Corporate Change, 9*(2), 211-253.

Cummings, J. L. (2002). Knowledge transfer across R&D units: An empirical investigation of the factors affecting successful knowledge transfer across intra- and inter-organizational units. (Doctoral dissertation, George Washington University, 2001). *Dissertation Abstracts International, 62* (11), 3848A. (UMI No. 3034605)

Daghfous, A. (2004). Absorptive capacity and the implementation of knowledge-intensive best practices. *S.A.M. Advanced Management Journal, 69*(2), 21-27.

Dallal, G. E. (2005). *The little handbook of statistical practice: Regression diagnostics, collinearity*. Retrieved April 21, 2005 from http://www.tufts.edu/~gdalla/LHSP.htm

Dekker, D., Krackhardt, D., & Snijders, T. (2003). Multicollinearity robust QAP for multiple-regression. Working Paper. Carnegie Mellon University. Retrieved September 21, 2004 from http://www.casos.ece.cmu.edu/casos_working_paper/dekker_2003_multicollinearity.pdf

De Long, D. & Fahey, L. (2000). Diagnosing cultural barriers to knowledge management. *Academy of Management Executive, 14*(4), 113-127.

Denning, S. (2001). Knowledge sharing in the North and South. In W. Gmelin, K. King, & S. McGrath (Eds.), *Development knowledge, national research, and international co-operation.* Edinburgh: CAS.

Dinur, A. (2002). Intrafirm knowledge transfer in multinational corporations: Considering critical context. (Doctoral dissertation, Temple University, 2002). *Digital Abstracts International, 63* (05), 2300A. (UMI No. 3057070)

Doz, Y., Santo, J., & Williamson, P. (2001). *From global to metanational: How companies win in the knowledge economy.* Boston: Harvard Business School Press.

Droege, S. B. & Hoobler, J. M. (2003). Employee turnover and tacit knowledge diffusion: A network perspective. *Journal of Management Issues, 15*(1), 50-64.

Ensign, P. C. (1999). Innovation in the multinational firm with globally dispersed R&D: Technological knowledge utilization and accumulation. *The Journal of High Technology Management Research, 10*(2), 203-221.

Evans, M. A. (2004). A case of supporting distributed knowledge and work in the U.S. Navy: The challenges of knowledge management to human performance technology. *Techtrends, 48*(2), 48-52.

Fienberg, S. E., Meyer, M. M., & Wasserman, S. S. (1985). Statistical analysis of multiple sociometric relations. *Journal of the American Statistical Association, 80*(389), 51-67.

Fisher, S. R. & White, M. A. (2000). Downsizing in a learning organization: Are there hidden costs? *Academy of Management, 25*(1), 244-251.

Flaherty, M. T. (2000). Limited inquiry and intelligent adaptation in semiconductor manufacturing. *Nature & Dynamics of Organizational Capabilities*, 99-124.

Garcia, M. U. & Vano, F. L. (2002). Organizational learning in a global market. *Human Systems Management, 21*, 169-181.

Ghoshal, S. & Bartlett, C. A. (1988). Creation, adoption, and diffusion of innovations by subsidiaries of multinational corporations. *Journal of Business Studies,* 365-388.

Gill, K. (2004). *Exploring human-centeredness: Knowledge networking and community building*. Paper presented at Building & Bridging Community Networks: Knowledge, Innovation, & Diversity through Communication Conference. Brighton, East Sussex, U. K. Retrieved July 12, 2004 from http://www.cmis.brighton.ac.uk/research/seake/cna/conference/proceedings/docs/Karamjit%20Gill.pdf

Granovetter, M. S. (1973). The strength of weak ties. *American Journal of Sociology, 78*(6), 1361-1381.

Gregersen, H. B., Morrison, A. J., & Black, J. S. (1998). Developing leaders for the global frontier. *Sloan Management Review, 40*(1), 21-32.

Gupta, A. K. & Govindarajan, V. (1991). Knowledge flow patterns, subsidiary strategic roles, and strategic control within MNCs. *Academy of Management Proceedings*, 21-25.

Gupta, A. K. & Govindarajan, V. (2000, Fall). Knowledge management's social dimension: Lessons from Nucor Steel. *Sloan Management Review*, 71-80.

Hampden-Turner, C. M. & Trompenaars, A. (1993). *The seven cultures of capitalism*. New York: Double-day.

Hampden-Turner, C. M., Trompenaars, F., Lewis, D., & Trompenaars, A. (2000). *Building Cross-cultural competence: How to create wealth from conflicting values*. New York: John Wiley & Sons.

Hansen, M. T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organizational subunits. *Administrative Science Quarterly, 44*, 82-111.

Hansen, M. T. (2002). Knowledge networks: Explaining effective knowledge sharing in multiunit companies. *Organization Science, 13*(3), 232-248.

Hansen, M. T. & Haas, M. R. (2001). Different knowledge, different benefits: Toward a productivity perspective on knowledge sharing in organizations. *Academy of Management Proceedings, MC*, C1-C6.

Hansen, M. T., Nohria, N., & Thomas, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review, 77*(2), 106-116.

Hanneman, R. A. (2001). *Introduction to social network methods*. Online course text, University of California, Riverside. Retrieved January 10, 2005, from http://faculty.ucr.edu/~hanneman/SOC157/TEXT/C1SocialNetworkData.html

Harris, R. G. (2001). The knowledge-based economy: Intellectual origins and new economic perspectives. *International Journal of Management Reviews, 3*(1), 21-40.

Hatch, N. W. (1997). Investment in learning capital: Enhancing the rate of learning by doing in semiconductor manufacturing. *Academy of Management Proceedings*, 427-431.

Hatch, N. W. & Mowery, D. C. (1998). Process innovation and learning by doing in semiconductor manufacturing. *Management Science, 44*(11), 1461-1477.

Haythornthwaite, C. (2002). Strong, weak, and latent ties and the impact of new media. *The Information Society, 18*, 385-401.

Hellstrom, T. & Malmquist, U. (2000). Networked innovation: developing the AXE110 "mini-exchange" at Ericsson. *European Journal of Innovation Management, 3*(4), 181-193.

Hinds, P. J., Carley, K. M., Krackhardt, D., & Wholey, D. (2000). Choosing work group members: Balancing similarity, competence, and familiarity. *Organizational Behavior and Human Processes, 81*(2), 226-251.

Hitt, M. A., Lee, H., & Yucel, E. (2002). The importance of social capital to the management of multinational enterprises: Relational networks among Asian and Western Firms. *Asia Pacific Journal of Management, 19*(2), 353-372.

Hoegl, M., Parboteeah, K. P., & Munson, C. L. (2003). Team-level antecedents of individuals' knowledge networks. *Decision Sciences, 34*(4), 741-770.

Hofstede, G. (1980). *Cultures consequences: International differences in work-related values* (Abridged ed.). Beverly Hills: Sage Publications.

Hofstede, G. (2001). *Cultures consequences: Comparing values, behaviors, institutions, and organizations across nations* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Hofstede, G. & Bond, M. H. (1984). Hofstede's culture dimensions: An independent validation using Rokeach's value survey. *Journal of Cross-Cultural Psychology, 15*, 417-433.

Holden, N. (2001). Knowledge management: Raising the spectre of the cross-cultural dimension. *Knowledge and Process Management, 8*(3), 155-163.

Hoopes, D. G. & Postrel, S. (1999). Shared knowledge, "glitches," and product development performance. *Strategic Management Journal, 20*(9), 837.

Huber, G. P. (1991). Organizational learning: The contributing processes and the literatures. *Organization Science, 2*(1), 88-115.

Huber, G. P. (2001). Transfer of knowledge in knowledge management systems: Unexplored issues and suggested studies. *European Journal of Information Systems, 10*, 72-79.

Hubert, L. J. (1987). Assignment methods in combinatorial data analysis. New York: Marcel Dekker.

Hubert, L. J. & Schultz, L. (1976). Quadratic assignment as a general data analysis strategy. *British Journal of Mathematical and Statistical Psychology, 29*, 129-241.

Inglehart, R., Basañez, M., & Moreno, A. (1998). *Human values and beliefs: A cross-cultural sourcebook*. Ann Arbor: University of Michigan Press.

Johnson, W. H. A. (2002). Leveraging intellectual capital through product and process management of human capital. *Journal of Intellectual Capital, 3*(4), 415-429.

Kalling, T. (2003). Organization-internal transfer of knowledge and the role of motivation: A qualitative study. *Knowledge and Process Management, 10*(2), 115-126.

Kessapidou, S. & Varsakelis, N. C. (2002). The impact of national culture on international business performance: The case of foreign firms in Greece. *European Business Review, 14*(4), 268.

Khurana, A. (1999). Managing complex production processes. *Sloan Management Review, 40*(2), 85-97.

King, K. (2002). Banking on knowledge: The new knowledge projects of the World Bank. *Compare, 32*(3), 311-326.

Kogut, B. & Singh, H. (1988). The effect of national culture on the choice of entry mode. *Journal of International Business, 19*(3), 411-432.

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

Kogut, B. & Zander, U. (1993). Knowledge of the firm and the evolutionary theory of the multinational corporation. *Journal of International Business Studies, 24*, 625-645.

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

Krackhardt, D. (1988). Predicting with networks: Nonparametric multiple regression analysis of dyadic data. *Social Networks, 10*, 359-381.

Krackhardt, D. (1993). *MRQAP: Analytic versus permutation solutions*. Working paper, Carnegie Mellon University. Pittsburgh.

Krackhardt, D. & Hanson, J. (1993). Informal networks: The company behind the charts. *Harvard Business Review, 71*, 104-111.

Lane, P. J. & Lubatkin, M. (1998). Relative absorptive capacity and interorganizational learning. *Strategic Management Journal, 19*(5), 461-477.

Last, M. & Kandel, A. (2002). Perception-based analysis of engineering experiments in the semiconductor industry. *International Journal of Image and Graphics, 2*(1), 107-126.

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

Lehesvirta, T. (2004). Learning processes in a work organization: From individual to collective and/or vice versa? *Journal of Workplace Learning, 16*(1/2), 92.

Lesser, E. L. & Storck, J. (2001). Communities of practice and organizational performance. *IBM Systems Journal, 40*(4), 831-841.

Levin, D. Z., Cross, R., & Abrams, L. C. (2002). The strength of weak ties you can trust: The mediating role of trust in effective knowledge transfer. *Academy of Management Proceedings, MOC*, D1-D6.

Lord, M. D. & Ranft, A. L. (2000). Organizational learning about new international markets: Exploring the internal transfer of local market knowledge. *Journal of International Business Studies, 31*(4), 537-589.

Lou, Y. (2001). Antecedents and consequences of personal attachments in cross-cultural cooperative ventures. *Administrative Science Quarterly, 46*, 177-201.

Lou, Y. (2004). Time-based experience and international expansion: The case of an emerging economy. *Journal of Management Studies, 36*(4), 505-535.

Malerba, F. & Orsenigo, L. (2000). Knowledge, innovative activities, and industrial evolution. *Industrial and Corporate Change, 9*(2), 289-314.

Manev, I. M. & Stevenson, W. B. (2001). Nationality, cultural distance, and expatriate status: Effects on the managerial network in a multinational enterprise. *Journal of International Business Studies, 32*(2), 285-303.

Marquardt, M. & Reynolds, A. (1994). *The global learning organization: Gaining competitive advantage through continuous learning*. New York: Irwin Professional Publishing.

Marr, B., Schiuma, G., & Neely, A. (2004). The dynamics of value creation: mapping your intellectual performance drivers. *Journal of Intellectual Capital, 5*(2), 312-325.

Marr, B. & Spender, J-C. (2004). Measuring knowledge assets – implications of the knowledge economy for performance measurement. *Measuring Business Excellence, 8*(1), 18.

Marsden, P. V. (1990). Network data and measurement. *Annual Review of Sociology, 16*, 435-463.

Marsden, P. V. (1993). The reliability of network density and composition measures. *Social Networks, 15*, 399-421.

Marsden, P. V. (2003). Recent developments in network measurement. In P. J. Carrington, J. Scott, & S. Wasserman Eds. *Models and methods in social network analysis*. New York: Cambridge University Press. Retrieved May 28, 2004 from http://www.wjh.harvard.edu/soc/faculty/marsden/

Marsden, P. V. & Campbell, K. E. (1984). Measuring tie strength. *Social Forces, 63*(2), 482-501.

Martin, X. & Salomon, R. (2003a). Knowledge transfer capacity and its implications for the theory of the multinational corporation. *Journal of International Business, 34*, 356-373.

Martin, X. & Salomon, R. (2003b). Tacitness, learning, and international expansion: A study of foreign direct investment in a knowledge-intensive industry. *Organization Science, 14*(3), 297-311.

Martz, W. B. Jr., & Shepherd, M. M. (2003). Testing for the transfer of tacit knowledge: Making a case for implicit learning. *Decision Sciences Journal of Innovative Education, 1*(1), 41-56.

McDonough, E. F. III, Kahn, K. B., & Griffin, A. (1999). Managing communication in global product development teams. *IEEE Transactions on Engineering Management, 46*(4), 375-386.

Mitsuhashi, H. (2003). Effects of the social origins of alliances on alliance performance. *Organization Studies, 24*(2), 321-339.

Moody, J. & White, D. R. (2003). Structural cohesion and embeddedness: A hierarchical concept of social groups. *American Sociological Review, 68*(1), 103-127.

Moreno, J. L. (1934), *Who shall survive?* Washington, DC: Nervous and Mental Disease Publishing.

Morosini, P. Shane, S., & Singh, H. (1998). National cultural distance and cross-border acquisition performance. *Journal of International Business Studies, 29*(1), 137-158.

Morrow-Howell, N. (1994). The M word: Multicollinearity in multiple regression. *Social Work Research, 18*(4), 247-251.

Mylonopoulos, N. & Tsoukas, H. (2003). Technological and organizational issues in knowledge management. *Knowledge and Process Management, 10*(3), 139-143.

National Opinion Research Center (2004). *General Social Survey (GSS) codebook. University of Chicago.* Retrieved June 1, 2004 from http://webapp.icpsr.umich.edu/GSS/

Nidumolu, S. R., Subramani, M., & Aldrich, A. (2001). Situated learning and the situated knowledge web: Exploring the ground beneath knowledge management. *Journal of Management Information Systems, 18*(1), 115-150.

Nonaka, I. & Konno, N. (1998). The concept of "Ba": Building a foundation for knowledge creation. *California Management Review, 40*(3), 40-54.

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

O'Donnell, D. (2004). Theory and method on intellectual capital creation: Addressing communicative action through relative methodics. *Journal of Intellectual Capital, 5*(2), 294-311.

O'Keeffe, T. (2003). Preparing expatriate managers of multinational organisations for the cultural and learning imperatives of their job in dynamic knowledge-based environments. *Journal of European Industrial Training, 27*(5), 233-243.

Palich, L. E. & Gomez-Mejia, L. R. (1999). A theory of global strategy and firm efficiencies: Considering the effects of cultural diversity. *Journal of Management, 25*(4), 587-606.

Persaud, A., Kumar, U., & Kumar, V. (2001). Harnessing scientific and technological knowledge for rapid deployment of global innovation. *Engineering Management Journal, 13*(1), 12-18.

Polanyi, M. (1966). *The tacit dimension*. New York: Anchor Day Books.

Prahalad, C. K. & Lieberthal, K. (2003). The end of corporate imperialism. *Harvard Business Review, 81*(8), 109-117.

Reagans, R. & McEvily, B. (2003). Network structures and knowledge transfer: The effects of cohesion and range. *Administrative Science Quarterly, 48*, 240-267.

Reagans, R. & Zuckerman, E. W. (2001). Networks, diversity, and productivity: The social capital of corporate R&D teams. *Organization Science, 12*(4), 502-517.

Rindfleisch, A. & Moorman, C. (2001). The acquisition and utilization of information in new product alliances: A strength-of-ties perspective. *Journal of Marketing, 65*, 1-18.

Roberts, J. (2000). From know-how to show-how? Questioning the role of information and communication technologies in knowledge transfer. *Technology Analysis & Strategic Management, 12*(4), 429-443.

Ross, D. N. (1999). Culture as a context for multinational business: A framework for assessing the strategy-culture 'fit'. *Multinational Business Review, 7*(1), 13-19.

Rowland, G. (2004). Shall We Dance? A Design Epistemology for Organizational Learning and Performance. *Educational Technology, Research, and Development, 52*(1), 33-48.

Rulke, D. L. & Galaskiewicz, J. (2000). Distribution of Knowledge, Group Network Structure, and Group Performance. *Management Science, 46*(5), 612-625.

Salk, J. E. & Brannen, M. Y. (2000). National culture, networks, and individual influence in a multinational management team. *Academy of Management Journal, 43*(2), 191-202.

Samiee & Mayo (1990). Barriers to trade with Japan: A socio-cultural perspective. *European Journal of Marketing, 24*(12), 48-66.

Schultz, M. & Jobe, L. A. (2001). Codification and tacitness as knowledge management strategies: An empirical exploration. *Journal of High Technology Management Research, 12,* 139-165.

Schulz, M. (2003). Pathways of relevance: Exploring inflows of knowledge into subunits of multinational corporations. *Organization Science, 14*(4), 440-459.

Seely Brown, J. & Duguid, P. (2000). Balancing Act: How to capture knowledge without killing it. *Harvard Business Review, 78*(3), 73-80.

Seely Brown, J. & Duguid, P. (2001). Creativity versus structure: A useful tension. *MIT Sloan Management Review, 42*(4), 93-94.

Shenkar, O. (2001). Cultural distance revisited: Towards a more rigorous conceptualization and measurement of cultural differences. *Journal of International Business Studies, 32*(3), 519-536.

Simonin, B. L. (1999). Transfer of marketing know-how in international strategic alliances: An empirical investigation of the role and antecedents of knowledge ambiguity. *Journal of International Business Studies, 30*(3), 463-490.

Solomon, P. R., Rosenthal, P., Spartz, M., Bosch-Charpenay, S., Bosch, O., & Richter, M. (2001). Advanced process control in semiconductor manufacturing. *Quality Congress. ASQ's Annual Quality Congress Proceedings,* 185-187.

Somekh, B. & Pearson, M. (2002). Intercultural learning arising from pan-European collaboration: A community of practice with a 'hole in the middle'. *British Educational Research Journal, 28*(4), 486-502.

Starbuck, W. H. (1992). Learning by knowledge-intensive firms. *Journal of Management Studies, 29*(6), 713-740.

Subramaniam, M. & Venkatraman, N. (2001). Determinants of transnational new product development capability: Testing the influence of transferring and deploying tacit overseas knowledge. *Strategic Management Journal, 22*(4), 359-378.

Triandis, H. C. (2000). Culture and conflict. *International Journal of Psychology, 35*(2), 145-152.

Triandis, H. C. (2004). The many dimensions of culture. *Academy of Management Review, 18*(1), 88-93.

Triola, M. F. (2001). *Elementary Statistics* (8th ed.). Boston: Addison-Wesley Longman

Trompenaars, F. (1996). Resolving international conflict: Culture and business strategy. *London Business School, 7*(3), 51-68.

Tsai, W. (2001). Knowledge transfer in intraorganizational networks: Effects of network position and absorptive capacity on business innovation and performance. *Academy of Management Journal, 44*(5), 996-1004.

Tsai, W. (2002). Social Structure of "Coopetition" within a multiunit organization: Coordination, competition, and interorganizational knowledge sharing. *Organizational Science, 13*(2), 179-190.

Uzzi, B. (1999). Social relations and networks in the making of financial capital. *American Sociological Review, 64*, 481-505.

Ward, A. (2000). Getting strategic value from constellations of communities. *Strategy & Leadership, 28*(2), 4-9.

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

Wenger, E. C. & Snyder, W. M. (2000). Communities of practice: The organizational frontier. *Harvard Business Review, 78*(1), 139-145.

West, J. (2002). Limits to globalization: Organizational homogeneity and diversity in the semiconductor industry. *Industrial and Corporate Change, 11*(1), 159-188.

Zander, I. (2002). The formation of international innovation networks in the multinational corporation: An evolutionary perspective. *Industrial and Corporate Change, 11*(2), 327-353.

Zander, U. and Kogut, B. (1995). Knowledge and the speed of the transfer and imitation of organizational capabilities: An empirical test. *Organizational Science, 6*(1), 76-92.

Zander, I. & Solvell, O. (2000). Cross-border innovation in the multinational corporation: A research agenda. *International Studies of Management and Organization, 30*(2), 44-67.

# APPENDIX A: CONSENT TO ACT AS A RESEARCH SUBJECT

Dear _____,

I am a student at the University of Phoenix working on a Doctorate of Management in Organizational Leadership. I am conducting a research study entitled “The Relationship between Cultural Distance, the Strength of Social Ties, and Tacit Knowledge Sharing in Multinational Corporations.” The purpose of this research project is to study knowledge sharing among process engineers in a multinational company in the semiconductor industry.

Your participation will involve answering a short questionnaire concerning your communications with other process engineers. You should be able to complete the questionnaire in about 15 minutes. Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, you can do so without penalty or loss of benefit to yourself. The results of the research study may be published but your name will not be used and your results will be maintained in strict confidence. Your identity will not be disclosed to your employer or anyone else.

In this research, there are no foreseeable risks to you.

Although there may be no direct benefit to you, the possible benefit of your participation is its potential for adding to the understanding of how multinational corporations can improve knowledge sharing.

If you have any questions concerning the research study, please call me in the U.S. at 503-241-7531.

Sincerely,

*Larry Buzan*

*Please click here to indicate your consent to participate in the research*

# APPENDIX B: SURVEY QUESTIONAIRE

1. How long have you worked for Xxxxxxxxx Corporation? Years:___ Months:___

2. At which site are you currently working?

| (1) Germany | (2) United States | (3) Singapore | (4) Japan |
|---|---|---|---|

3.How long have you worked at this site? Years:___ Months:___

4. Are you currently a delegate or expatriate? Yes:___ No:___

5. Have you previously been a delegate or expatriate? Yes:___ No:___

6. If yes, please select the site(s)

| (1) Germany | (2) United States | (3) Singapore | (4) Japan |
|---|---|---|---|

7. Please indicate your gender: Male:___ Female:___

8. Please indicate your country of origin: _____

The following engineers have been identified as having **similar work responsibilities**. Please select any engineers from this group with whom you have ever discussed process or yield related problems or improvements.

| Select Engineers | Work Site | Last Name: | First Name: |
|---|---|---|---|
| □ | Germany | Aaaaa | Bbbbb |
| □ | United States | Aaaaa | Bbbbb |
| □ | Singapore | Aaaaa | Bbbbb |
| □ | Japan | Aaaaa | Bbbbb |

Please select **any other** engineers, from the following list, with whom you have ever discussed process or yield related problems or improvements.

| Select Engineers | Work Site | Last Name: | First Name: |
|---|---|---|---|
| (Select from pull-down list) ▼ | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

9. For each of the individuals you have selected or named, how would you describe your relationship with that person? Are you distant, less than close, close, especially close, or a close personal friend?

| Name _____ | (0) Distant | (1) Less Than Close | (2) Close | (3) Especially Close | (4) A Close Personal Friend |
|---|---|---|---|---|---|

10. For each of the individuals you have selected or named, how often do you discuss process or yield related problems or improvements which **are not** explicitly documented in Xxxxxx's Class 3, 4, or 5 Process Test Notices (PTNs) or Process Implementation Notices (PINs): Less than once a year, at least once a year, at least once a month, at least once a week, or almost every day?

| Name _____ | (1) Less than once a year | (2) At least once a year | (3) At least once a month | (4) At least once a week | (5) Almost every day |
|---|---|---|---|---|---|

11. For each of the individuals you have selected or named, please indicate which modes of communication you use to share information.

| Name _____ | (1) Face-to-Face | (2) Telephone or video conference | (3) E-mail | (4) Xxx's Communities of Practice and Interest (CoPI) |
|---|---|---|---|---|

Dear _____,

Thank you for taking the time to participate in this survey. As previously mentioned, your name and your individual responses to the survey questions will never be disclosed to anyone else. You may obtain a copy of the overall results from this study by sending me an Email request at larry.buzan@xxxxxx.com or you may call me in the U.S. at 503-241-7531.

Sincerely,

*Larry Buzan*

# APPENDIX C: PERMISSION TO USE CULTURAL DISTANCE

-----Original Message-----
From: LARRY BUZAN
To: bruce.kogut@insead.edu
Cc: singhh@wharton.upenn.edu
Sent: 5/26/2004 6:58 AM
Subject: Permission to use Cultural Distance

May 25, 2004

Dr. Bruce Kogut, PhD
Professor of Strategy and Management
INSEAD, Fontainebleau, France
Boulevard de Constance
77305 Fontainebleau, Cedex
France

Dear Dr. Kogut,

I am a Doctoral Candidate at the University of Phoenix, in the Doctor of Management program. I am preparing a proposal to study the relationship between cultural distance, the strength of social ties, and tacit knowledge sharing in a multinational corporation. I am writing to ask for your written permission to use the formula for cultural distance (Kogut & Singh, 1988) in my proposed study. In the proposed study, the original formula for cultural distance will be adapted to include Hofstede's (2001) fifth dimension of national culture, Long- Versus Short-Term Orientation. The formula will also be generalized to compute the cultural distance between any pair of countries from Hofstede's list of national cultures. I am also asking for your permission to make these adaptations.

The formula will only be used for this dissertation. Proper citation and reference to the original work will be made. You will receive one copy of the final dissertation promptly upon completion.

My mentor at the University of Phoenix is Dr. Jay Klagge. His Email address is jayklagg@email.uophx.edu <mailto:jayklagg@email.uophx.edu>. Please feel free to contact him with any questions or concerns.

Thank you for your support of my research.
Best Regards,

Larry Buzan
Doctoral Candidate
2387 SE Kelly
Gresham, OR 97080
lbuzan@email.uophx.edu <mailto:lbuzan@email.uophx.edu>
phone: (503) 219-7531 or (503) 667-7982

References:

Hofstede, G. (2001). Cultures consequences: Comparing values, behaviors, institutions, and organizations across nations. Thousand Oaks, CA: Sage Publications.

Kogut, B. & Singh, H. (1988). The effects of national culture on the choice of entry mode. Journal of International Business, 19, 411-432.

**From:** Singh, Harbir
**To:** 'KOGUT Bruce' ; 'LARRY BUZAN '
**Sent:** Wednesday, May 26, 2004 7:19 AM
**Subject:** RE: Permission to use Cultural Distance

Dear Larry:

I completely agree with Bruce on this. I wish you all the best in your work.

-----Original Message-----
**From:** KOGUT Bruce [mailto:Bruce.KOGUT@insead.edu]
**Sent:** Wednesday, May 26, 2004 1:19 AM
**To:** 'LARRY BUZAN '; KOGUT Bruce
**Cc:** Singh, Harbir
**Subject:** RE: Permission to use Cultural Distance

Dear Larry,

There are no property rights on published measures, but only the norm that you cite the original paper. You are free to use it and to publish the results anywhere you would like.

good luck,
Bruce Kogut

# APPENDIX D: PERMISSION TO USE SURVEY QUESTIONS

----- Original Message -----
From: "LARRY BUZAN" <lbuzan@email.uophx.edu>
To: <bmcevily@andrew.cmu.edu>
Cc: <rr2018@columbia.edu>
Sent: Sunday, May 30, 2004 11:28 PM
Subject: Permission to use survey questions

May 30, 2004

Dr. William McEvily Jr. PhD
Associate Professor of Organizational Behavior and Theory
Carnegie Mellon University
Tepper School of Business
5000 Forbes Ave.
Pittsburg, PA 15213

Dear Dr. McEvily,

I am a Doctoral Candidate at the University of Phoenix, in the Doctor of Management program. I am preparing a proposal for a study of knowledge sharing in a multinational semiconductor corporation. I am writing to ask for your written permission to use a portion of your survey questionnaire described in the article by Reagans & McEvily (2003) in my study. I would like your permission to use your measure for emotional closeness as a function of tie-strength. In your survey, emotional closeness was described as distant, less than close, close, or especially close. This appears to be a variation of the standard categories used in the General Social Survey (GSS) conducted routinely by the National Opinion Research Center (NORC). I would also like permission to adapt your survey questions for the control variables of advice and friendship.

These survey questions will only be used for my proposed dissertation. Proper citation and reference to the original work will be made. You will receive one copy of the final dissertation promptly upon completion.

My mentor at the University of Phoenix is Dr. Jay Klagge. His Email address is jayklagg@email.uophx.edu. Please feel free to contact him with any questions or concerns.

Reference:
Reagans, R. & McEvily, B. (2003). Network structure and knowledge transfer: The effects of cohesion and range. Administrative Science Quarterly, 48, 240-267.

Thank you for your support of my research.

Best Regards,
Larry Buzan

Doctoral Candidate
2387 SE Kelly
Gresham, OR 97080
lbuzan@email.uophx.edu
phone: (503) 219-7531 or (503) 667-7982

From: "Bill McEvily" <bmcevily@andrew.cmu.edu>
To: "LARRY BUZAN" <lbuzan@email.uophx.edu>
Sent: Monday, May 31, 2004 8:55 AM
Subject: Re: Permission to use survey questions

Larry,

Yes of course, you are welcome to use the survey questions. In fact, I don't think my permission is required provided that you acknowledge the source of the questions via citation. I should also mention that we adapted and borrowed the survey questions from Ron Burt.

Good luck with you dissertation and I look forward to seeing your work in the future.

Best,
Bill

-----Original Message-----
**From:** LARRY BUZAN [mailto:lbuzan@email.uophx.edu]
**Sent:** Sunday, May 30, 2004 11:46 PM
**To:** Smith-Tom
**Subject:** Permission to use survey questions

May 30, 2004

National Opinion Research Center
University of Chicago
1155 East 60th Street
Chicago, IL 60637

Dear NORC,

I am a Doctoral Candidate at the University of Phoenix, in the Doctor of Management program. I am preparing a proposal for a study of knowledge sharing networks in a multinational semiconductor corporation. I am writing to ask for your written permission to use, at no charge, a portion of NORC survey questions under the subject heading of Social Networks from the GSS codebook of variables. I am requesting permission to use the NORC questions and Likert scale response categories for the following questions: CLOSE, question 315; TALK. question 319; and KNOWN, question 320. I would also like permission to adapt these survey questions as it becomes necessary to suit my study requirements.

These survey questions will only be used for my proposed dissertation. Proper citation and reference to NORC will be made. You will receive one copy of the final dissertation promptly upon completion.

My mentor at the University of Phoenix is Dr. Jay Klagge. His Email address is jayklagg@email.uophx.edu. Please feel free to contact him with any questions or concerns.

Thank you for your support of my research.
Best Regards,

Larry Buzan
Doctoral Candidate
2387 SE Kelly
Gresham, OR 97080
lbuzan@email.uophx.edu
phone: (503) 219-7531 or (503) 667-7982

**From:** Smith-Tom
**To:** LARRY BUZAN
**Sent:** Tuesday, June 01, 2004 4:18 AM
**Subject:** RE: Permission to use survey questions

You have permission to use our item. We would appreciate a final copy of your dissertation.