The Roles and Impacts of Boundary Spanners and Boundary Objects in Global Project Networks

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ABSTRACT

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Globalizing is a key dynamic that is both impacting and reshaping the architecture, engineering, and construction (AEC) industries. Evolving with the twentieth century technological advances such as information technology, AEC firms are now capable of collaborating in a dispersed manner both on the projects and among participants. Because of the global outlook of firms, particularly to remain competitive and to reach new markets, project network participants, are becoming increasingly multi-cultural and multi-lingual. This participant diversity, both individually and organizationally, can lead to boundary formation. Though past research has explored the boundary spanning capabilities within organizations, little is known about the roles and impacts of boundary spanning, both as individuals and as objects, in global project networks. I investigate global project networks in order to assess the emergence, roles and impacts of various boundary spanning capabilities using both quantitative and qualitative research techniques. Data was collected from three different global project networks: 1) two project networks collaborating face-to-face, one was comprised of Indians and Americans, the other was identical but also contained an Indian national who had studied and worked in the U.S.; 2) an experimental setting comparing multi-cultural, cultural-boundary spanned and mono-cultural project networks; and 3) three days of design review meetings within a project network of U.S. and Indian engineers. Firstly, network

analysis and grounded theory are applied in order to observe the emergence and role of cultural boundary spanners. In the second, quantitative statistical analysis is applied in order to observe the impact of cultural boundary spanners on performance. Finally in the third, network analysis and grounded theory is used to observe the role of boundary objects in negotiating knowledge. The findings have significant implications in improving the effectiveness of global project network collaborations.

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> *"In the politics of human life, consistency is not a virtue… to be consistent means standing still or not moving."*
>
> – Saul Alinsky, Rules for Radicals

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Dedicated to Luna and Rooney,

who make me a better person.

Chapter 1

INTRODUCTION

"You can flourish in this flat world, but it does take the right imagination and the right motivation."

"The world is being flattened. I didn't start it and you can't stop it, except at great cost to human development and your own future. But we can manage it, for better or worse."(Friedman 2005, p. 469)

Thomas L. Friedman

Technological advancements in the early 20th century have undeniably changed the world forever. Advancements in medicine have allowed for societies to prosper due to increased life expectancies. Environmental advancements have allowed for most of the world to benefit from water treatment and sanitation. Communication advancements have allowed for critical information and news to spread instantly and for people from around the globe to communicate in real-time. Along with these advancements, technological advancements have also facilitated what is known today as Globalization. Seen as a 'hot topic' since the latter half of the twentieth century, the main drivers of globalization, besides the shift of trade and investment barriers, are the advances in communication, transportation, and information technology (Acosta et al 2010).

In the book *The World is Flat*, Friedman (2005), breaks down globalization in an attempt to explain and understand why the world is now a level playing field (i.e. flat) for multinational competitors. Overall, the theme remains as is stated in the above excerpt: organizations and individuals must teach themselves how to get the most out of this dynamic global economy and it is through innovation, i.e. in thinking outside of conventional management practices, one can succeed in this context. What Friedman was alluding to was that the changes towards globalization, particularly organizational change, were not without their challenges. As a result, organizations without global perspective and access to global resources may lack the competitiveness to survive and succeed in today's economy.

Global Engineering and Offshore Outsourcing of Engineering Services

Globalization has also significantly impacted engineers and engineering organizations. Architecture, engineering and construction (AEC) organizations, whether international or domestic, must have a global outlook in order to either remain competitive or simply be informed of their industry performance around the world (Devinney et al 2000). Local AEC firms can have access to projects around in the world, therefore increasing their range of exposure and competition. New demands from customers have forced engineering organizations to design and build for particular markets, each of which has different settings and cultures (Acosta et al 2010). Research on engineering and construction organizations found six key areas in which organizations must excel in order to succeed with clients requiring a global outreach. To this end, organizations must: 1) match the dynamics of a global market, 2) leverage advanced information technology systems to foster communication between constituents in the global market, 3) learn to think globally so as to effectively delegate work to culturally and linguistically global partners, 4) make effective use of suppliers, 5) gain local knowledge, and 6) develop a set of standards that apply in all cases, regardless of their geographical location (Kini 2000). Consistent with these findings is the need for these organizations to develop global strategies that are as dynamic as the environment in which they work.

One proven global strategy that was originally applied to the manufacturing industry after the Second World War is offshore outsourcing or 'offshoring'. 'Offshore' refers to any country outside the home country, usually referring to developed nations such as the United States, Canada, Europe and Australia. 'Outsourcing' refers to tasks and processes that are performed outside the boundaries of the organization (Carmel and Tjia 2005). In this research, offshoring of engineering services is defined as engineering services transferred from domestic locations to other locations, both by outsourcing the services to other organizations and by establishing subsidiaries in an offshore location. The most common offshore locations for these countries include: India, China, Eastern Europe and South America, due to the low cost of wages and the abundance of a well-educated and trained workforce. Though offshoring in engineering organizations remains highly scrutinized due to the perception of a diminishing domestic need of specialized talent and employment (NAE 2008), economics research has found evidence that this is not the case. Mankiw and Swagel (2006) found that the increase in employment overseas in U.S. based multinational companies actually positively contributed to an increase in employment locally in the U.S. parent companies. Despite the positive or negative *response* to offshoring, there remain obvious benefits in practice. The competitive advantage gained through offshore outsourcing of engineering services goes beyond that of labor arbitrage, engineering organizations can also have access to local knowledge and markets that were once unattainable (Bryant 2006), and therefore expanding their possibilities for success.

There are a number of researchers investigating the offshoring phenomenon (Overby 2003; Carmel and Tjia 2005; Bryant 2006; Ang and Inkpen 2008; Acosta et al 2010), however the concepts and dynamics of offshoring organizations are not yet well understood. This is because most offshoring research has been focused on the IT-intensive industries and relatively little research has focused on professional or business services such as AEC (Levine 2009). Globalization has expanded the outsourcing of multiple business services to include international partnerships between consultants, contractors, suppliers and owners. Outsourcing of business services such as AEC services requires a change in how engineers formulate, design and solve problems. Organizations cannot simply have a narrow perspective on their own production and facilities; they must now be regarded as globally dispersed enterprises with information and people forced to move across organizational and national boundaries.

Global Project Networks and National Cultural Boundaries

For engineering projects, this globally dispersed enterprise is known as a global project network, which remains a popular area of inquiry in engineering project organization research. In his classical research into organizational behavior, Powell (1990) suggests that network forms of organization are particularly suited for knowledge sharing and innovation above that of hierarchical and pure market structures. Because of the competitive-driven goals and the potential for innovation, Powell's findings also suggest that project networks are an organizational structure well suited for the dynamics of the global market. In his later research, Powell et al. (1996) found that diversity and experience were two drivers within networks that facilitated increased network performance. Diversity is also a critical component in global project networks, as organizations are not only faced with interorganizational collaborations but they do so within the context of national cultural difference as well. In terms of global engineering networks, common practice often occurs at the interorganizational and cross-national cultural boundary level, which involves different specializations from product lifecycle to supply chain. Global engineering project networks by nature have globally distributed resources, while maintaining common work practices (Zhang et al 2007). However, regardless of location, engineering services are monitored and controlled by governance systems, such as the international building code (IBC), and supported by complex engineering information systems, such as building information modeling (BIM) tools.

Despite the similarities between global engineering practices, the practices that constitute the work of global project networks also vary particularly based on the impact of cultural diversity that characterizes a globalized workforce. These differences manifest as organizational and national cultural boundaries. When global project networks encounter difficulties working with offshore partners, they most often involve the national-cultural boundaries between network participants and organizations (Ang and Inkpen 2008). National-cultural boundary formation in global project networks occurs due to the diverging cultures among network participants and results in problems of cultural understanding and communication (Levina and Vaast 2008). Hofstede (1991, p.5) defines culture as the "collective programming of the mind which distinguishes the members of one group or category of people from another." Similarly, Trompenaars and Hampdem-Turner (1998, p.13) define it as a "system of meaning that dictates what we pay attention, how we act, and what we value." Though these definitions focus on different aspects of culture, they both highlight how culture is subjective and is based on a shared set of values and assumptions that a group of people collectively accept and use. The subjectivity of national culture in global project networks can create boundaries (Levina and Vaast 2008) that often lead to difficulties in collaboration and the emergence of conflict (Mahalingam and Levitt 2007).

Many social scientists have attempted to develop models to define and understand the concepts of national culture (Kluckhohn and Kelly 1945; Linton 1945; Kroeber and Kluckhohn 1952; Useem and Useem 1963; Triandis 1972; Hofstede 1983). However, the most widely accepted model was developed by Geert Hofstede in the 1980's. In a research he conducted with IBM employees across the world, he found that national culture can be characterized in terms of five cultural dimensions: 1) *uncertainty avoidance* is the extent to which people are threatened by uncertain situations, 2) *power distance* is the extent to which people expect power to be distributed unequally among members of society, 3) *Individualism/Collectivism* is the extent to which people focus on themselves versus the society as a group, 4) *Masculinity/Femininity* is the extent to which gender roles are defined in society, and 5) *Short-term/Long-term Orientation* is the extent to which people focus on short-term versus long-term relationships (Hofstede 1991). The possible combinations of these varying dimensions within a global project network setting can ultimately result in a lack of trust (Doney 1998) and effectiveness

(Levina and Vaast 2008), which is imperative to successful global collaborations. Researchers have also identified that organizations see cultural diversity as a major risk and a critical factor in the success of global project network initiatives (Ang and Inkpen 2008). In order for networks to be effective, researchers have identified that global project networks require a different understanding of work processes (Hass 2010). Though the success of global teams can often be attributed to the emergence of sophisticated information technology that now enables fluent collaboration in geographically dispersed teams (Carmel and Tjia 2008), the management of interpersonal relationships and the development of effective distributed collaborative practices underlies the advantages of advances in technology.

In order for engineers to succeed within global project networks, the technical core knowledge gained through both their education and experience does not necessarily suffice. An engineer's knowledge must now be supplemented with nontechnical 'soft skills' that include: interpersonal communication, understanding of geographically situated culture, international laws, and social norms of interaction (Kini 2000). When organizations do not acknowledge these potentially influential factors, heterogeneous interpretations and practices can coexist which can divide networks and inhibit collaboration effectiveness. As a result, research has identified the need for organizations within these project networks to also identify, manage and exploit their internal resources when strategizing to collaborate globally (Devinney et al 2000; Ang and Inkpen 2008; Levina and Vaast 2008; Haas 2010). Porter (1990) discussed the competitive advantage of nations, which is related to the competitive advantage of organizations, i.e. in those cases where firms attain international success due to the characteristics of the nations they belong to. Within global project networks, organizations strive to improve their cultural-intelligence (Ang and Inkpen 2008), managerial practices (Levina and Vaast 2008), knowledge sharing (Haas 2010) and boundary-spanning practices (Levina and Vaast 2005; Ratcheva 2009).

Boundary Spanning in Global Project Networks

Interactions between participants in culturally and geographically distributed teams have been found to result in conflict that can inhibit team performance (Kumar and Dissel 1996; Hinds and Bailey 2003; Hinds and Mortensen 2005; Mahalingam and Levitt 2007). Global project networks often rely on technological tools to facilitate collaboration in virtual project teams (Jarvenpaa and Leidner 1999; Maznevski and Chudoba 2000) where managing across national-cultural boundaries is recognized as a critical factor and key managerial challenge that requires additional time and effort to prepare teams for success (Zhang et al 2007; Ang and Inkpen 2008). Because of this, researchers have begun to investigate means and methods of successful global, cross-boundary collaborations in order to understand and manage dispersed engineering projects in a dynamic global environment (Maznevski and Chudoba 2000; Carmel and Agarwal 2001). One key finding from these studies is the saliency of boundaries that exist within global networks, and only by actively managing these boundaries (i.e. by successfully spanning these boundaries) can teams begin to collaborate effectively.

Espinosa and colleagues (2003) identified four boundaries that can exist in geographically distributed collaboration: 1) geographical boundaries, i.e. time, language and culture; 2) functional boundaries, i.e. expertise and specializations; 3) identity boundaries, i.e. levels, integration and multiple features; and 4) organizational boundaries, i.e. in-house or outsourcing. Any of these boundaries can play a significant role within interorganizational collaborations, particularly for those in a global environment. Investigators agree that it is important for organizations to focus on both relationships between organizations and the external environment (Aldrich and Herker 1977) and on providing organizations with boundary spanning capabilities that allow for this liaison. Aldrich and Herker (1977, p.218) define boundary spanning roles as linking "organizational structure to environmental elements, whether by buffering, moderating, or influencing the environment," where the environment is treated as information available to the organization through search or exposure. In a survey conducted by Ancona and Caldwell (1992), they found that there was a positive correlation between boundary spanning activity, within and between organizations, and performance as well as a higher rating of group cohesiveness. However, Chevrier (2003) found that managers in multi-national project networks often do nothing when encountered with cross-cultural differences, which can contribute to an overall reduction of project performance. Therefore, boundary spanners, either in the form of individuals or objects, can significantly improve the collaborative process within global project networks.

Boundary spanners, i.e. those individuals in boundary spanning roles, who explicitly and implicitly cross both interorganizational boundaries and cross-cultural boundaries, are critical to project success. In an empirical study of organizations facing multiple boundaries such as distributed project networks, Espinosa and colleagues (2003) identified a mediating role that must occur in order to overcome the challenges of working across cultural boundaries. In order to alleviate distance (both literally and figuratively) within global project teams, a tactical approach is implementing a 'cultural liaison' that can facilitate cultural, linguistic, and organizational flow of information by bridging cultures, mediating conflict and resolving cultural miscommunications (Carmel and Agarwal 2001). This cultural liaison is known in global engineering services project network research as a cultural boundary spanner (Di Marco et al 2010). Hong (2010) identified that multi-cultural team effectiveness can be promoted by the bicultural members acting as boundary spanners and mediating conflicts. A study of firm-level intercultural capabilities found that firms looking to address issues between managers from different cultural contexts must develop boundary spanners with a high degree of cultural intelligence, an individual's capability to function and manage effectively in a culturally diverse setting, within their firms (Ang and Inkpen 2008). A survey of expatriates working in multinational corporations in Hong Kong found significant benefits when they engaged in boundary spanning roles, diminishing the overall psychological consequences expatriate managers generally experience when overseas (Au and Fukuda 2002). Based on the above presented previous research, cultural boundary spanners are key players in bridging path through which cross-cultural knowledge, skills, and abilities can be exploited within global project networks.

Research has also investigated the boundary spanning capabilities of objects, as 'boundary objects' and 'artifacts' in the AEC industries (Fleischmann 2006; Gal et al 2008; Phelps and Reddy 2009) and more specifically in global environments (Sapsed and Salter 2004; Haas 2010). Because global project networks can be temporal, i.e. in those cases where collaboration only occurs throughout the duration of the project, it is often challenging to facilitate knowledge transfer due to the boundary formation (Levina and

Vaast 2008), commitment (Carmel and Agarwal 2001) and trust limitations (Jarvenpaa and Leidner 1999) imposed by the geographical, national cultural and organizational distances (Carmel and Agarwal 2001). In a study of construction projects, Phelps and Reddy (2009) found that boundary objects can aid in transferring tacit knowledge and guiding collaboration in a collaborative setting with diverse imbedded information and roles. AEC organization research has identified communication infrastructure boundary objects (identified as 2D and 3D modeling technologies) as intermediaries, which become an effective shared boundary mechanism where the network can mutually identify as a group, allowing for fluency in cross-organization communication and organizational identity (Gal et al 2008). Establishing a network identity is particularly useful in global project networks, which often have difficulty building group cohesiveness (Zhang 2007). Brown and Duguid (2001) argue that boundary objects not only enable collaboration but they also promote interorganizational negotiations. Based on their distributed and collaborative nature, negotiations are a significant process to decision making and establishing common knowledge within global project networks; therefore the use of boundary objects for negotiations is highly of interest for global project network research.

Research Questions and Format of Dissertation

While previous research has developed a robust understanding of why boundary spanning is critical to developing more effective collaborations within and between organizations, research on the role of boundary spanning in global project networks is much less robust. Boundaries that are relevant to global project networks include: 1) geographical boundaries; 2) national-cultural boundaries; 3) organizational boundaries; and 4) discipline boundaries. It is important to differentiate between global-project networks, where little research exists on the mediating roles spanning these salient boundaries, and non-global project networks, where network research does exists but cannot necessarily be applied to that of global project networks. Therefore, since little is known about the roles and impacts of boundary spanning, by both individuals and objects, in global project networks, this research targets that existing gap.

In this dissertation, I empirically observe global project networks in an attempt to explore the roles of boundary spanners and boundary objects, in order to establish a better understanding of their impact on project effectiveness, performance and the establishment of common knowledge through negotiation. The dissertation follows a three-paper format. The research questions investigated are:

1. How do cultural boundary spanners emerge in cross-cultural engineering services networks? How does the emergence of cultural boundary spanners influence the effectiveness of cross-cultural engineering services work?
2. What is the impact of cultural boundary spanners on the performance of global project networks?
3. What role do boundary objects play in negotiating complex knowledge in global engineering services networks?

The aim of the first paper is to empirically explore cross-cultural engineering services networks, where national-cultural boundaries exist due to differences in country context and how the inclusion of a cultural boundary spanner contributes to increased project effectiveness, which would otherwise be difficult to attain. The second paper builds on the first in identifying the impact on performance of cultural boundary spanned multi-cultural networks compared to purely multi-cultural and mono-cultural networks. Finally, the third paper applies the findings of the first and second papers to an authentic, industrial context by observing the salient role played by boundary objects as boundary spanners in negotiations of cross-cultural project networks. The main goal of the three papers is to illustrate the boundary spanning practices in global project networks in order to theorize about the role of boundary spanning capabilities of actors, both individuals and objects, which can lead to better, more effective project outcomes.

By applying social network analysis and supporting these quantitative findings with an in-depth qualitative data analysis I attempt to discover both the physical and figurative emergence and subsequent role of cultural boundary spanners in Chapter 2. Chapter 3 expands this methodological approach by using regression statistics to compare the performance of spanned multi-cultural networks, un-spanned multi-cultural networks, and mono-cultural networks. Using network analysis, Chapter 4 focuses on egocentric networks that form around boundary objects used in negotiations to discover how distributed knowledge becomes common knowledge in global project networks. Chapter 5 discusses the contributions of the research to our current understanding of global project network dynamics. In Chapter 6, I discuss the limitations of the research and I also suggest potential streams for future research. Finally, a reference section is provided for a bibliographic list of the publications used in the dissertation.

Chapter 2

THE EMERGENCE AND ROLE OF CULTURAL BOUNDARY SPANNERS IN GLOBAL ENGINEERING PROJECT NETWORKS[1]

ABSTRACT

Engineering project networks are increasingly global in scope and outsourcing increasingly common. Along with globalizing trends in project delivery, the workforce is also globalizing. It is common for engineers to move to other countries as expatriate workers or as emigrants to pursue job opportunities in other firms. Where much is known about global networks of engineers collaborating on projects, little is known about the mediating role played by individuals that share the same nationality as an international partner on a project. In this paper, we examine two project teams executing complex, reciprocally interdependent design projects in India. One team was comprised of Indians and Americans. The other team was identical, but also contained an Indian national who had studied and worked in the U.S.A. Both teams worked on similar design schedule

[1] This paper was co-authored with Professor John E. Taylor and Pauli Alin. It is published in the ASCE Journal of Management in Engineering. The citation of the journal version is as follows:

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optimization problems. Over the duration of three days we examined the interactions of the teams assembled to finalize their designs. Through quantitative network analyses and qualitative observations of the cross-cultural interactions, we found the Indian expatriate to play a cultural boundary spanning role resolving cross-cultural knowledge system conflicts and increasing collaboration effectiveness. We induce a propositional theoretical model of cultural boundary spanning in global engineering project networks.

INTRODUCTION

As the engineering workforce globalizes, a growing number of engineers have lived and worked in multiple countries and can speak multiple languages (Haas 2006). As differences between the cultural origin of individuals and that of the country in which they are working emerge, conflicting culturally dependent perceptions can create boundaries dividing members of an engineering team (Cramton and Hinds 2005). These boundaries become increasingly important for companies that offshore work to other countries requiring cross-cultural engineering teamwork. This is particularly challenging in engineering services delivery where global project networks of firms deal with a myriad of task, specialization, resource and other boundaries in the execution of complex, reciprocally interdependent projects (Bryant 2006, Chan and Tse 2003, Nayak and Taylor *in press*). Researchers have shown that the differences in cultural contexts are still present in offshore collaborations and from these differences boundaries are created that can prohibit knowledge transfer (Chen et al. 2009, Levina and Vaast 2008, Ozorhon et al. 2008).

For global engineering project networks, complex design knowledge must be exchanged frequently and iteratively. Researchers have identified the critical role that boundary spanners can play in increasing the efficiency of knowledge exchanges across teams and organizations (Cross and Prusak 2002, Levina and Vaast 2005, 2006). Others have argued that it should be the role of the management within globally distributed organizations, not the individuals, to integrate the culturally diverse team members within the organization (Miller et al. 2000, Porter 1995). If spanning cultural boundaries is a critical competence in effective offshoring of complex work, then we need further research on cultural boundary spanners to understand how they emerge and how they can enhance global project success. In this manuscript we initiate such a dialogue by observing two cross-cultural engineering design project networks developing an optimal schedule design for a complex engineering services project. Both networks were comprised of Indians and Americans working together on a project in India. However, one of the teams included an Indian expatriate with experience working in both the United States and India. Using social network analysis, we first quantitatively examined the centrality of the cultural boundary spanner over the three day observation period. Then we adopted a qualitative approach to understand the emergent role of the cultural boundary spanner in the cross-cultural engineering design work.

GLOBAL OUTSOURCING OF ENGINEERING SERVICES

In order for firms to remain competitive both globally and locally, engineering services firms are developing new strategies to achieve cost and schedule reductions without compromising on quality (Bryant 2006, Kini 2000). Outsourcing work to offshore locations has given firms the alternative to seek work from remote locations with lower wages, less stringent labor laws, and a professional work force that is willing to contribute significant overtime hours. Though offshoring in the past was exploited for less demanding tasks, such as call centers and customer support, it has now transformed to technically-oriented, complex tasks (Levina and Vaast 2008). Researchers have begun to examine the elements that determine the effectiveness of cross-cultural engineering design collaborations by examining how differing perspectives across teams from different countries may explain efficiency problems (Nayak and Taylor *in press*). Bryant (2006) argues that despite some evidence of successful cross-cultural collaborations in engineering services, the differences of national contexts often create boundaries between teams from different nations. These national cultural boundaries are one of the greatest sources of conflict (Chan and Tse 2003, Levina and Vaast 2008). Researchers have shown that crossing boundaries and thus overcoming conflicts requires boundary spanning practices, such as an individual or set of individuals who act as boundary spanners (Bossink 2004, Friedman and Podolny 1992, Levina and Vaast 2005.

CULTURAL BOUNDARY SPANNING IN GLOBAL ENGINEERING SERVICES NETWORKS

The more cultural diversity between partners, the more difficulty a team will have establishing relationships. Weak interpersonal relationships, in turn, will impede adequate knowledge exchange processes within culturally diverse teams (Luo 2001). The success of cross-cultural collaborative engagements requires another form of team participant than just the team leader (Ansett 2006). Luo (2001) concluded that because members with varying cultural backgrounds find it difficult to communicate within cross-cultural joint ventures, having a number of culturally related group members allows for seamlessness in coordination and communication. To adapt to the globalizing cross-cultural team working environment, many firms have chosen to designate some team members to bridge the gap between team members with different backgrounds (Cross and Parker 2004). Adopting this practice is in line with the suggestion that organizations should appoint certain persons to span boundaries between units (Aldrich and Herker 1977, Friedman and Podolny 1992). These boundary spanners should be capable of crossing the boundaries between units with different backgrounds (Williams 2002).

In a recent study, Levina and Vaast (2008) studied offshore collaboration in information systems development and found that a middle manager on the onshore team can act as a boundary spanner to mediate the negative effects arising from status and cultural differences. Middle managers, due to their central network position and social capital, are conceptualized as agents capable of renegotiating status hierarchies. However, research on the actual effectiveness of cultural boundary spanners in global networks of firms has been limited, and the results have been somewhat mixed. Luo (2006) examined boundary spanning leadership decision-making effectiveness in global joint ventures and found that the boundary spanner played a role in suppressing the negative influence of national cultural differences in interparty attachment, but not in reducing conflict. Friedman and Podolny (1992) concluded that it is not clear whether nominating persons to boundary spanning positions actually leads to effective boundary spanning.

In settings where cross-cultural conflicts are expected, a key boundary to be spanned is at the boundary between cultures. Cultural boundary spanners should possess the knowledge to renegotiate the cultural boundaries that develop. Thus, we define a cultural boundary spanner in cross-cultural project networks as a member of the project team that provides vital cultural insight and background that the entire network draws on to get its work done. Following Levina and Vaast's (2005) distinction, we further specify that cultural boundary spanners are not necessarily formal team leaders or project managers, but can be any team members who connect the members of culturally distinct sub-teams in project networks through their knowledge of the collaborative counterparts' backgrounds. Despite the importance of spanning cultural boundaries in global project networks, researchers have largely ignored the emergence and emergent role of a cultural boundary spanner in cross-cultural collaborations. In this manuscript we examine how individual actors resolve conflicts in cross-cultural engineering services project networks by spanning boundaries. We ask *how does a cultural boundary spanner emerge in cross-cultural project networks and how does the emergence influence the effectiveness of cross-cultural engineering services work*?

RESEARCH SETTING AND METHODS

Research Setting

To capture the interactions and role of cultural boundary spanners in complex cross-cultural project execution, we observed two cross-cultural project teams. Researchers have described the need to carefully design empirical studies of global teams to avoid as much as possible the interacting effects of other boundaries (Espinosa et al. 2003). For this purpose, we used two graduate student teams (hereafter Team 1 and Team 2) composed of engineering students with engineering work experience from two universities, one in India and one in the United States. Both teams had nine members.

Both cross-cultural engineering services networks were divided into two sub-teams: one sub-team composed of American engineers and one sub-team composed of Indian engineers.

Both teams were required to work together in a task interdependent project network to complete the computer-aided design (CAD) and organizational models required to schedule a complex design project. In both teams, the sub-team composed of Americans was responsible for developing an organizational simulation-based construction schedule and the Indian sub-team was responsible for developing a 3-D CAD model based on a set of existing plans and drawings. The synchronization of the models resulted in a 4-D CAD model with the simulated schedule produced by the U.S. sub-teams. Time-space conflicts identified in the 4-D CAD model required further changes in the schedule which were then re-examined in the organizational simulation model and input again into the 4-D CAD model.

Team 1's project was to model the extension of a subway line in a dense, urban U.S. city. Their model was comprised of 27 distinct activities that required three separate interventions in order to reach an optimal completion date. Team 2's project was to model a high-tech hospital facility in a dense, urban U.S. city. It required modeling 23 tasks and also required three interventions to complete the project on schedule. The key difference between the two teams was that Team 1 contained an Indian expatriate (hereafter referred as a cultural boundary spanner, or CBS) living in the U.S. as part of the U.S. team. He was born and raised in India but had moved to the U.S. in order to complete his engineering studies and following his undergraduate studies emigrated to the U.S. as a working engineer. Involving a team member with significant experience in both sub-team cultures to Team 1 enabled us to observe whether such a nominated boundary spanner (Levina and Vaast 2005) could facilitate boundary spanning at the national cultural boundary. In this paper we refer to the members of Team 1 as US1, US2, US3, CBS, I1, I2, I3, I4, and I5 and the members of the Team 2 as US5, US6, US7, US8, I6, I7, I8, I9, and I10. Sub-team members from the United States have a 'US' designation and sub-team members from India have an 'I' designation. We describe the nominated cultural boundary spanner on Team 1 as CBS.

Data Collection

Three days of face-to-face meetings took place in Chennai, India in May 2008. The meetings lasted between 2 and 5 hours. The discussed topics included the coordination of both teams' interdependent complex design schedules, the design and implementation of interventions to optimize the schedule for each project, and the completion of a final report and presentation of the cross-cultural teams' results. During these meetings, we observed the intra-cultural and cross-cultural communication and recorded all interactions between teams. Here, we define interaction as a two-way communication between two individuals. We used both audio and video recordings, and the recordings were later transcribed into text for further analysis. This data collection effort is described in Table 1. Following the initial data collection and analysis, we shared our results with the cultural boundary spanner in Team 1 in two interviews of approximately two hours each. His recollections of the teamwork confirmed our early analysis regarding team dynamics and the boundary spanning emergence in the project networks.

Table 1: Data collected on Team 1 and Team 2

	Number of observed interactions	Hours of audio and video	Pages of transcribed text
Team 1	1247	18	80
Team 2	875	12	60

Identifying Cultural Boundary Spanner Emergence

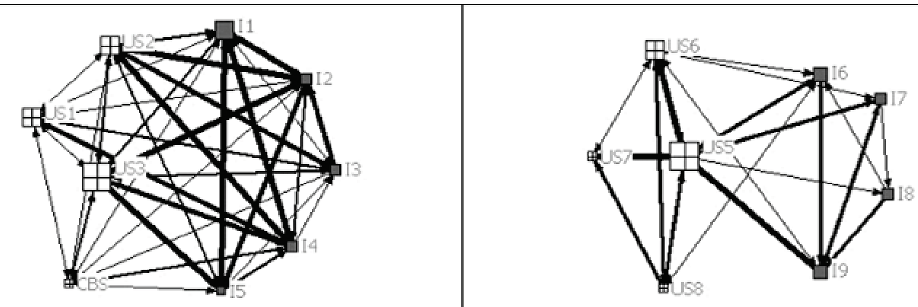
To identify if cultural boundary spanning emerged in either team, we used social network analysis (SNA). SNA is a quantitative research method that can be used in mapping out and identifying the flow of information and network relationships in a graphical form (Cross and Parker 2004, Moreno 1960). Chinowsky and colleagues (2008) describe SNA as a valuable method for studying patterns in construction and engineering teams. We first entered all dyadic interactions between team members into spreadsheets and then imported the data into an SNA software program, UCINET 5 for Windows. UCINET 5 utilizes algorithmic routines to comprehensively analyze social networks (Borgatti et al. 1999). We then used NetDraw, an SNA visualization program that creates a sociogrammatic display of networks.

The SNA implemented by UCINET 5 generates values between 0 and 1 (1 being the most important and 0 being the least) for three measures of positions for individuals or 'links' within the network. Among the several quantitative measures within SNA, centrality measures were chosen for this study to define the positioning of the cultural boundary spanner within the network (team). We found that centrality measures were the most appropriate for our analysis as it satisfied both the quantitative rank and the degrees of centrality within the teams as well as displayed the most comprehensive network diagrams for visualization of the cultural boundary spanner's position in the team. This position is determined from the observed interactions explained above. Centrality measures include; degrees of centrality (CD), which is the measure of the overall importance of the link in order to transfer information; betweenness centrality (CB), which is the measure by which one link mediates between other vertices; and closeness centrality (CC), which is the measure of the total distance between one vertex and all other vertices (de Nooy et al. 2005). Kilduff and Tsai (2003:29) explain the measure of betweenness centrality in organizational social networks where those with higher values of CB (closest to 1) are 'actors who bridge across structural holes… in the sense of being the go-betweens for those actors not directly connected to each other.' It is important to note these values in order to determine which actor within cross-cultural collaborations 'bridge the gap' between the unconnected participants, in our case the U.S. and Indian sub-teams. Table 2 below displays the mathematical representation and the formulas used to calculate the above relative centrality measures. Note that for this study in particular x is the unit (the team member), n is the number of units (sum of the team members in each team) and U is the set of all units (the team itself).

Table 2: Mathematical Representation of Relative Centrality Measures

Centrality Measure	For Each Individual x	Relative Centrality Measures
Degrees of Centrality, $C_D(x)$	$c_D(x) = \text{degree of individual x}$	$C_D(x) = \frac{c_D(x)}{\text{highest degree}}$ $C_D(x) = \frac{c_D(x)}{n-1}$
Closeness Centrality, $C_C(x)$	$c_C(x) = \frac{1}{\sum_{y \in U} d(x,y)}$ where $d(x,y)$ is the length of the shortest path between x & y	$C_C(x) = (n-1) \cdot c_C(x)$
Betweenness Centrality, $C_B(x)$	$c_B(x) = \sum_{y<z} \frac{\text{\# shortest paths between y \& z through individual x}}{\text{\# shortest paths between y \& z}}$	$C_B(x) = \frac{c_B(x)}{(n-1)(n-2)}$

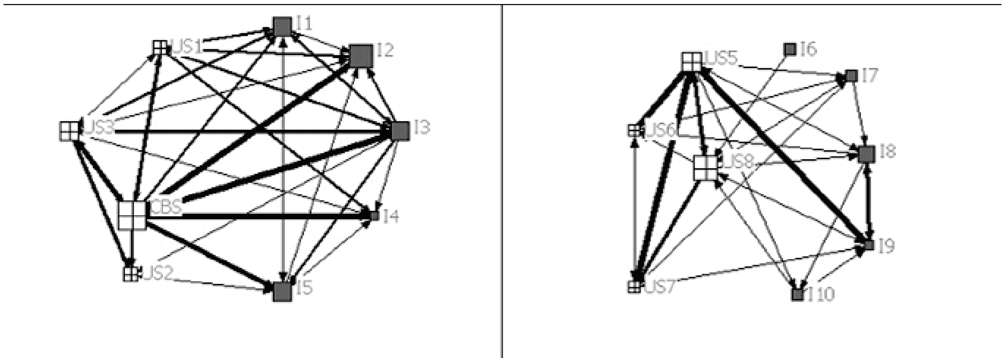
The output for all the defined values (CD, CB, CC) was calculated for each individual, at an aggregate level for each network of sub-teams, and for each day. These values are included in Figures 1, 2 and 3 below, along with SNA diagrams of the communications for the period indicated. The centralization values for the entire network are also displayed under the network diagrams of the respective figures. The more centralized the network (i.e. to more central one link is within the network) the higher the value. The thickness of the node-connecting links that can be observed from the communication network diagrams at the top of Figures 1, 2 and 3 represent 'tie strengths,' or richness of interactions. The communication network sociograms of the collaborative interaction patterns enabled us to examine whether the cultural boundary spanner emerged as a central node in the network.



Day 1 – Team 1				
Network Centrality = 0.28571				
Network Closeness Centrality = 0.38095				
Network Betweenness Centrality = 0.25223				
No.	Name	C_D	C_B	C_C
1	I1	0.875	0.889	0.006
2	I2	0.875	0.889	0.006
3	I3	0.875	0.889	0.006
4	I4	0.875	0.889	0.006
5	I5	0.875	0.889	0.006
6	US1	0.750	0.800	0.000
7	US2	0.125	0.533	0.000
8	US3	1.000	1.000	0.256
9	CBS	0.750	0.800	0.000

Day 1 – Team 2				
Network Centrality = 0.61905				
Network Closeness Centrality = 0.62663				
Network Betweenness Centrality = 0.52381				
No.	Name	C_D	C_B	C_C
1	I6	0.714	0.778	0.333
2	I7	0.143	0.500	0.000
3	I8	0.143	0.467	0.000
4	I9	0.286	0.583	0.000
5	I10	-	-	-
6	US5	0.857	0.875	0.571
7	US6	0.429	0.636	0.000
8	US7	0.143	0.500	0.000
9	US8	0.429	0.636	0.000

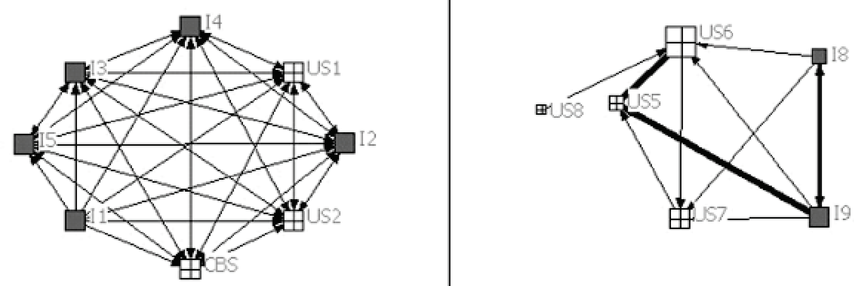
Figure 1: Team 1 and Team 2 Interactions on Day 1



Day 2 – Team 1				
Network Centrality = 0.78571				
Network Closeness Centrality = 0.85557				
Network Betweenness Centrality = 0.56473				
No.	Name	C_D	C_B	C_C
1	I1	0.375	0.615	0.018
2	I2	0.250	0.571	0.000
3	I3	0.250	0.571	0.000
4	I4	0.250	0.571	0.000
5	I5	0.250	0.571	0.000
6	US1	0.750	0.800	0.179
7	US2	0.125	0.533	0.000
8	US3	0.250	0.571	0.000
9	CBS	1.000	1.000	0.589

Day 2 – Team 2				
Network Centrality = 0.47619				
Network Closeness Centrality = 0.53643				
Network Betweenness Centrality = 0.46259				
No.	Name	C_D	C_B	C_C
1	I6	0.125	0.500	0.000
2	I7	0.143	0.438	0.000
3	I8	0.571	0.700	0.524
4	I9	0.429	0.636	0.071
5	I10	0.286	0.500	0.000
6	US5	0.714	0.778	0.548
7	US6	0.143	0.438	0.000
8	US7	0.286	0.500	0.000
9	US8	0.500	0.667	0.000

Figure 2: Team 1 and Team 2 Interactions on Day 2



Day 3 – Team 1				
Network Centrality = 0.00000				
Network Closeness Centrality = 0.0				
Network Betweenness Centrality = 0.0				
No.	Name	C_D	C_B	C_C
1	I1	1.000	1.000	0.000
2	I2	1.000	1.000	0.000
3	I3	1.000	1.000	0.000
4	I4	1.000	1.000	0.000
5	I5	1.000	1.000	0.000
6	US1	1.000	1.000	0.000
7	US2	1.000	1.000	0.000
8	US3	-	-	-
9	CBS	1.000	1.000	0.000

Day 3 – Team 2				
Network Centrality = 0.60000				
Network Closeness Centrality = 0.61778				
Network Betweenness Centrality = 0.62000				
No.	Name	C_D	C_B	C_C
1	I6	-	-	-
2	I7	-	-	-
3	I8	0.200	0.455	0.000
4	I9	0.600	0.714	0.400
5	I10	-	-	-
6	US5	0.200	0.500	0.000
7	US6	0.800	0.833	0.700
8	US7	0.400	0.625	0.000
9	US8	0.200	0.500	0.000

Figure 3: Team 1 and Team 2 Interactions on Day 3

Exploring Cultural Boundary Spanner Emergence

We were also interested in exploring how cultural boundary spanners emerge in cross-cultural project networks. We followed a grounded theory approach which enables researchers to discover concepts of theoretical interest from data (Glaser and Strauss 1967). First, we chose the discussions (excerpts of transcribed text) in which the team was in disagreement and then classified the discussions according to the type of conflict that occurred. However, as all conflict situations did not fit pre-existing categories we gave labels to the non-fitting conflicts (Miles and Huberman 1994), and eventually new categories of conflict in cross-cultural teams emerged. We initially used existing conflict literature to focus our analytical efforts, therefore, our approach to data analysis could be described 'middle-zone theorizing' in which initial examples are chosen systematically (Eden and Huxham 1996). After we had identified and labeled all relevant conflicts, we analyzed the role of the cultural boundary spanner and other members of the global team that intervened to resolve conflicts.

CULTURAL BOUNDARY SPANNER EMERGENCE

Quantitative Findings - Day 1

During the first day of cross-cultural sub-team interactions, the team member who had been facilitating communications between the teams prior to the face-to-face interactions was the most central individual in both Team 1 and Team 2. This is represented in communication network diagrams in Figure 1 where sub-team member US3 in Team 1 and member US5 in Team 2 are the most central on the U.S. sub-teams. These individuals are the most dominant in terms of degrees of centrality and tie strengths for the first day. For Team 1 in particular, US3 is the main link of information flow. It is worth noting that the cultural boundary spanner (CBS) interacts with all the team members at least once, especially with his Indian counterparts, on the first day of team interaction, despite his overall low degree of centrality (0.750). The cultural boundary spanner's involvement within this first day of discussions, though he was not the dominant communicator, still has significance within the communication. This is due largely to his increasing participation towards the end of day 1. The communication network diagrams illustrate sparse communication spanning cross-cultural boundaries across sub-teams in Team 2. In Team 2 there was limited cross-cultural interaction during the entire first day. All but one cross-cultural communication occurred between US5 and I6. Individual centrality measures below the communications network diagrams in Figure 1 indicate that each sub-team member on Team 2's individual closeness centrality and betweenness centrality is on average less than that of Team 1.

Quantitative Findings - Day 2

In day 2, Team 1's cultural boundary spanner (CBS) emerged as the most central individual within the communications network with a degree of centrality and betweenness of 1.00, as well as the highest closeness centrality in the team of 0.589. This is illustrated in the communication network diagram in Figure 2. The high degrees of centrality and betweenness are due to the fact that the ties are very strong with the Indian sub-team counterparts and there were a large number of communications. It is also important to point out that not only is the cultural boundary spanner the most central individual in the communication network, but that the other individuals' centralities were reduced as he emerged to become the central link of communication. The cultural boundary spanner is not only the most communicating actor in the network, but is also the go-between within the network for information and the closest to all other team members. The network diagram of Team 1 also demonstrates a number of strong ties that span cross-cultural sub-team dyads that do not pass through CBS. US3 continues to interact with all the team members, but the strength of the ties spanning to and from US3 are much weaker.

Team 2's most central team member also changed from day 1 to day 2. The individual centralities of Team 2 are weak; with even the most central link (US5) only exhibiting approximately 71% of full centrality. This indicates there is no single individual who coordinated communication. The network centralization of Team 1 is greater than that of Team 2 due to the high centrality of the cultural boundary spanner. Team 2's network centralization is lower because of the lack of a central team member. It is noteworthy that there is also an increase in cross-cultural interactions from day 1 to day 2, as clearly both sides needed to collaborate to execute the interdependent modeling task. Nevertheless, the tie strengths in Team 2's cross-cultural communications remain relatively weak compared to within sub-team, intra-cultural communication.

Quantitative Findings - Day 3

In day 3, the final day of team interactions and the day that the teams presented their engineering solutions, we again observe contrasting communication network results. Team 1's network diagram, contained in Figure 3, reveals all the participating team members were equally central (CD= 1.00 & CB=1.00) for all members in reference to one another. Each team member also demonstrates the same amount of interactions to all other members of their team. The closeness centrality for this team is zero because no member exhibits closer ties in reference to all other members in the team, another display of their equality. Because there are no node differences in reference to the team, the overall network centralities are also zero as there are no deviations. Team 1, by the end of day 3 became a fully integrated team. All members in Team 1 communicated as equal stakeholders to the final joint development effort of their project. Note that team member US3 was not present during these interactions due to the fact that she took on a relatively isolated role in the preparation of the final project presentation. On day 3, team member US5 was most central in Team 2, however, the overall quality of the interactions were poor and there was little cross-cultural sub-team evidence of group cohesion observed. Like on day 2, on day 3 no one member exhibited full centrality in the communication network. The highest degree centrality was US6 with only 80% centrality. No single team member took the initiative to interact with all members of the project team.

THE EMERGENT ROLE OF CULTURAL BOUNDARY SPANNERS

The communication network diagrams illustrate how a cultural boundary spanner moved from a peripheral role in day 1 to a central role in day 2. We also observe that the communications of the team with the benefit of the cultural boundary spanner achieved equilibrium in communication across all members of the team by day 3. Team 2, who did not have the benefit of a cultural boundary spanner, was unable to establish consistent communication across the cross-cultural sub-teams and members of the team became more isolated by day 3. This demonstrates quantitatively that a cultural boundary spanner can become a central actor in a complex engineering cross-cultural project network. However, it provides little detail to explain how that emergence occurred. In this section we examine the content of Team 1's communications in order to understand how this peripheral actor in the network emerged as a central actor and how that may have led to equilibrium in the communications of the project communication network.

Following the lead of other researchers of cross-cultural and international interactions (Hinds and Bailey 2003, Mahalingam and Levitt 2007), we focused our analysis on how the team addressed conflicts or difficulties that arose during the interaction. These difficulties included a large number of national cultural conflicts that originated from discrepancies in knowledge at the level of national-cultural systems. We labeled these as knowledge system conflicts. These knowledge discrepancies were not created by differences in individual-level variables such as level or type of education, age, profession, or language, but rather from the different customs, norms and institutions in the U.S. and India. We then focused our analysis on how these conflicts were addressed by the cultural boundary spanner or other members of the team to span the cross-cultural boundary and address the knowledge system conflicts that emerged during the collaboration.

During the team face-to-face meetings, the conflicts we identified between the U.S. and Indian sub-teams were largely a function of the national cultural boundary that separated them. The cultural boundary present was an obstacle that both Team 1 and Team 2 had to mediate in order to collaborate effectively and complete their complex, task-interdependent engineering modeling project. In many cases conflicts arose due to unfamiliarity with linguistic norms. In the following example US1 notes to US3 how linguistic differences were impacting the collaboration effectiveness:

> *US3: Wow, this is more time consuming for them.*
> *US1: Well, actually, a lot of the tasks for them didn't change very much. They had to rearrange. There's such a… an in between where their English is sped up … Even though it's the same language.*

There were also a number of instances of differences in local work practices that emerged as the team began to collaborate. In the following interaction, US3 and US1 discuss the concept of surveying with one of their Indian counterparts:

> *US2: Hey, it's pretty much like surveying. Like surveying you have coordinates and you're trying to link from a station. Like, you know, land surveying.*
> *Indian3: Land surveying.*
> *US2: You guys know land surveying right? It's like you have coordinates you use and you pull it from the total station, you can pull it to AutoCAD, different points and it gives you a map of what you're surveying.*
> *Indian3: No.*

US2: You don't.

Such conflicts emerged in day 1 for both Team 1 and Team 2 (although our analysis will focus principally on Team 1). As both teams attempted to begin the task interdependent design of interventions required for the project, the accumulation of these conflicts caused the formation of the national cultural boundary early in the first day of the collaborative process. This finding is in line with previous literature that argues that differences in national cultural backgrounds often lead to the emergence of national cultural boundaries (Espinosa et al. 2003, Levina and Vaast 2008, Ozhorhon et al. 2008). This leads us to formulate the following proposition:

Proposition 1: Differences in national cultural backgrounds give rise to national cultural boundaries which lead to the emergence of knowledge system conflicts.

Among the knowledge system conflicts we identified during the collaborations, more than half were occurring as a direct result of the national cultural boundary. The team assignment itself also resulted in conflicts that were not particularly relevant to the diverse cultural backgrounds of the team members. However, by distinguishing these knowledge system conflicts as such we were able to isolate the origin and resolution of these various conflicts within both teams being observed. These team assignment knowledge system conflicts were often negotiated across cultural boundaries and provided further opportunities to understand the cross-cultural engineering services network collaboration effectiveness. An example of a team assignment conflict below illustrates how these conflicts involve cross-cultural understandings:

US1: So they take the total length of the tunnel and divide it by how many days you're going to have it on task and… right now we're doing it by month you said?
I3: Not actually but…
CBS: per minute, per second.

I3: Actually yeah, why don't we do it like this, per second you can change it to thirty days. Per second is equal to thirty days.
US1: So when you're breaking the test then, you're breaking them down by length?
I3: By length, actually during modeling, during this 3-D modeling we have made a segment equal to one meter…
US1: So segment 20 in your design is the same as segment 1 but just in a different location.
I3: Yeah
US1: And then when it builds it runs the model. And then they can tell it to you in their schedule where uh… reinforcement stuff is.
US3: I think I understand.

What is being negotiated in this particular instance is the unit convention within Team 1. The U.S. members had difficulty understanding which convention was used by their Indian counterparts in order to create the model. Conflicts such as this occurred due to the misunderstandings and eventually the accumulation of these conflicts affected the collaboration performance. Thus, we propose the following:

Proposition 2: Knowledge system conflicts reduce collaboration effectiveness.

For the remainder of the qualitative analysis we focus on the interactions of Team 1 to understand how the cultural boundary spanner emerged to resolve the knowledge system conflicts that were experienced by both Team 1 and Team 2. We are specifically interested in exploring how the cultural boundary spanner's role led to collaboration effectiveness as evidenced by the equilibrium of communications from the day 3 communication network. We found that the cultural boundary spanner consistently emerged (in both English and in the regional Indian language Tamil) to mediate the majority of the identified knowledge system conflicts. We classified the knowledge system conflicts into four categories: linguistic conflicts, team assignment conflicts, work process conflicts, and local knowledge conflicts. An example of an intervention by the cultural boundary spanner to resolve a linguistic conflict was with regards to the lexicon for describing a construction hauling vehicle:

US3: Wait, wait, time out. What's a lorry?
US1: Dump truck.
[Laughter]
CBS: You use dump truck, here we use lorry.
US3: Okay.

This is an example of a very direct intervention taken in order to clarify what a 'lorry' was. Also, the cultural boundary spanner played a particularly important role addressing conflicts relating to his local knowledge of both India and the United States. He was able to translate the local norms to both sub-teams:

US3: The start date is June…
I3: So you enter the date it's month, date-
US3: Month, date, year.
US2: Yeah, it's opposite here.
I3: Normally we do date, month, year, not like this.
[CBS and Indian3 converse - CBS explains in Tamil how the Americans compose their dates]
US3: There's probably something you can do in here to change it.
US1: So everything I sent to you was in month, date format.

The cultural boundary spanner in this case explained the difference to the Indian member to overcome a misunderstanding which would have significantly hampered the 4-D modeling efforts. Other examples of the CBS resolving knowledge system conflicts involve explaining much more complex national differences such as construction processes and labor laws. Additional evidence of the important role of the cultural boundary spanner was observed when he negotiated that the team went to lunch together; sensing uncertainty about how to interact, he specifically requested that both the Indian and US sides '*sit and mix together'* during lunch.

Toward the end of day 2 another cultural boundary spanning process was observed. Team members other than the nominated cultural boundary spanner began to take the initiative to address knowledge system conflicts and, although the resolution to these conflicts was less efficient, two other members of the Team 1's sub-teams (one U.S. and one Indian) emerged as cultural boundary spanners in practice. This appeared to be triggered by the successful earlier knowledge system conflict resolution that the rest of the team observed the nominated cultural boundary spanner resolve. In the following example American and Indian engineers begin to take on cultural boundary spanning roles:

US1: Yeah, it won't let you.
I3: You cannot make it into a text file? Export, save it.
US3: And I was having issues saving it as this. It just like changed the dates, it over-rided simulations. There's something in the program that's just defaulting outside of what we're introducing. That's why our baseline isn't matching up to the actual.
I2: We have to match the TBM date to the planned date, what should it be?
US3: Good question.
US2: What?
I2: What should we do to match the TBM date to the planned date?
US2: Oh, maybe change the… adjust the probabilities maybe?
US1: No, every time you introduce a probability it's already some kind of error.
US3: But this already is supposed to be the realistic schedule, like the I guess what, I don't know what function is built into this or how it's analyzing it, but if you want us to do that you could probably try to override it with milestones with these, and then try to put like-
I2: So add milestones.

This interaction between the U.S. and Indian sub-teams shows that both sides are learning how to communicate and span boundaries in order to effectively collaborate. This was an emergent mediating managerial practice (Levina and Vaast 2008) where knowledge system conflicts were being resolved by team members other than the cultural boundary spanner. Though these interventions may seem relatively subtle to the entire scope of our analysis, none of these subtleties were observed within Team 2 which lacked a cultural boundary spanner and failed to achieve collaboration effectiveness during the face-to-face interactions. Therefore, our data suggests that both nominated and emergent cultural boundary spanners can mediate the effect of knowledge system conflicts on collaboration effectiveness at national cultural boundaries. This suggestion is in line with existing research on boundary spanning emergence: for example, Levina and Vaast's (2005) analysis shows how a nominated boundary spanner was able to encourage the boundary spanning emergence. As the other team members within Team 1 became more accustomed to spanning boundaries created by the differences in their national cultural backgrounds, the number and severity of conflicts reduced significantly. This process contributes to an explanation of how Team 1 achieved communication network equilibrium over the three days of interaction. This leads to the following proposition:

Proposition 3: Nominated cultural boundary spanning is a managerial practice that can directly mediate the effect of knowledge system conflicts on collaboration effectiveness.

As these management practices became intrinsic within Team 1's collaborative practices, the team was able to focus on the task they needed to complete instead of trying to make sense of cross-cultural differences. Team 2, on the other hand, lacked the triggering process necessary for cross-cultural team collaborations to be effective, resulting in their team's reduction in communications and relative isolation of the sub-teams. We argue that because of lack of formal management structures in cross-cultural offshoring project networks, nominated and emergent cultural boundary spanning constitutes an important management practice in such networks:

Proposition 4: Nominated cultural boundary spanning is a managerial practice that can enable cultural boundary spanning in practice to emerge.

Proposition 5: Emergent cultural boundary spanning in practice is a managerial practice that can mediate the effect of knowledge system conflicts on collaboration effectiveness.

A related argument was put forth by Levina and Vaast (2008), whose findings suggest that while boundaries may constrain managerial practice, effective managerial practices in offshoring can also mediate the negative effect of boundaries. Levina and Vaast (2008) also argued that it is mainly the differences in country contexts that give rise to boundaries that, in turn, inhibit collaboration effectiveness in offshoring. Our findings provide additional strength to this causal argument concerning offshoring project networks.

TOWARD A MODEL OF CULTURAL BOUNDARY SPANNING IN GLOBAL ENGINEERING PROJECT NETWORKS

Engineering projects are increasingly executed by cross-cultural teams. In this paper we demonstrated that when cultural boundaries are crossed it can lead to cross-cultural knowledge system conflict. In order for cross-cultural engineering teams to collaborate effectively, these teams need members who can span boundaries and thus mitigate knowledge system conflicts, particularly during team formation. Research to date on boundary spanning has not explored how these cultural boundary spanners emerge. Our exploration of cultural boundary spanner emergence finds that differences in national cultural backgrounds give rise to national cultural boundaries (P1). These boundaries result in knowledge system conflicts (P2) that are detrimental to collaboration performance. These claims are corroborated at a high level by Hofstede's (1983) work on the dimensions of culture, but more recent research on global collaborations also supports this argument (Bryant 2006, Levina and Vaast 2008, Mahalingam and Levitt 2007). We find that when potentially detrimental knowledge system conflicts occur, nominated cultural boundary spanners can mitigate them by negotiating boundaries (P3) and thus forming new 'joint fields' that enable team members from different national cultural backgrounds to pursue common goals (Levina and Vaast 2005:337). The concept of joint field creation is of strategic importance. Dyer and Song (1997) argue that successful management of global conflicts can lead to inimitable team culture and subsequent competitive advantage.

Our findings indicate that the nominated cultural boundary spanner can positively influence team performance by triggering other team members to assume boundary spanning roles (P4). We further proposed that the emergent cultural boundary spanner has a positive effect on management practice through negotiating boundaries and thus reducing knowledge system conflict (P5). Extending Levina and Vaast's (2008) process-oriented findings of managerial practices as boundary mediators, we conclude that in global engineering project networks where national cultural boundaries are present, the combination of both nominated and emergent boundary spanners constitutes a key managerial practice. Finally, because managing cultural boundaries in global project networks and successful team coordination has a positive relationship to collaboration effectiveness (Hoegl et al. 2004); we assert that managerial practice composed of both nominated and emergent boundary spanners leads to higher performance in global cross-cultural teams. A propositional theoretical model of cultural boundary spanning in global engineering project networks to achieve collaboration effectiveness is shown in Figure 4.

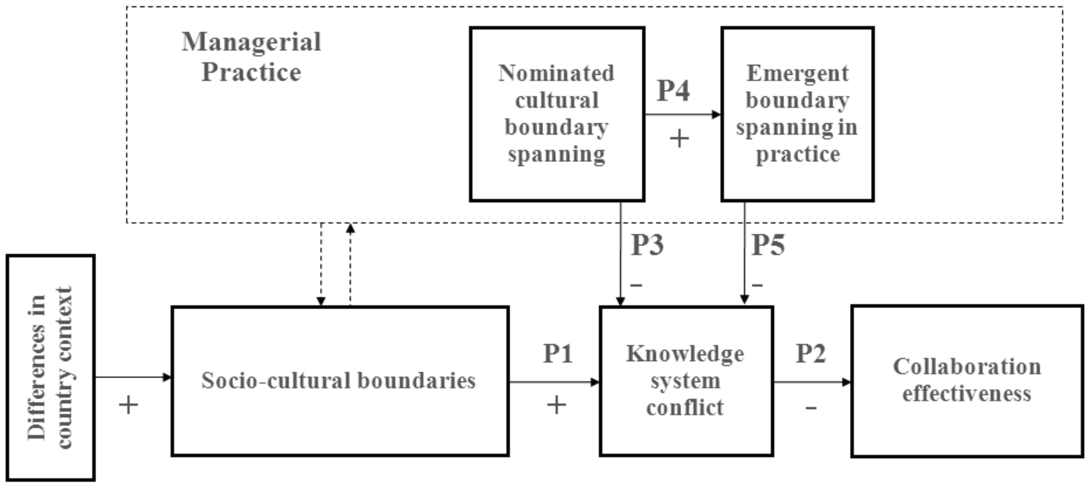


Figure 4: Model of Cultural Boundary Spanning Practice in Global Project Networks

LIMITATIONS

The teams studied consisted of individuals participating in a project for a graduate level course, not working in an industrial setting. This imposed limitations in the research in that teams in a class setting are motivated by their grade results as opposed to monetary or professional recognition they could receive when working in a multinational project network. It is important to note, however, that the graduate students participating in the projects were either part-time students at present working in design or construction firms or full-time students with several years of prior professional experience. This enabled all team members to act professionally towards the project assignment and to be knowledgeable about the design and construction systems involved in the two projects. Moreover, the projects the two teams investigated were real current projects on which one of the team members was working. The findings fundamentally demonstrate the impact a cultural boundary spanning team member has on the collaboration effectiveness of a cross-national network of firms or individuals engaged in a complex interdependent task. Researchers have demonstrated that laboratory studies can increase theoretical understanding of organizational phenomena and therefore the results of such research can be generalized to broader industrial settings (Dobbins et al. 1988). Our findings establish a baseline understanding for future research and observations of collaboration in global project networks.

CONTRIBUTIONS AND FUTURE DIRECTIONS

This paper drew from previous research on cross-cultural conflicts and boundary spanning in offshoring project networks. Our work extends the literature on boundary spanners by addressing the crucial questions of 'which boundaries should be spanned' and 'should boundary spanners be nominated or emergent from practice' (Levina and Vaast 2005:355). First, we argued that in global project networks, it is important that the national cultural boundaries are spanned. Second, we showed that the relationship between nominated and emergent boundary spanners is more complex than the existing literature suggests; both types of boundary spanners are needed for cross-cultural engineering services project collaboration effectiveness, but nominated boundary spanners are particularly important because they can trigger emergent boundary spanning processes. Ericksen and Dyer (2004) and Hoegl and colleagues (2004) emphasize the importance of early stages of team formation in overall team success. Our findings from two global engineering project networks corroborate the argument; it is crucial to get things right from the start. Our findings show how a cultural boundary spanner can facilitate this process.

The contribution of this research lies in demonstrating the centrality of and facilitation role a cultural boundary spanner can play in a cross-cultural project network. However, it is not clear what characteristics of individual boundary spanners may allow them to take this role. Research indicates that there are many facets to the personality of a boundary spanner and how their competence is measured in the transfer knowledge from one organization to the next (Williams 2002). Further research is needed to characterize, not just the indentified boundary spanner, but also the boundary spanners that emerge unexpectedly in practice in global projects and to quantify the impact on performance when cultural boundary spanning occurs.

Chapter 3

THE IMPACT OF CULTURAL BOUNDARY SPANNERS ON GLOBAL PROJECT NETWORK PERFORMANCE[2]

ABSTRACT

Architecture, engineering and construction projects are becoming increasingly global. In addition to understanding cultural differences, global project managers must be aware of the effects of these differences on performance. In this paper we empirically examine the impact of cultural boundary spanners on global project network performance. Past research has examined collaboration in project networks comprised of organizations from multiple countries. However including cultural boundary spanners to resolve cultural differences and investigating the resulting impact on performance has received limited attention. Through quantitative analyses of project network performance and participant communications, we found that cultural boundary spanned multi-cultural networks significantly outperformed multi-cultural networks without cultural boundary spanners and performed comparably to mono-cultural networks in initial performance. Analysis of

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[2] This paper was co-authored by Professor John E. Taylor and was published in the Engineering Project Organization Conference 2010. The full version is currently accepted for publication in the Engineering Project Organization Journal. The citation is as follows:

Di Marco, M. and Taylor, J. (2010). "The Impact Of Cultural Boundary Spanners On Global Project Network Performance." *Proceedings of the Engineering Project Organization Conference,* Lake Tahoe, CA.

participant communications revealed that cultural boundary spanners communicated significantly more than other project participants during the first project which may have been a key factor enabling those networks to achieve the initial performance of mono-cultural networks. Cultural boundary spanners can play a crucial role in off-setting the initial performance liability of working across cultural and linguistic boundaries in global project networks.

INTRODUCTION

Globalization has far reaching impacts on architecture, engineering and construction (AEC). Distributed, multi-cultural and virtual project networks are redefining the AEC industry. Organizations have recognized that global project networks require a distinct strategic approach (Kini 2000). Global project networks entail work being conducted across organizational and national boundaries, which creates asymmetric challenges and conflicts (Nayak & Taylor 2009). The distinct national cultures within global project networks are deeply imbedded in the individuals and organizations that populate them. This means that the underlying attitudes, thought patterns, assumptions and expectations of each culture can be significantly different and when brought together in a professional environment—such as a global AEC project network—can lead to conflicts that are difficult to resolve. The way in which global networks and organizations produce, diffuse, transfer, broker and translate project knowledge across both organizational and cultural boundaries has been of growing interest to the research community.

A key to gaining a competitive advantage in the globalizing AEC industry involves organizing a project network's systems, skills, and persons in order to mitigate potential problems. In global project networks, this requires developing appropriate global knowledge transfer procedures (Javernick-Will & Levitt 2010). Skill development in the global context includes a comprehensive inter-firm cultural intelligence (Janssens & Brett 2006, Ang & Inkpen 2008) where the key persons are global project managers (Miller et al. 2000) and immigrant managers (Levina & Kane 2009). Previous research observing collaboration across national boundaries has identified criteria for global project networks to collaborate more effectively (Levina & Vaast 2008, Di Marco et al. 2010, Hong 2010), yet we still know little about the potential performance impact of involving individuals that have spent considerable amounts of time living, studying and working in the countries of their international counterparts on a project. The aim of this paper is to empirically examine how a cultural boundary spanner can influence performance by spanning cultural and linguistic boundaries in global project networks.

CULTURAL IMPLICATIONS AND PERFORMANCE MEASURES OF GLOBAL PROJECT NETWORKS

Organizational research that explores intercultural collaborations has evolved beyond that of Hofstede's (1991) cultural indices. Scholars have found that cultural diversity can decrease performance (Porter 1995, Barkema et al. 1997, Brouthers & Brouthers, 2001). Like Hofstede (1991), they argue that culturally diverse participants in a project network will have different values and norms and that these may decrease both financial and schedule efficiency (Mahalingam & Levitt 2007, Makino & Beamish 1998). While some researchers identified a negative impact on effectiveness in global project networks, others investigated cross-national joint ventures and found performance to improve as a result of cultural diversity (Shenkar and Zeira 1992, Park and Ungson 1997, Chan et al.

2004, Ozorhon et al. 2008). Ozorhon and colleagues (2010) recently studied both the internal and external factors affecting performance in international collaborations on the basis of three factors: 1) the project, 2) the international partnership, and 3) the inter-firm organization. Using proxies for performance, their results were inconclusive as to the performance impact of collaborating within a multicultural environment. A key requirement to evaluate the success of global project networks is a performance measurement to compare project network performance directly. To date, researchers have focused on evaluating global project networks based on effective collaboration (Vadhavkar & Pena-Mora 2000, Manzoni et al. 2007, Levina & Kane 2009, Hong 2010) or comparing aggregate performance in terms of overall project success and failure (Cooke-Davies 2002, Cheah et al. 2004, Fong & Kwok 2009). A focus on collaboration effectiveness is only an indicator of performance and may not reflect the actual performance impact of a national cultural boundary in global project networks. Moreover, aggregate measures of performance may not accurately capture the performance impact of one or more cross-cultural boundaries on a large and complex global project. We need research narrowly focused on performance at the cross-cultural boundary to understand the performance implications of working across cultures.

CULTURAL BOUNDARY SPANNERS IN GLOBAL PROJECT NETWORKS

As the AEC industry adapts to trends in globalization and project networks collaborate inter-culturally, network participants are bound to encounter a distinct set of conflicts due to differences in national culture (Chan & Tse 2003, Hinds & Bailey 2003, Powell 2006, Mahalingam & Levitt 2007, Chen et al. 2009). Researchers have found a number of key practices to reduce conflicts within global networks. Particularly, some have studied the roles played by participants within global organizations to mitigate conflicts such as the role of expatriates (Yates 1989, Au & Fukuda 2002, Mahalingam & Levitt 2005), immigrant managers (Levina & Kane 2009) and cultural boundary spanners (Di Marco et al. 2010). In this paper, we will focus on the performance impact of cultural boundary spanners in global project networks. Cultural boundary spanners are not necessarily formal team leaders or project managers, but can be any member of a team that can provide vital cultural insight from which the entire project network can draw upon to enact work. Put simply, a cultural boundary spanner is an individual whose understanding of the multiple cultures and languages—common to their collaborative counterparts within the network—is sufficient to connect members in a global project network.

There have been a number of attempts to empirically examine how boundary spanners improve collaboration effectiveness. Ancona and Caldwell (1992) found that teams with boundary spanning capabilities, have a tendency to be perceived as more effective, and are therefore more likely to achieve their final goals. Luo (2006), though not specifically looking at conflict resolution, researched cross-cultural joint ventures and found boundary spanners to play a key role in mitigating cultural differences in cross-cultural collaborations. Some researchers find that boundary spanners can increase the chances of success in interorganizational collaboration (Aldrich & Herker 1977, Ancona & Caldwell 1992) and more specifically cross-cultural organizations (Ansett 2005). These studies are critical to understanding cultural boundary spanning; however, they do not measure the performance implications of involving cultural boundary spanners in global project networks. The measure of how cultural boundary spanners impact global project network performance has been qualitatively examined through constructs such as success and failure (Chua 1999, Cheah et al. 2004), through their boundary-spanning capabilities (Hong 2010) or through their ability to increase collaboration effectiveness (Di Marco et al 2010). It is not known to what extent (or if at all) cultural boundary spanners impact the actual performance of global project networks. In this manuscript we examine how cultural boundary spanners impact collaborative performance by spanning national cultural boundaries and linguistic barriers that can challenge global engineering project network collaborations.

RESEARCH METHODOLOGY

Hypotheses

We chose to test the extent to which cultural boundary spanners impact performance by adopting an experimental design by Çomu and colleagues (*in press*). That study examined the dual impact of cultural and linguistic differences on project network performance and found that, on average, multi-cultural networks experienced worse initial performance; however, their adaptation performance over five successive projects outperformed that of mono-cultural networks. The multi-cultural networks were able to overcome these boundaries enabling those networks on average to surpass the mono-cultural networks in terms of project performance by the fourth project. In our research, we replicated their experiment to compare the initial and adaptation performance to a new set of multi-cultural project networks that included a cultural boundary spanner. We measured performance in this study as the time required to execute and successfully complete a project, evaluating each network over a period of five consecutive projects.

Global project networks with a cultural boundary spanner may be able to achieve the initial performance advantages of working in a mono-cultural network, while maintaining the adaptation performance benefits of working in multi-cultural networks. Multi-cultural settings have been shown to improve creativity and problem solving ability, resulting in a more comprehensive approach to engineering challenges (Ozorhon et al. 2008). We postulate that the mediating role of the cultural boundary spanner will enable global project networks to potentially overcome the initial performance liabilities of working across cultural and linguistic boundaries. Moreover, we postulate that a strong adaptation performance will also be achieved by multi-cultural project networks with a cultural boundary spanner. To examine these conjectures we tested the following hypotheses:

Hypothesis 1 a): Including a cultural boundary spanner in multi-cultural project networks will result in better initial performance than multi-cultural networks without a cultural boundary spanner.

Hypothesis 1 b): Including a cultural boundary spanner in multi-cultural project networks will result in statistically indistinct initial performance compared to mono-cultural networks.

Hypothesis 2 a): Including a cultural boundary spanner in multi-cultural project networks will result in better adaptation performance than multi-cultural project networks without a cultural boundary spanner.

Hypothesis 2 b): Including a cultural boundary spanner in multi-cultural project networks will result in better adaptation performance than mono-cultural project networks.

As many researchers have observed, conflicts may arise between diverse cultural and linguistic members in a team (Chan & Tse 2003, Levina & Vaast 2008), which in turn can negatively impact performance, leading to a poor initial performance (Çomu et al. *in press*) or low project quality (Bryant 2006). In contrast, appointing a boundary spanner within a nationally diverse team has been observed to create improved group identity with increased frequency of intra-team contact within healthcare organizations (Richter et al. 2006). Di Marco and colleagues (2010) demonstrated that in an engineering context, cross boundary difficulties were alleviated by cultural boundary spanners due to their potential to improve collaboration effectiveness. We anticipate that when cultural boundary spanners participate in global networks, they will intervene to resolve the conflicts that arise and develop between culturally distinct members. If we can demonstrate through Hypothesis 1b that the presence of a cultural boundary spanner in a multi-cultural network enables those networks to approach the initial performance of mono-cultural networks, then it is useful to understand the communications that occur over successive projects. On the first project interaction, we anticipate that the cultural boundary spanner will mediate most communications, resolving cultural and linguistic conflicts that emerge. However, over successive projects, we anticipate that a shared understanding will develop requiring less communications by the cultural boundary spanner. This would align with Di Marco and colleagues' finding that the centrality of a cultural boundary spanner dissipates after initial conflicts are resolved. That finding was related to collaboration effectiveness and did not examine whether such communication patterns correlated with performance. By collecting the frequency of interactions occurring between members of cultural boundary spanned project networks, we will test the following hypotheses:

Hypothesis 3 a): Cultural boundary spanners communicate more frequently than non-cultural boundary spanners in initial global project network collaboration.

Hypothesis 3 b): The frequency of cultural boundary spanner communications relative to non-cultural boundary spanners decreases with successive global project network collaborations.

Experimental Design

We replicated the experimental procedures in a study conducted by Çomu and colleagues (*in press*) for mono-cultural and multi-cultural project networks; however we included a cultural boundary spanner in the multi-cultural networks. Only by strictly adhering to the same procedures could we directly compare and contrast the measured performance results for cultural boundary spanned networks to those previously collected for multi-cultural and mono-cultural networks. To examine the initial and adaptation performance in global engineering project networks, a set of independent and interdependent tasks were developed. The overarching scenario of the experiment was modeled on the design and construction process of an engineering project. To emulate this process, we required the participation of three distinct roles in every project network. These included: an architect, an engineer and a contractor. The objective of each project was thus to design, specify and build a model of a building. Each assembled project network was comprised of all three roles, and together they were required to complete up to five successive projects, of a similar nature. By having only one representative for each role in the simulated project networks, there is a possibility the assembled networks would adopt a team structure. However, the following features of the simulated project networks were included in the formulation of the experimental tasks and the participant interactions to address this possibility (Çomu et al. *in press*):

- Each individual role had its own distinct and independent set of tasks which it necessarily completed separately from the other individuals in the network.
- Each role had a portion of its task dependent on the output of another role. For example, the engineer needed to get the design from the architect to develop the specifications and the contractor needed both the design and specifications to assemble the model. In the rework phase, the architect depended on the contractor if there were insufficient materials to construct the original design.
- The participants conveyed only the necessary information (i.e., the graph paper with the design and specifications).
- The participants were spatially separated from each other at three different tables in the same room to ensure each role did not collaborate on the independent tasks but that they could still communicate.
- The time required to complete the five successive projects was a maximum of 90 minutes leaving insufficient time for a team to complete its formative stage or move on to other later stages of team formation.

At the start of each experiment, a brief presentation was delivered to all three participating roles, providing instructions and an explanation of the general procedure of the experiments. During the presentation researchers encouraged communication in any language, suggesting that this was important to their success as a network because only through interactions would they overcome the challenges of the various projects. The first project began when the architect was given an envelope that included a sheet of graph paper and a list of design requirements. These included the number of interior and exterior walls, doors and windows, as well as the orientation of a building to be designed. The architect had to then draft a plan and elevation views of the building described. Once this first task was complete, the design schematic was passed to the engineer who in turn specified the dimensions and types of materials to be used for the building. This was based upon a set of hypothetical building code requirements provided to the engineer. The building code remained unchanged throughout the successive projects. Once the building layout was adjusted to the required specifications, the graph paper was then given to the contractor whose task was to build the model to the design and specifications provided. This was accomplished with a limited number of Lego® blocks provided. We observed and noted the communications of all three network participants. Once the building was complete, the constructed model was inspected by the research team to ensure it conformed to the required design and specifications. If errors were found, a punch list was prepared and the project network was tasked with adjusting the design, specifications and the model. This rework time was included in the total time required to complete each project.

Once the first project was complete, the network participants moved on to the second project, and then the third and so on until up to five projects were completed. A limited 90 minute period was set to complete the five projects. In order to compare the results of the cultural boundary spanned project networks with those collected by Çomu and colleagues (*in press*) a total of thirty participants were recruited to populate ten project networks. To maintain consistency across the 10 cultural boundary spanned project networks, in all cases the cultural boundary spanner (CBS) held the role of architect, the international participant (INT) held the role of the engineer, and the American citizen (US) held the role of the contractor. As in Çomu and colleagues' study, our research design included only participants recruited from the Columbia University student body studying at either the undergraduate or graduate level. All the U.S. citizen participants were native English speakers. The international student participants recruited were required to have been in the United States for less than three years. Finally, the cultural boundary spanner participants recruited were required to have been born in a foreign country, to have lived in the U.S. for at least 5 years, to have received either their high school diploma or an undergraduate degree in the U.S. and to have strong command of both English and their native language to be eligible to participate in the experiments. The INT participants had to share the same nationality and maternal language as the recruited CBS participants. This experimental design consideration was critical in order to ensure that the CBS was capable of spanning cultural and linguistic differences. Each of the ten project networks examined involved a different country for the nationality of the CBS and INT participants to remove any bias that may have been produced by focusing on one or a small number of countries (e.g., due to similarities in language or other factors). The backgrounds of the participants were not taken into account since the assigned tasks were sufficiently general that they didn't require specialized knowledge.

The data sample size of this research therefore consisted of approximately 50 projects, each with an associated initial and adaptation performance value, which allows for comparison between project performance values and similarly sized data sets for mono-cultural and multi-cultural project networks. The cultural boundary spanned networks were encouraged to communicate in whichever language they were most comfortable with; in our case, either English or the maternal language common to the CBS and INT. Table 3 below summarizes the national origin of each participant in all thirty of the project networks.

Table 3: Project Network Experimental Design

Project Networks								
Cultural Boundary Spanned Multi-Cultural			***Multi-Cultural***			***Mono-Cultural***		
Network #1	CBS	Turkish	***Network #11***	*INT*	*Turkish*	***Network #21***	*US*	*American*
	INT	Turkish		*INT*	*Chinese*		*US*	*American*
	US	American		*INT*	*Indian*		*US*	*American*
Network #2	CBS	French	***Network #12***	*INT*	*Greek*	***Network #22***	*US*	*American*
	INT	French		*INT*	*Colombian*		*US*	*American*
	US	American		*INT*	*Turkish*		*US*	*American*
Network #3	CBS	Korean	***Network #13***	*INT*	*Chinese*	***Network #23***	*US*	*American*
	INT	Korean		*INT*	*Israeli*		*US*	*American*
	US	American		*INT*	*Nigerian*		*US*	*American*
Network #4	CBS	Taiwanese	***Network #14***	*INT*	*Vietnamese*	***Network #24***	*US*	*American*
	INT	Taiwanese		*INT*	*Chinese*		*US*	*American*
	US	American		*INT*	*Indian*		*US*	*American*
Network #5	CBS	Chinese	***Network #15***	*INT*	*Turkish*	***Network #25***	*US*	*American*
	INT	Chinese		*INT*	*Chinese*		*US*	*American*
	US	American		*INT*	*Kazak*		*US*	*American*
Network #6	CBS	Indian	***Network #16***	*INT*	*Indian*	***Network #26***	*US*	*American*
	INT	Indian		*INT*	*French*		*US*	*American*
	US	American		*INT*	*Chinese*		*US*	*American*
Network #7	CBS	Greek	***Network #17***	*INT*	*Chinese*	***Network #27***	*US*	*American*
	INT	Greek		*INT*	*Thai*		*US*	*American*
	US	American		*INT*	*Korean*		*US*	*American*
Network #8	CBS	Nigerian	***Network #18***	*INT*	*Chinese*	***Network #28***	*US*	*American*
	INT	Nigerian		*INT*	*Indian*		*US*	*American*
	US	American		*INT*	*Taiwanese*		*US*	*American*
Network #9	CBS	Venezuelan	***Network #19***	*INT*	*Bulgarian*	***Network #29***	*US*	*American*
	INT	Venezuelan		*INT*	*Chinese*		*US*	*American*
	US	American		*INT*	*Cypriot*		*US*	*American*
Network #10	CBS	Russian	***Network #20***	*INT*	*Russian*	***Network #30***	*US*	*American*
	INT	Russian		*INT*	*Indian*		*US*	*American*
	US	American		*INT*	*Chinese*		*US*	*American*

Note: Italicized data entries are sourced from Çomu et al. (*in press*)

Data Collection

Each network was required to complete up to five successive projects. The participants were instructed that their performance depended on how quickly they could design, specify and build each project to conform to the required standards. To measure their performance quantitatively, each network's performance was assessed by measuring the time taken to complete each of the five successive projects. Additionally, data on the number of communications by each participant on each project was collected. Throughout the projects, a standard procedure was used to collect the data. The results were then used to compare the performance of the cultural boundary spanned networks to that of mono-cultural and non-cultural boundary spanned multi-cultural networks. In order to minimize the potential impact of external factors on individual network performance, a controlled experimental environment was utilized for all experiments which was also identical to the environment utilized by Çomu et al. (*in press*).

FINDINGS

The project performance results of the three network study groups—cultural boundary spanned multi-cultural, mono-cultural and multi-cultural project networks—are presented in Table 4. It is important to note that not all of the project networks were able to complete all five of the successive projects. The asterisks on the right of some of the project performance values represent the networks that were unable to complete all five projects. Those data are projected using a fitted regression. The missing performance results were predicted through fitting a learning curve to the collected data points. Wright (1936) empirically derived a straight-line logarithmic model for learning curves and we utilized this method in our research to project any missing values. The model in equation 1.1 assumes that the learning improvement rate follows a straight line in a logarithmic scale as described in equation 1.2.

$$y_a = x \cdot a^n \qquad (1.1)$$

$$\log (y_a) = n \log (a) + \log (x) \qquad (1.2)$$

Where;

y_a = the duration of the a^{th} project

x = the duration of the first project

$n = \log_2 LR$

LR = learning rate

Table 4: Project Network Performance Durations (in seconds)

Network Type	Network #	Project #1	Project #2	Project #3	Project #4	Project #5
Cultural Boundary Spanned Multi-Cultural Project Networks	Network #1	1,341	785	596	603	452
	Network #2	1,658	975	643	625	482
	Network #3	1,575	1,409	905	410	330*
	Network #4	1,203	787	720	646	491
	Network #5	1,678	1,006	563	356	337
	Network #6	1,616	699	490	443	364
	Network #7	1,523	726	453	296	270
	Network #8	1,572	1,250	823	608	523*
	Network #9	1,130	697	487	360	251
	Network #10	1,516	1,055	783	524	442*
	Average	**1,481**	**939**	**646**	**487**	**394**
Multi-Cultural Project Networks	*Network #11*	*2,523*	*740*	*399*	*362*	*219**
	Network #12	*1,911*	*956*	*746*	*407*	*369**
	Network #13	*1,984*	*1,196*	*1,091*	*880**	*776**
	Network #14	*2,598*	*1,071*	*557*	*387**	*284**
	Network #15	*2,136*	*807*	*619*	*694*	*457**
	Network #16	*2,029*	*1,129*	*988*	*770**	*662**
	Network #17	*1,915*	*1,062*	*545*	*378*	*307**
	Network #18	*2,693*	*1,155*	*826*	*579**	*454**
	Network #19	*2,881*	*900*	*530*	*326**	*230**
	Network #20	*1,515*	*754*	*542*	*392*	*255*
	Average	***2,219***	***977***	***684***	***518***	***401***
Mono-Cultural Project Networks	*Network #21*	*1,472*	*944*	*543*	*456*	*487*
	Network #22	*1,346*	*448*	*391*	*324*	*380*
	Network #23	*1,665*	*929*	*593*	*375*	*326**
	Network #24	*1,514*	*1,104*	*911*	*1,144*	*925**
	Network #25	*1,981*	*987*	*657*	*614*	*458**
	Network #26	*948*	*338*	*204*	*225*	*179*
	Network #27	*860*	*762*	*612*	*562*	*555*
	Network #28	*1,395*	*1,816*	*408*	*323*	*293**
	Network #29	*1,933*	*1,077*	*712*	*913*	*644**
	Network #30	*1,129*	*502*	*349*	*310*	*277*
	Average	***1,424***	***891***	***538***	***525***	***452***

Note: Italicized data entries are sourced from Çomu et al. (*in press*)

*Projected Results

The learning rates for each of the ten networks in the experiment were calculated from the equations (1.1) and (1.2) above. The projected values were derived from the data collected from each project network. They do not impact the adaptation performance calculated for each project network. To the contrary, these projected data points are calculated from the adaptation performance (or learning rate) for each project network. This prevents the extrapolated data of the incomplete projects from having any bearing on the adaptation performance allowing for inferences to be made regarding the average learning rate (adaptation performance) across the project networks studied.

Hypotheses 1a and 1b: Initial Performance of Cultural Boundary Spanned Project Networks

Previous research from Levina and Vaast (2008) as well as Di Marco and colleagues (2010) suggests that cultural boundary spanned networks might initially outperform multi-cultural project networks due to improvements in collaboration effectiveness. But they did not measure the performance improvements this may have enabled and they did not consider how initial performance might compare to that of mono-cultural project networks. From Table 2 above, we observe that in the first project, the cultural boundary spanned networks were able to outperform the multicultural networks on average. The average initial performance of the cultural boundary spanned project networks was 33% faster (i.e. the less time taken to complete a project the better the initial performance of the networks) from that of the multi-cultural networks. Also, the average cultural boundary spanned network performance was within 4% of that of the mono-cultural networks. This result is supported by a t-test. When comparing the multi-cultural and the cultural boundary spanned multi-cultural project networks, we found them to be statistically distinct with a *p* value of 0.0029 which is well below the significant level of 0.05 [Hypothesis 1a supported]. When comparing the initial performance results for the mono-cultural (U.S. only) and cultural boundary spanned (CBS) multi-cultural networks, we found the initial performance between these two groups to be statistically indistinct with a *p* value of 0.71, far greater than the 0.05 value required for the two samples to be distinct [Hypothesis 1b supported].

Hypotheses 2a and 2b: Adaptation Performance of Cultural Boundary Spanned Project Network

Based on the regression techniques used to predict the unknown data entries, we were able to logically estimate the average adaptation performance (expected learning rate) of each project network, as they worked successively through up to five building projects. The adaptation performance, or *learning rate,* of all cultural boundary spanned multicultural project networks are presented in Table 5, along with the adaptation performance results for the previously examined mono-cultural and multi-cultural networks. The results demonstrate that, on average, adaptation performance of cultural boundary spanned networks is 0.57, which is approximately 20% higher than that of multi-cultural networks, but about 3% lower than that of mono-cultural networks. Given the improved initial performance of the cultural boundary spanned networks, we would expect the learning rate of the multi-cultural networks be greater as there is more opportunity for enhanced performance over time. The r-squared values are the measures of association for determining how well the actual data of performance is predicted through the learning rate function. The r-squared values for each of the adaptation performance results for Networks #1 through #10 can be found in Table 5 below. The values range from 0.83 to 0.99, with an average of 0.95. This represents an accurate estimation for predicting the actual learning rate of the cultural boundary spanned project networks. We again conduct a t-test to statistically compare the adaptation performances of the project networks. Comparing multi-cultural and mono-cultural project networks with cultural boundary spanned project networks resulted in *p* values greater than 0.05, therefore we reject Hypotheses 2a and 2b.

Table 5: Project Network Adaptation Performance

Network Type	Network #	Adaptation Performance	R^2	Average Adaptation Performance	Average R^2
Cultural Boundary Spanned Multi-Cultural Project Networks	Network #1	0.65	0.96	**0.57**	**0.95**
	Network #2	0.59	0.98		
	Network #3	0.50	0.83		
	Network #4	0.71	0.95		
	Network #5	0.48	0.97		
	Network #6	0.53	0.97		
	Network #7	0.46	0.99		
	Network #8	0.61	0.95		
	Network #9	0.54	0.98		
	Network #10	0.59	0.96		
Multi-Cultural Project Networks	*Network #11*	*0.36*	*0.97*	***0.48***	***0.96***
	Network #12	*0.49*	*0.96*		
	Network #13	*0.68*	*0.95*		
	Network #14	*0.38*	*1.00*		
	Network #15	*0.55*	*0.82*		
	Network #16	*0.63*	*0.96*		
	Network #17	*0.44*	*0.98*		
	Network #18	*0.47*	*0.99*		
	Network #19	*0.34*	*1.00*		
	Network #20	*0.48*	*0.98*		
Mono-Cultural Project Networks	*Network #21*	*0.59*	*0.94*	***0.59***	***0.86***
	Network #22	*0.57*	*0.82*		
	Network #23	*0.48*	*0.98*		
	Network #24	*0.83*	*0.58*		
	Network #25	*0.54*	*0.98*		
	Network #26	*0.49*	*0.92*		
	Network #27	*0.81*	*0.95*		
	Network #28	*0.45*	*0.66*		
	Network #29	*0.64*	*0.81*		
	Network #30	*0.54*	*0.97*		

Note: Italicized data entries are sourced from Çomu et al. (*in press*)

Hypothesis 3a and 3b: Cultural Boundary Spanner Frequency of Communications

We anticipated cultural boundary spanners would carry out a significant role in the initial stages of collaboration intervening to resolve conflicts encountered across the cultural and linguistic boundary within the global project network. We hypothesized they would communicate more frequently as they mediated communications between the international participant and the U.S. participant in their project network. During each of the five projects we observed and recorded the communications of the three members of the network. The average of observed communications across the 10 project networks was calculated for each project. The average frequency of communications for each of the network members decreased over the five successive projects. The average frequency of observed communications was far greater in the initial project at 137 average communications. In the ensuing four projects average observed communications reduced to 55 in the second project, 28 in the third, 17 in the fourth and only 8 communications on average in the fifth project.

To examine hypotheses 3a and 3b, we plotted the average number of observed cultural boundary spanner (CBS) and non-cultural boundary spanner (Non-CBS) communications over each of the five projects in the experiment (please refer to Figure 5). In the first project, there is significantly more communications involving the CBS, than the Non-CBS participants. A t-test comparing the two sample means for all ten of the cultural boundary spanned networks for the first project also showed that the CBS and Non-CBS communication frequency are statistically distinct sets of data ($p<0.001$). The average number of communications by the CBS was 108 in the first project, while the average number of communications by the non-CBS participants was 29. Based on this difference and the strength of the t-test result for these two samples, we find strong support for Hypothesis 3a.

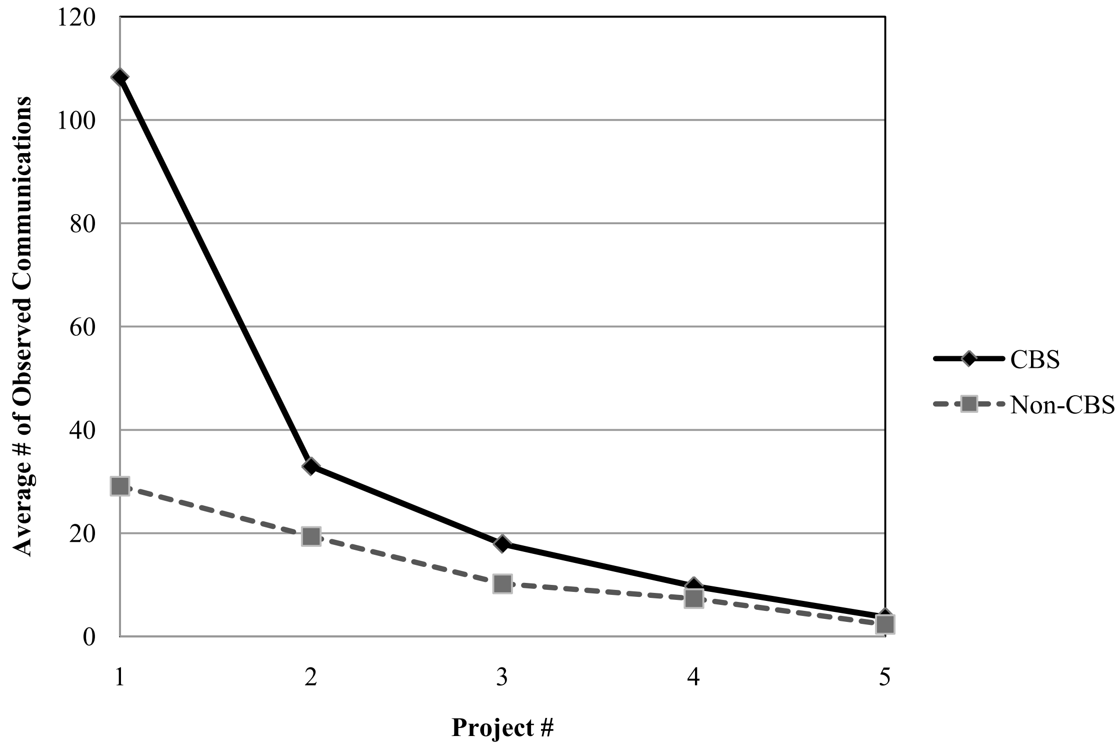

Figure 5: Average Number of Observed Communications per Project Involving Cultural Boundary Spanners & Non-Cultural Boundary Spanners

Over time across successive projects, the variance of communication frequency between CBS and non-CBS participants narrowed. In fact, by the second project the *p* value in the t-test comparing CBS and non-CBS samples increased to nearly 0.2. In the remaining projects the *p* value increased up to a value of 0.5. The average number of observed communications for both the CBS and Non-CBS participants converged to approximately the same point by the fifth project. Since the variance in the frequency of communications decreased to non-significant levels by the second project and continued to decrease, Hypothesis 3b is supported.

DISCUSSION

In this paper we investigated the impact of cultural boundary spanners on performance in culturally and linguistically diverse project networks. Statistical analysis of our results revealed that a participating CBS within global project networks can significantly improve initial network performance when compared to multi-cultural networks without cultural boundary spanners ($p < 0.05$). The t-test for paired two sample means also demonstrated that CBS networks, at the initial stages of collaboration, are statistically indistinct from mono-cultural project networks in terms of performance. In other words, cultural boundary spanned multi-cultural project networks in this study performed as well on the first project as the mono-cultural networks. This is in stark contrast to the findings of Çomu and colleagues (*in press*) in which the average time to complete the first project took the multi-cultural networks over 50% longer than the mono-cultural networks. The cultural boundary spanned networks performed as well as the mono-cultural networks initially while still outperforming the mono-cultural networks by the fourth project.

Including cultural boundary spanners in a global project network may negate the performance liabilities created by the challenges of working in culturally and linguistically diverse environments. Much of the extant literature on cross-cultural collaborations suggests that researchers focus on the barriers and conflicts associated with cultural differences (Hinds & Bailey 2003, Mahalingam & Levitt 2007, Levina & Vaast 2008) as opposed to the business opportunities. Firms involved in global project networks may be able to benefit from cultural diversity. By the fourth project in this empirical study the culturally and linguistically diverse networks began to outperform mono-cultural networks on average. Our research suggests it may be possible to achieve mono-cultural network initial performance levels and still outperform mono-cultural networks within several projects by implementing a cultural boundary spanner in a multi-cultural network. The AEC industry is globalizing with increasing competition by international firms domestically, expansion of domestic firms into international markets, and offshore outsourcing collaborations where both firms remain in their respective countries. In all of these cases, a global project network of firms must identify ways to achieve strong performance to remain competitive. The inclusion of a cultural boundary spanner, particularly in initial global project collaborations, may significantly enhance global project performance.

We also compared the adaptation performance of mono-cultural and multi-cultural networks with that of the cultural boundary spanned networks. The experimental results showed that the adaptation performance for multi-cultural networks with cultural boundary spanners was worse than multi-cultural networks without cultural boundary spanners and approximately equivalent to the learning rate of mono-cultural networks. We can observe these results in Figure 6 which contains a graph of the average adaptation performance (learning curves) of all three network study groups. The cultural boundary spanned networks began to outperform the mono-cultural networks between the third and fourth projects; at approximately the same time the multi-cultural project networks began to outperform the mono-cultural networks in the Çomu and colleagues study (*in press*). The faster adaptation performance of the multi-cultural project networks compared to the cultural boundary spanned and mono-cultural networks is somewhat expected given their need to overcome the challenges that led to the poor initial performance. We applied a statistical t-test analysis to ascertain whether the adaptation performances were statistically distinct between the study groups. Although there was an observable difference in the adaptation performance of cultural boundary spanned and non-cultural boundary spanned project networks (p = 0.15), the t-test results did not support Hypotheses 2a or 2b. Further research is needed to examine and verify whether a significant difference exists between adaptation performance and the type of network.

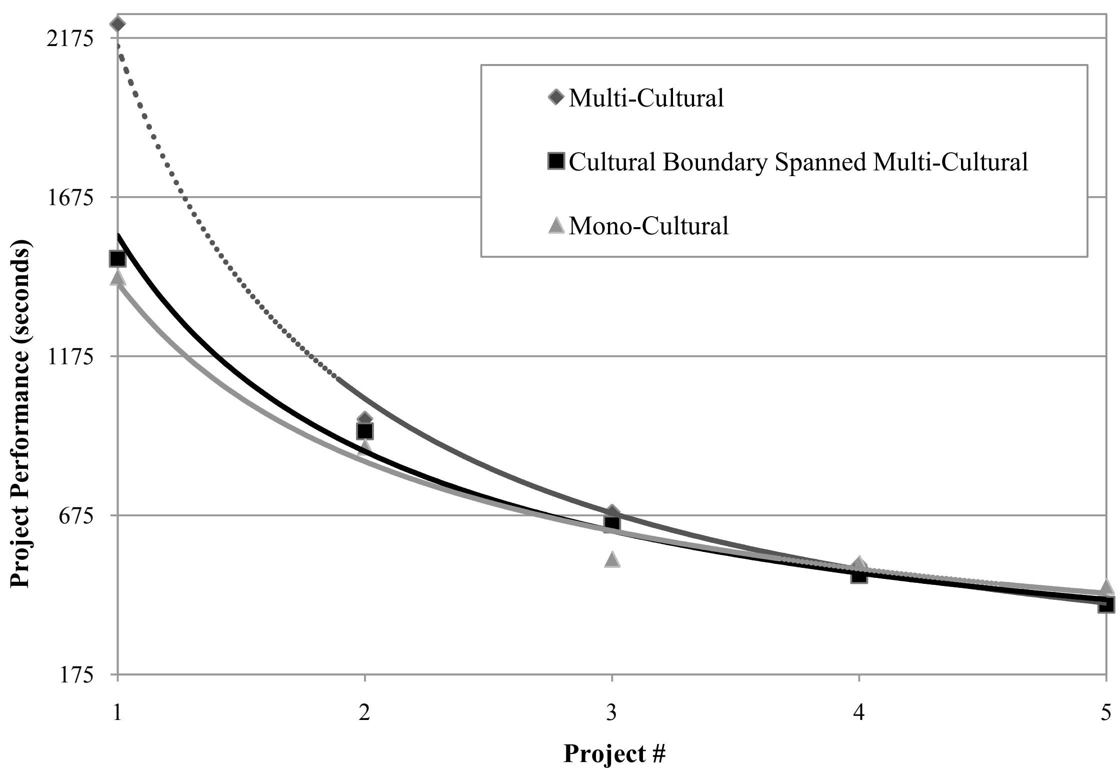

Figure 6: Average Performance of Multi-Cultural, Cultural Boundary Spanned Multi-Cultural, and Mono-Cultural Project Networks

We also found that during the initial stages of collaboration (particularly during the first project) the CBS communication frequency was significantly greater than the non-CBS communications. Yet, this greater frequency of CBS communications decayed quickly. Both Hypothesis 3a and 3b were supported. Analysis of the observed communications revealed a significant difference in the average communication frequency of the network members in the first project. Although the variance in the frequency of communications dissipated over the course of the five projects, the results show that the CBS played a boundary spanning role which was a critical factor in initiating and facilitating communication between the INT and the US members. We posit that this boundary spanning effort by the CBS enabled this multi-cultural project network to achieve the initial performance level of a mono-cultural project network. This finding is interesting considering the two network types have different characteristics and belong to different cultural, social and economic backgrounds which make their coordinated project efforts and motivation quite different. In order to increase the likelihood that performance objectives are attained, fostering communications by the individuals that span cultural boundaries may provide an effective mechanism to engender knowledge transfer, mutual understanding and, ultimately, improved performance.

By utilizing cultural boundary spanners in a global project network at the initial stages of collaboration, the benefits are two-fold. The skills of the cultural boundary spanner can be employed to mitigate the cultural and linguistic boundaries at the initial stages of collaboration. And overcoming these initial collaboration barriers and increasing the overall performance of the networks may allow for a higher probability of innovation and creative problem solving over successive projects. Research has shown that multinational diversity in organizations can lead to an increase in innovativeness (Miller, Fields, Kumar, & Ortiz 2000, Page 2007); however this capability is seldom reached due the cultural and linguistic conflicts resulting in short-lived collaboration attempts. Global networks given the opportunity to work together over successive projects may release the potential for creating new knowledge and innovation. Hence, the capability of cultural boundary spanners can be leveraged within global project networks in order to make learning and knowledge transfer across contexts less arduous, and may facilitate innovation in global project networks. In our experiments, this may have been the factor that enabled the culturally and linguistically diverse project networks with and without a cultural boundary spanner to outperform mono-cultural networks by the fourth project.

Notwithstanding the findings of our research and the potential impact of cultural boundary spanners to impact innovativeness, researchers have shown that cultural boundary spanners do not necessarily emerge to span cultural boundaries (Levina & Kane 2009). Cultural considerations, lack of effective communication skills and intercultural competency are factors that may impact the degree to which cultural boundary spanners are effective in global projects. Managers, especially expatriates who have no knowledge of their collaborative counterparts' background, may be viewed as dictatorial figures that are indisputable and are viewed to have all the answers and solutions by members of the project network which can be a barrier to collaboration effectiveness (Yates 1989, Levina & Kane 2009). The Levina and Kane findings also suggest that managers can potentially possess ethnocentric attitudes towards the local counterparts which may cause conflict, strained relationships and most of all the inability to cross salient national cultural boundaries. Perhaps by empowering and training these individuals as cultural boundary spanners and placing them in cultural boundary spanning roles with the purpose of fostering communication and improving collaboration, the effectiveness of such expatriates can improve and their knowledge of the various cultures represented on the global project be exploited. We need further research to identify the specific cultural boundary spanning skills to ensure effective participation of the CBS. These competencies may include adequate linguistic knowledge, awareness and sensitivity to cultural differences, and understanding local customs and norms. Developing such skills and exploiting the role of cultural boundary spanners in global project networks may enable projects to more predictably achieve project objectives in initial collaborations. Approximately 40% of international joint ventures have been shown by researchers to perform poorly (Beamish & Delios 1997), thus finding ways to develop and exploit cultural boundary spanners may represent a critical competence for firms and networks of firms executing global projects to achieve.

IMPLICATIONS

Global collaborations may fail to meet project objectives due to miscommunication and inefficient project delivery (Bryant 2006). A survey of construction industry respondents in 2004 found that while the majority of firms (48%) aimed to reduce their engineering costs by more than 10% by offshore outsourcing portions of engineering design to low-cost nations, very few firms (2%) expected an overall project delivery time decrease of more than 10% due to outsourcing this work (NAE 2008). An article in CIO magazine aimed at uncovering the secret costs of outsourcing indicated that the transition cost—the initial cost of collaboration—of sending work overseas is often times the largest impediment to productivity (Overby 2003). The significance of our findings to these statistics is that cultural boundary spanners may be a catalyst for the initial transition periods in a cross-cultural venture and eliminate the 'hidden cost' associated with both the transition period and the cultural and linguistic differences. Researchers have identified the need for firms to develop refined cultural intelligence mechanisms that have managerial, competitive and structural implications in order to collaborate with their culturally distinct colleagues effectively (Ang & Inkpen 2008). This research suggests that a critical capability in working in global project networks is to identify team members who naturally possess a high degree of cultural intelligence to utilize these members to improve global project network performance. We postulate that cultural boundary spanners may answer the call for cultural intelligence at the critical intersection between cultures on global AEC projects.

In global project networks, the wide range of players involved include: executives, managers, project leaders and members of the multi-cultural project network. Some work locally, others travel as expatriates to their collaborator's location. All are involved in the challenge of achieving high performance objectives and collaborating effectively in a culturally diverse global network. In addition to the technical, managerial, leadership and interpersonal skills required for successful project execution in the AEC industry, training in cultural boundary spanning may be needed to develop and exploit cross-cultural competences. This includes both knowledge about other cultures and the ability to capture the potential benefits that arise out of cultural differences. Even untrained individuals placed into project networks with critical cross-cultural boundary spanning knowledge were able to significantly impact performance of multicultural networks in this idealized experiment. Training may be necessary to capture similar performance benefits in an industrial setting.

CONTRIBUTIONS, LIMITATIONS AND FUTURE RESEARCH

We demonstrated how including a cultural boundary spanner in global project networks can significantly improve the initial performance while maintaining the adaptation performance of a project network. These performance implications should raise awareness in AEC firms and help them to understand the benefits of introducing a cultural boundary spanner into their network, particularly in the early stages of collaboration. This extends earlier research focused on collaboration effectiveness (Levina & Vaast 2008, Di Marco et al. 2010) by empirically measuring and comparing the performance impact of cultural boundary spanners to mono-cultural and non-cultural boundary spanned multicultural networks as control groups (Çomu et al. *in press*). Cultural boundary spanners facilitate the bridging of cultural and linguistic differences from the beginning of a cross-cultural collaboration and provide a common ground for mutual understanding to be established between diverse team members. As a result, we expect cultural boundary spanned project networks to not only perform better, but to also take better advantage of the diverse set of skills and understandings provided by the culturally diverse participants. This can ultimately prepare the foundation for sustained and effective collaboration.

Although the research we conducted has valuable practical implications for AEC firms and networks of firms, the limitations must also be noted. An important limitation of this study relates to the fact that the participants being examined were students and were guaranteed monetary compensation irrespective of their overall performance. Quite possibly, with some form of professional recognition associated with the tasks carried out, we might have observed different results had the experiment been performed with industry practitioners working on actual global engineering or construction projects. Furthermore, even though we are testing the capabilities of a cultural boundary spanner to span cultural boundaries in order to improve performance; the number of cultural boundaries being spanned between the cultural boundary spanned networks (two boundaries) and the multi-cultural project networks (three cultural boundaries is not consistent. Yet this would also introduce other causal factors and, hence, we believe that the ability to control the various factors influencing performance in the experimental environment outweighed the benefits which may have been gained by conducting a natural experiment in the field of nearly identical projects with nearly identical team sizing and other variables which would certainly have impacted performance. Future research should examine other project network compositions. For example, the inclusion of cosmopolitans that do not share a cultural or linguistic background with the international participant but who have lived in multiple countries and speak multiple languages (Haas 2006) may have a positive impact on performance even without specific experience working in the countries of the partner organizations. Future research should examine how cosmopolitans and other emerging roles in global project networks can impact performance. Another important limitation to consider is that global project networks, the individual participants of those networks, and their relevant network organizations are influenced by different types of culture such as organizational culture, project culture, and national culture. Research has demonstrated that organizational culture is an important predictor of performance (Ozorhon et al. 2008, Ozorhon et al. 2010). Future research may also explore how types of culture other than national culture impact performance and how varying combinations of organizational, project and national culture impact performance.

Chapter 4

NEGOTIATING THROUGH BOUNDARY OBJECTS IN GLOBAL DESIGN PROJECT NETWORKS[3]

ABSTRACT

Technological boundary-spanning tools have been shown to create, co-create and share knowledge in the architecture, engineering and construction (AEC) industry in the form of boundary objects. Global project networks of firms often use models that function as boundary objects for collaboration across the geographic, time and cultural distances that separate them. Past research has shown that boundary objects are effective at the interface between individuals and organizations, but little is known about the role these objects play towards negotiation outcomes in global project networks. In this manuscript we explore the role of boundary objects in negotiating complex design knowledge across national and organizational boundaries. We observed a three day series of design review meetings involving U.S. and Indian engineering firms. We applied network analysis to empirically observe the salient role boundary objects play towards negotiation outcomes. We also conducted a qualitative analysis of each negotiation in order to link the negotiation processes with negotiation outcomes. We found that boundary objects play a critical yet complex role in establishing mutual understanding and resolving conflicts

[3] This paper is co-authored with Professor John E. Taylor and Pauli Alin.

across boundaries. These findings have important implications for firms collaborating across organizational and national boundaries in global project networks.

INTRODUCTION

As engineering firms become increasingly multinational, the projects they execute are accomplished by a workforce increasingly diverse in terms of cultures, languages, norms and standards. Research has shown that networks of firms collaborating in a global context experience geographical, temporal and cultural boundaries and that these boundaries often lead to conflicts that can hinder successful collaboration (Chan and Tse 2003; Hinds and Mortensen 2005). In short, the era of global projects is quickly changing the way project networks are managed (Kini 2000; Bryant 2006; Anantatmula and Thomas 2010). Following the shift toward more globally dispersed engineering services operations; researchers have also shifted their focus from intra-firm to inter-firm collaboration in engineering services. Researchers have argued that inter-firm collaboration occurs in heterogeneous project networks where knowledge and expertise are dispersed (Boland, Lyytinen, and Yoo 2007; Taylor and Levitt 2007).

An integral part of coordinating work in distributed global engineering services project networks is the decision making process. The decision making process involves: schedule, scope and budget maintenance; quality control; and project network integration. While some researchers have identified the significance of formalized decision making processes within distributed teams (Bourgault et al 2008) others have highlighted that when knowledge and expertise are dispersed, knowledge must be negotiated for successful project network coordination (Adair 2008; Okhuysen and Bechky 2009).

Negotiation refers to “a discussion between parties in order to reach an agreement” (Carnevale and Pruitt 1992:532). Hofstede (1991) observed and identified the consequences of diversified national differences in the workplace; where further research identified that successfully executing impartial negotiations within cross-cultural construction projects can be a complex and intricate process (Pheng and Leong 2000). If successful, negotiations lead to common knowledge that enables communication between actors (Carlile 2004).

To assist network participants in negotiations, project networks often adopt advanced engineering systems and technologies, such as shared databases and other interorganizational systems. These technologies can play a significant role in project networks, as they enable the creation of intermediate objects that enable network participants to negotiate differences across boundaries (Boland, Lyytinen, and Yoo 2007; Carlile 2002). For example, in the architecture, engineering and construction (AEC) industries building information modeling (BIM) tools are often used to share design modeling work in and across firms in AEC project networks. The models developed by these tools become boundary objects that connect the disparate work of the project network participants. Previous research has shown how such boundary objects can assist the project network participants to achieve common knowledge in negotiating complex engineering project contracts across boundaries (Koskinen and Makinen 2009). However. little research has examined whether boundary objects can facilitate the emergence of common knowledge when complex design knowledge is negotiated. Moreover, little is known about the potential role of boundary objects in negotiation outcomes in the increasingly common global engineering services project networks where national cultural boundaries are crossed. The aim of this paper is to empirically observe the role of boundary objects in negotiating knowledge across boundaries within global project networks.

NEGOTIATING IN GLOBAL PROJECT NETWORKS

In parallel with the globalization of the business environment and the emergence of multinational organizations, national cultural considerations in negotiations have become an important focal area for researchers. National culture may negatively affect negotiation style (George et al. 1998) which in turn can negatively impact negotiation outcomes in global engineering services project networks. Researchers have predicted that cultural differences in negotiation will likely become more significant with the increase in multicultural and interrelated environments (Carnevale and Pruitt, 1992), which is the situation in global engineering services project execution. More recently, Pheng and Leong (2000) examined international construction projects and identified that negotiation challenges are more prevalent when cultural differences exist. Furthermore, in distributed global project environments, if the project parameters are unsuccessfully negotiated, clients may develop unrealistic expectations resulting in unsatisfactory project results (Javed et al 2006). Research has also shown how outcomes in global project negotiations can have suboptimal outcomes due to their cross-cultural context (Kopelman and Olekalns, 1999), but that the negotiation outcomes can be enhanced if the technologies used by the project enable the creation of boundary objects (Boland, Lyytinen, and Yoo 2007; Carlile 2002).

BOUNDARY OBJECT USE IN GLOBAL DESIGN PROJECT NETWORKS

A boundary object, as defined by Carlile (2002:451), "establishes a shared syntax or language for individuals to represent their knowledge across boundaries." In global engineering design contexts characterized by boundaries between nationalities and cultures, boundary objects may establish a shared syntax or language among the project network participants. Recent research observing technological boundary object use in the AEC industry describes that 2-D Computer Aided Design (CAD) and 3-D BIM tools can facilitate cross-organizational collaborations (Taylor 2007; Gal et al 2008). AEC industry researchers posit that even non-technological boundary objects—such as drawings, specifications and reports—can assist collaboration in diverse environments (Phelps and Reddy 2009). These studies support the argument that boundary objects may be useful in design centered negotiations in global engineering services project networks.

Carlile (2002, 2004) discusses boundary objects in an engineering design context and argues that boundary objects can assist in creating common knowledge among dispersed design teams. Common knowledge is useful because it facilitates communication between otherwise dispersed actors (Carlile 2004), thus enhancing coordination between the actors (Okhuysen and Bechky 2009). Gal and colleagues' (2008) studied the strong links that exist between boundary objects, organizations and their practices, identifying technological boundary objects as a form of knowledge broker for project networks. Project organizational research has also demonstrated that the evolution of knowledge in engineering design teams is enabled by the existence of boundary objects (Whyte, Ewenstein, Hales, and Tidd 2007). Though previous research has alluded to the applications and benefits of boundary objects in a global framework, little research focuses specifically on how boundary objects may give rise to common knowledge in negotiating complex design knowledge in the context of global engineering services project networks.

BOUNDARY OBJECTS IN NEGOTIATIING COMPLEX DESIGN KNOWLEDGE

There have been several recent efforts to observe how boundary objects are used in negotiating complex design knowledge in engineering and design project networks. In this manuscript we understand complex design knowledge as both explicit and tacit design task related knowledge whose components depend on larger knowledge systems (Hansen, 1999). As for negotiations in particular, an ethnographic study of design projects found that boundary negotiating artifacts can function as boundary objects across design boundaries when the design project is simple and the knowledge required is routine, or non-complex (Lee 2007). This would suggest that boundary objects are useful in allowing for a shared understanding between design groups when non-complex design knowledge is negotiated, but less useful when complex design knowledge is negotiated. Challenging this suggestion, however, a more recent study of project contract negotiations found that visual representations functioned as boundary objects and facilitated negotiating complex knowledge in construction projects (Koskinen and Makinen 2009). The research posited that in order to reach a shared understanding during project contact negotiations, complex design knowledge must be presented both through documentation and experience. This argument is corroborated by Carlile's (2002:452) finding that objects which provide "a concrete means" for presenting different knowledge can function as effective boundary objects. Extending Carlile's (2002) work, Dirckinck-Holmfeld (2006) found that many different types of objects can function as effective boundary objects and facilitate cross-boundary negotiations. Dirckinck-Holmfeld (2006) suggests that effective boundary objects are situational and that the effectiveness of boundary objects in facilitating negotiations is related to the objectives of the negotiating participants.

In sum, past research has found that when visual representations and other boundary negotiating artifacts work as boundary objects, they can assist in negotiations in design project networks. Nonetheless, there appears to be little research on whether boundary objects can facilitate the emergence of common knowledge when complex design knowledge is negotiated across national cultural boundaries in global engineering services project networks. This lack of research is problematic: if coordination in global engineering and design project networks requires that complex design knowledge is negotiated across boundaries, then we should understand better how such knowledge may be negotiated across boundaries with the help of boundary objects. In this paper we seek to address this research problem by studying empirically how complex design knowledge is negotiated across boundaries in global engineering project networks where boundary objects are present. We refer to such negotiation as *design-centered negotiation*.

METHODOLOGY

Research Setting

A fundamental shift is occurring in the structure of engineering project execution. As markets globalize, new demands are imposed on engineers and engineering organizations. It is now seen as both easy and efficient to create products overseas due to the advancement in both real-time internet communications and worldwide logistical networks (Acosta, Leon, Conrad, and Malave 2010). Engineering work has been impacted by the global dispersion of firms and it is not uncommon that engineers relocate to other countries as required by their employers. In this paper, we discuss ethnographic data collected from a large-scale engineering services firm based in the United States. Its U.S. based engineers collaborated with its India based engineers on an engineering, procurement and construction (EPC) refinery project that included both gas and coker plants. For this study we empirically observed a 90% design review meeting over the span of three days at the company's office in India. The project network participants observed included the Indian design team members, the U.S. design team members and the U.S. client representatives.

Data Collection

Three days of 90% design review meetings took place in India where the participants were present both face-to-face and by phone. The primary purpose of the design review meeting was for all firms within the network to go through the 3D model simultaneously by both the Indian and U.S. engineers and therefore approve/reject elements of the design as they saw fit. The 3D model of the plants included all piping layout and sizing; equipment specifications; civil and structural components, mechanical components and construction specifications. Due to the distributed nature of the design collaboration as well as the interdependence of their tasks, negotiations across the national cultural boundaries were required to reach agreements on the sections to approve or reject and finally reach a final design. The design would then be issued to the owner for final approval and subsequently into issued for construction plans. The meeting days lasted between 6 and 10 hours. Each of the meetings were recorded and transcribed in order to follow a grounded approach (Corbin and Strauss 1990). Field notes were taken during the observed meetings, as well as during semi-structured interviews (Spradley 1979) with a number of network participants, over the three day span to supplement the audio recordings. Following the 90% design review meetings, a number of follow-up interviews were conducted at a later date in order to discuss the design review process with the U.S. project network participants.

Data Analysis

The observation of the design review project network conducted by the investigators allowed for a many-sided relational approach for development of the organizational understanding of the design review process (Emerson et al. 2001). During the meetings the researchers focused on how boundary objects influenced cross-national cultural negotiations. Five different types of boundary objects were identified in mediated negotiation across the national-cultural boundary between the U.S. and Indian engineers: 1) 3-D computer models (3DM); 2) Piping and Instrumentation Drawings (PNID); 3) Change Order Directive documents (DI); 4) Standards and Specification documents (S&S); and 5) Issued for Construction documents (IFC). We adopted the definition for negotiation stated previously by Carnevale and Pruitt (1992:532) "negotiation involves discussion between the parties with the goal of reaching agreement." The focus of the data analysis was on the negotiations that occurred during the design review and where the national cultural boundary was crossed. Each negotiation was identified and noted. Each of these negotiation instances was further isolated and the interactions involving the U.S. engineers (US1, US2, US3, US4, US5, US6, US7, US8), the Indian engineers (IN1, IN2, IN3, IN4) and boundary objects (3DM, PNID, DI, S&S, IFC) were recorded for each.

Over the three days, a total of 1,428 interactions were recorded; of these approximately one third directly involved the identified boundary objects. We define interactions as follows: an interaction occurs when one participating engineer refers to another engineer or a boundary object. Table 6 below contains a breakdown of the interactions by category of participant: boundary objects, U.S. engineers, and Indian engineers. Each interaction involved two network participants (two vertices) that are connected by a link (or an edge) that represents an interaction existing between them. Each participant can either be the initiator or the receiver for each interaction. In this case, both the U.S. and the Indian participants have the possibility of being present as either the initiator or receiver in each interaction. However, a boundary object can only be involved in an interaction by either a U.S. or Indian participant making reference to it, therefore this does not allow for reciprocal action, and can only be present as the receiver. Therefore of the 1,428 total interactions, both the U.S. and the Indian participants have the possibility of being present 1,428 times each, due to the two vertices that make up one interaction; while the boundary objects can also be present 1,428 times, due to its unidirectional nature.

In order to quantitatively observe the role of boundary objects in the observed negotiations, network analyses were conducted of all the recorded interactions for each negotiation. Network analysis allows the researcher to focus on boundary object roles in negotiations in order to further evaluate the cross-boundary negotiation process. Kilduff and Tsai (2003:19) recognize the distinctive features of network research as integrating "quantitative, qualitative and graphical data, allowing for a more thorough and in-depth analysis." Past research has demonstrated the effectiveness of network analysis in understanding dynamics in project networks (Pryke 2005; Chinowsky et al 2008; Di Marco et al 2010). Network research also facilitates a macro and micro linkage analysis, where we can observe both the macro-level dynamics at the boundary between organizations (and national cultures in this case), as well as micro-level dynamics between individuals within the project network.

Table 6: Negotiation Interactions Observed in 90% Design Review Meetings

Group	# Interactions	% of Total
Boundary Object	419	29
U.S.	1,268	89
Indian	766	54
Total	1,428	

We were also interested in observing the process through which boundary object-facilitated negotiation outcomes emerged. Therefore, we conducted a grounded qualitative analysis (Strauss and Corbin 1998) on each of the negotiation instances identified during the three days of design review meetings. From the transcribed data, we segregated the instances of negotiation in order to further analyze them at a more micro-level. A total of 67 negotiations were identified and recorded, each of which involved some form of boundary object use. After we identified and described each negotiation we analyzed the role of the boundary objects and their role in the negotiation processes and outcomes.

FINDINGS

Quantitative Observations of All Participant and Object Interactions

In network research, roles can be represented by clusters of attributes that are associated with a specific position or value within the network. These positions are demonstrated through a number of practical network graph metrics. The specific metrics we observed were: 1) degrees of centrality, more specifically in-degree since the interaction with a boundary object can only be unidirectional; 2) betweenness centrality; and 3) clustering coefficient. Each of the metrics for the vertices is normalized to a maximum attainable value of 1. The in-degree centrality measure represents the directional consideration of the number of edges connected to and pointing to a particular vertex (or participant). Betweenness centrality is a measure of how much removing the node will disrupt the connections between other nodes in the network. Nodes with high betweenness centrality act as brokers within the network. Finally, the clustering coefficient is a numerical attribute that focuses on the egocentric network (the network associated to a single node or 'ego') and measures the density of the network that surrounds the ego network based on its neighbors (or alters) (Hansen, Shneiderman, and Smith 2010). Nodes with less than two alters have a clustering coefficient of zero. Table 7 below describes the mathematical representations of the network metrics used in the context of this analysis. In Table 7, x represents one network participant: either a U.S. engineer, an Indian engineer or a boundary object; n is the total number of network participants: including all U.S. engineers, Indian engineers and boundary objects; k(x) is the number of neighbors, or alters, for participant x; and e(x) is the number of connected pairs between the alters of participants of x.

Table 7: Mathematical Representation of Network Graph Metrics

Network Metric	For Each Individual x	Network Graph Metric Formula
Degrees of Centrality, $c_D(x)$	$c_D(x) = \text{degree of participant x}$	$C_D(x) = \frac{c_D(x)}{\text{highest degree}}$ $C_D(x) = \frac{c_D(x)}{n-1}$
Betweennes s Centrality, $c_B(x)$	$c_B(x) = \sum_{y<z} \frac{\text{\# shortest paths between y \& z through participant x}}{\text{\# shortest paths between y \& z}}$	$C_B(x) = \frac{c_B(x)}{(n-1)(n-2)}$
Clustering Coefficient, CL(x)	$e(x) = \text{\# of links between alters of participant x}$	$CL(x) = \frac{e(x)}{k(x)(k(x)-1)}$

The descriptive graph metrics for each participant within the studied global engineering services project network negotiations can be found in Figure 7 below along with an overall network diagram of all negotiation interactions. Figure 7 illustrates the significant cumulative role the boundary objects played in negotiations across national cultural boundaries in our data on global engineering services project networks. The graph metrics indicate that the 3-D model (3DM) is clearly the central participant with all other boundary objects also demonstrating a high degree of centrality. The betweenness centralities do not have any significance in this case due to the unidirectional nature of the edges towards the boundary objects. The average clustering coefficient for the network participants are: U.S. engineers = 0.298; Indian engineers = 0.557; and boundary objects = 0.752. The higher average clustering coefficient of the boundary objects demonstrates how the density of interactions in the project network negotiations was greater surrounding them. The clustering coefficient results demonstrate the repeated emphasis the network participants make during each negotiation and how densely connected the network is that surrounds each of the boundary objects. Despite the fact that the frequency of interactions involving the boundary objects were far less than the other participant interactions, their high clustering coefficient demonstrates how densely focused each negotiation was on the boundary objects.

ID	*In-Degree*	*Betweenness Centrality*	*Clustering Coefficient*	*NEGOTIATION NETWORK*
IFC	0.235	0.000	1.000	
DI	0.353	0.003	0.900	
PNID	0.353	0.026	0.667	
IN3	0.176	0.003	0.667	
S&S	0.294	0.007	0.650	
IN2	0.176	0.008	0.633	
US4	0.176	0.007	0.633	
IN4	0.235	0.015	0.548	
3DM	0.588	0.081	0.544	
US5	0.059	0.013	0.450	
IN1	0.529	0.158	0.379	
US8	0.235	0.106	0.357	
US1	0.471	0.254	0.324	
US2	0.471	0.346	0.314	
US3	0.471	0.488	0.302	
US6	0.118	0.003	0.000	
US7	0.000	0.000	0.000	

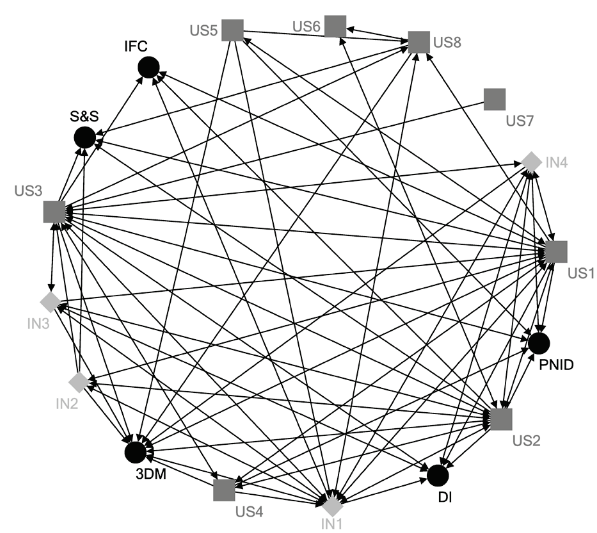

Figure 7: Negotiation Network Metrics and Graph

Quantitative Analyses of Specific Boundary Objects

Kilduff and Tsai (2003) define egocentric networks as networks that form around a single node, the ego. An ego-centric network includes the egos' direct links and the links among egos' direct links, which involve the egos' alters. Since the boundary objects in this research are identified and their direct and indirect links to the other networks participants are traced, we can generate a series of egocentric networks for each of the boundary objects studied. In the study of global engineering services project networks, the participants of interest are the boundary objects (the egos) and the U.S. and Indian engineers that refer to them (the alters). Egocentric network analysis involves analyzing the reciprocal and transitive nature of relationships (Scott 2000). Reciprocity means that the alters of a boundary object interact with each other. Transitivity means that two alters of a boundary object are linked. The analysis of reciprocal and transitive relations of egos and alters is known in egocentric network research as balance theory (Kilduff and Tsai 2003).

Balance theory is often used to interpret interpersonal relationships within organizations; however research has shown how balance theory can also be useful in understanding knowledge transfer at the interorganizational level (Larson 1992). Figure 8 includes both the reciprocity and transitivity of the alters (US1, US2, US3, US4, US5, US6, US7, US8, IN1, IN2, IN3, IN4) for each of the identified boundary objects (IFC, PNID, DI, 3DM, S&S). These relationships are present in the ties and arrows that connect the alters. For each of the egocentric networks presented in Figure 8, reciprocal relationships are represented by double arrows, while transitive relationships are represented by single arrows.

As we demonstrated for the network that included all participants in Figure 7, the nature of the high clustering coefficient for each of the boundary objects reveals the dense connectivity of the alters the boundary objects are associated with. Figure 8 also shows, along with the highly dense negotiating participant relationships within the global network, that each of the egocentric networks being analyzed contains cross-cultural relationships, where knowledge can be exchanged across boundaries. In global project networks, boundary objects play an important role in establishing cross-boundary common knowledge during design-centered negotiations. For each of the boundary objects in Figure 8, we can directly observe the reciprocity and transitivity of the cross-boundary alter interactions. Larson (1992) found that reciprocity and transitivity in interorganizational interactions leads to trust building, alliance formation and, most importantly, knowledge exchange which is an integral component to effectively attaining favorable project negotiation outcomes in a global engineering services project network setting. In a cross-boundary setting, knowledge and information embedded within one side of the boundary could more effectively be transferred when alters from different national-cultures have balanced relations and are therefore reciprocally and transitively connected.

Of the five boundary objects shown in Figure 8 the egocentric networks with the most reciprocal relations, where all (or almost all) the relations between alters are reciprocal, are ‘IFC’ (issued for construction), ‘PNID’ (piping and instrumentation drawings) and ‘DI’ (change order directives document). Besides their fully balanced relationships, the ‘IFC’ and ‘PNID’ egocentric networks also contain three cross-boundary interactions, where knowledge is being negotiated across national-cultural boundaries. Therefore, for negotiations involving either ‘IFC’ or ‘PNID’ boundary objects, the participants interact equally amongst themselves in order to reach a resolution. Boundary object ‘DI’ however has all but one reciprocal relation, between alters IN3 and US1, and has nine cross-boundary alter interactions which also demonstrates highly balanced relations. Boundary object ‘3DM’ (the 3-D model) egocentric network is composed of the most cross-boundary interactions (there are 15 such interactions). Though not all interactions between alters are reciprocal, they are transitive and therefore still promote a densely structured cross-boundary organization where knowledge can be transferred. For the boundary object 'S&S' (standards and specifications), though most of the relations (excluding relation IN2 to US3) are reciprocal, the egocentric network is less dense due to the lack of interactions between alters IN2 and US8 and the overall lack of participation of alter US8 with the rest of the rest of the alters. The 'S&S' boundary object also has three cross-boundary interactions where knowledge transfer occurred.

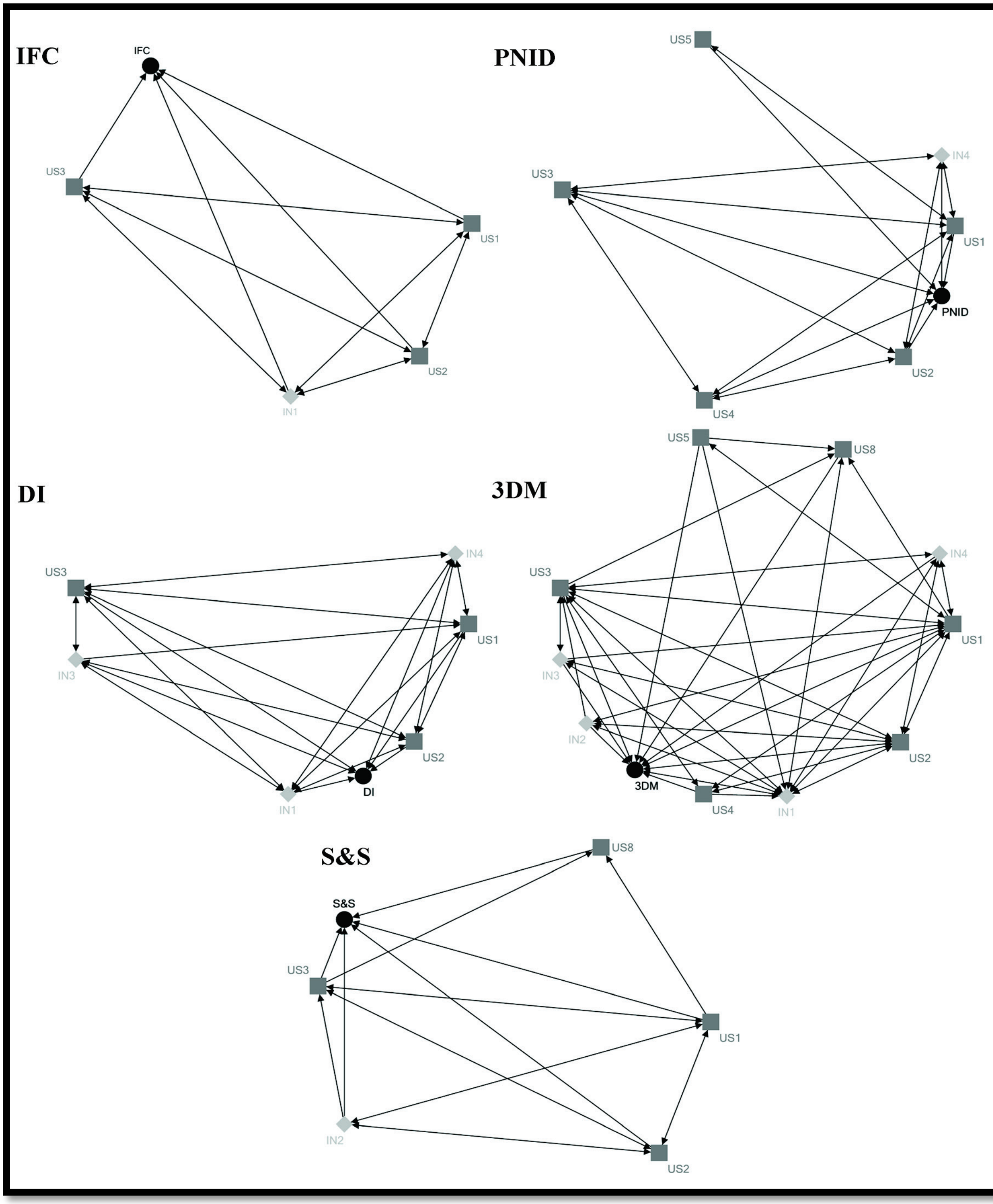

Figure 8: Egocentric Boundary Objects (DI, IFC, 3DM, PNID, S&S) and Alters Network Graphs

Qualitative Analyses of the Role of Boundary Objects in Negotiating Complex Design Knowledge

Extant literature posits that boundary objects can mediate knowledge negotiation across organizational boundaries in engineering projects (Boland et al. 2007; Koskinen and Mäkinen 2009; Taylor 2007). We observed that these boundary objects mediated negotiating knowledge across the national-cultural boundary by *drawing attention, enabling clarification,* and *justifying negotiation outcomes*. We will discuss each of these constructs separately in the following sections, as well as propose how each impact design-centered negotiation across national cultural boundaries.

Drawing attention. We observed that the boundary objects drew attention to particular aspects of the knowledge being negotiated. By drawing attention, a boundary object enables the individuals to focus on a particular aspect of knowledge and thus facilitate negotiation across the boundary. For example, during a negotiation on how the Indian engineers should respond to the U.S. engineers' verbal directions, the 3-D computer model functioned as a boundary object. It drew the negotiation participants' attention to the particular issue of steam mount installation directions. In the middle of the back-and-forth discussion on whether the U.S. team members should be giving verbal directions in the first place, the 3-D model functioned as a boundary object when a U.S. engineer (US1) pointed to it while talking:

> US1: "*In a way, we are guessing. See here?"* [Using a laser pointer to point out the installation in 3DM]

US1's comment indicates that at this point the engineers were not sure whether verbal directions were actually necessary ("*we are guessing*"). The comment also shows how the boundary object drew the participants' attention to a specific point in the 3-D model depicting steam mount installations ("*See here?*"). After the engineers' attention was drawn to the specific point in steam mount installations, they could focus on the specific installation arrangement. US2 commented:

> US3: "*I don't like the arrangement with it being over here* [Pointing to the arrangement in the 3-D Model] *because you can't include this blind, you don't want to block everything in.*"

US3's comment illustrates how the boundary object enabled the engineers to focus on the installation arrangement ("I don't like the arrangement") and as a result to understand the steam mount installation better ("because you can't include this blind"). The engineers learned that the current steam mount design was flawed.

Knowledge in project networks is often dispersed across different geographical locations (Bresnen, Goussevskaia and Swan 2005). In the engineering project network we studied, knowledge was dispersed across the U.S. and Indian operations. However, particular interactions among individuals and objects in project networks may lead to "local knowledge," or knowledge that is shared by the geographically dispersed individuals who come together to interact in a specific, local context (Yanow 2004:11-12; Alin et al. *in press*). The U.S. and Indian engineers' focus on the steam mount design resulted from their particular interaction between each other and the 3-D model. As a result of this particular interaction, local knowledge about the insufficiency of the verbal directions emerged. Our data thus suggest that by drawing attention, boundary objects can help individuals across the boundary to focus on a particular aspect of knowledge and transform dispersed knowledge to local knowledge. We summarize the analysis with the following propositions:

Proposition 1: By drawing attention, boundary objects enable design-centered negotiation participants to focus on particular aspects of existing dispersed knowledge.

Proposition 1.1: When design-centered negotiation participants across a national cultural boundary focus on particular aspects of existing dispersed knowledge, local knowledge can emerge.

Enabling clarification. The boundary objects also enabled the project network participants to clarify the emergent local knowledge. For instance, in the example discussed above the negotiating engineers developed local knowledge through focusing their attention to the steam mount installation design. When negotiating the steam mount installation design further, the engineers clarified how the steam mounts should be designed. A U.S. engineer (US2) described:

> US2: "*Well, this one is a steam line directly off… directly into the drum* [pointing to the line in the 3DM]. *So we need two details. You need one for when you have steam and oil and one [for] steam.*"

US2's quote illustrates how the 3D model functioned as a boundary object enabling the engineers to clarify local knowledge about steam mount design. The boundary object first enabled US2 to understand how the steam line connects to a drum ("*this one is a steam line directly off… directly into the drum*"). As a result, he was able to clarify knowledge about the complexity of the required design ("*so we need two details*"). After clarifying knowledge about the complexity of the design, the engineers discovered that verbal comments and directions were insufficient at this design phase. The same U.S. engineer (US2) remarked:

> US2: "*We need to be careful not to act on comments. We need to get something in writing and directions… right now you are not working from directives…*"
>
> IN1: *"Well no, I am working from a verbal…"*

The comment by US2 illustrates that once the engineers at the boundary developed local knowledge about the steam mounts and clarified that knowledge further, they discovered that due to the complexity of the design, the verbal directions were insufficient ("We need to get something in writing"). The response by IN1 further confirms that the Indian team was working from a verbal direction ("I am working from a verbal"). The boundary object enabled the negotiating engineers clarify the local knowledge about the steam mount installation design and discover that the required design was more complex than previously thought. This clarifying negotiation led to clarified knowledge about both the steam mount installation design and the design communication practices. We summarize this analysis with the following propositions:

Proposition 2: By enabling clarification, boundary objects enable design-centered negotiation participants to clarify local knowledge.

Proposition 2.1: When design-centered negotiation participants across a national cultural boundary clarify local knowledge, knowledge becomes clarified.

Justifying outcomes. The boundary objects enabled the engineers to justify negotiation outcomes across the national cultural boundary. In justifying a negotiation outcome, a boundary object enables an individual to frame the outcome so that all participants at the boundary can agree to it. For example, the outcome of the engineering team negotiation was that directions concerning certain types of designs (e.g. steam mount installation design) should be given in writing. The 3-D model (3DM) functioned as a boundary object in justifying this outcome so that both U.S. and Indian engineers at the boundary could agree to it. The 3DM boundary object enabled the engineers to establish that the Indian engineers were indeed working based on verbal directions. The boundary object enabled a U.S. engineer (US1) to suggest that there was a problem with verbal directions:

> US1: "*Right now you're working without [confirmation] --- you are working from a verbal.*"
>
> IN 1: "*Okay*"

These two quotes show how the boundary object enabled US1 to argue that a specific design change was communicated to the Indian engineers only verbally (US1: "you are working from a verbal") and that the Indian engineers agreed to this (IN1: "Okay"). Next, the boundary object enabled another U.S. engineer (US2) to confirm this argument:

> US2: "*I know you're kind of [working] from a tag… but it is still verbal"*

By enabling US2 to demonstrate that what was included in the current design was based on verbal directions ("it is still verbal"), the boundary object made it explicit to the engineers at the boundary that many design changes by the U.S. engineers were communicated to Indian engineers as verbal directions. As a result, the engineers were able to start suggesting how the communication practice could be improved by switching into written directions. Another U.S. engineer (US3) commented:

> US3: "*[That is] all we got, that is everything. This covers what you have changed, okay? And then I would e-mail these, I mean electronic, you know? Send it electronically to [the lead engineer], okay, and me."*

US3's comment shows how the boundary object helped the engineers to come up with highly specific suggestions ("I would email these") to improve the cross-boundary knowledge exchange. At this point engineers across the national cultural boundary agreed that the verbal directions were insufficient and that the Indian engineers should switch to using written documents. A comment by IN1 illustrates this cross-boundary agreement:

> IN1: "*Okay and then I will ask my designer to make these changes* [gesturing to the PNID in his hands] *and markup the PNID and scan this and I will send them to…*"

IN1's comment shows how the Indians agreed to giving the directions in writing ("Okay") and specified how they will give them ("I will ask my designer make these changes and markup the PNID"). The data thus demonstrate that this knowledge negotiation led to agreement across the national cultural boundary. The cross-boundary agreement on the negotiation outcome was facilitated by the PNID boundary object as the boundary object provided justification to the developing knowledge that verbal directions were insufficient and giving directions in writing was needed. Once the negotiation outcome became justified, different parties at the national-cultural boundary could agree to it because they understood what the negotiated knowledge meant for their work and why it was important. Carlile (2004) argues that when individuals across the boundary agree upon the negotiated knowledge, it leads to common knowledge that is permanently shared by the individuals at the boundary. Our data corroborate the argument and suggest that if individuals at the national-cultural boundary agree on the local clarified knowledge, common knowledge can emerge. We summarize this analysis with the following propositions:

Proposition 3: By justifying outcomes, boundary objects assist design-centered negotiation participants to agree on the local clarified knowledge.

Proposition 3.1: When design-centered negotiating individuals across a national cultural boundary agree on local clarified knowledge, common knowledge can emerge.

MODEL OF BOUNDARY OBJECT-MEDIATED NEGOTIATION IN GLOBAL PROJECTS

When boundaries are crossed in global project networks, existing knowledge held by the dispersed project network members from different participants can be difficult to negotiate. Current literature on knowledge negotiation suggests that boundary objects may mediate knowledge negotiation by enabling the individuals at the boundary to represent, clarify and explain knowledge across the boundary (Carlile 2006; Whyte, Ewenstein, Hales and Tidd 2007). The findings presented in this research contribute to these arguments in the following ways: 1) we specified that boundary objects can draw attention to specific knowledge (P1), thus helping the participants to focus their attention and develop local knowledge (Yanow 2004; Alin et al. *in press*) (P1.1); 1) we confirm and extend Dirckinck-Holmfeld's (2006) research, and find that the boundary objects presented in this study were effective because the global project network's participants had a shared problem of reaching a final design of the EPC refinery project; 3) In line with extant literature we also observed that boundary objects can align negotiating participants (Lee 2007) and further enable them to clarify local knowledge (Carlile 2006) (P2), and thus help clarified knowledge to emerge (P2.1); 4) finally, we found that boundary objects facilitated negotiating participants by justifying outcomes (P3), leading to shared understanding (Koskinen and Makinen 2009) and a cross-boundary mutual agreement on common knowledge (Carlile 2004) (P3.1). We summarize these contributions and propositions in a theoretical model of boundary object-mediated knowledge negotiation in global projects in Figure 9.

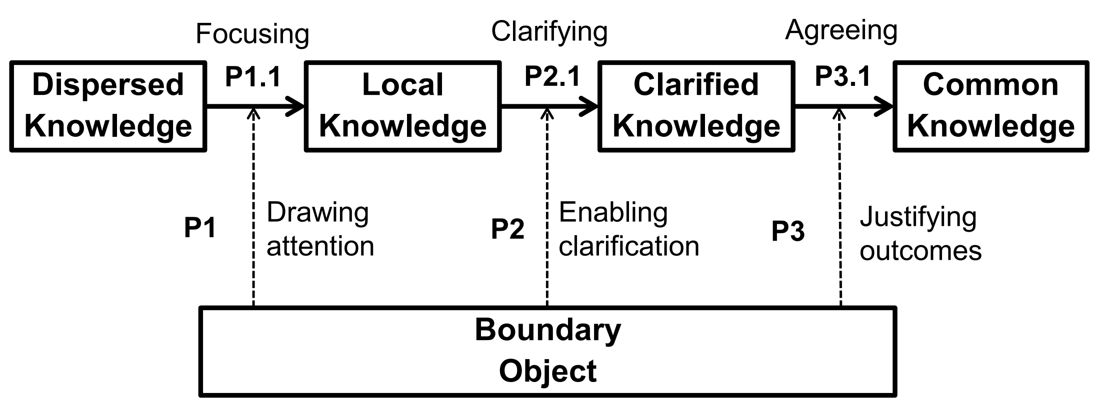

Figure 9: Model of Boundary Object-Mediated Negotiation in Global Projects

In order to provide further validation for the propositional theoretical model presented in Figure 9, we provide a negotiation case from among the 67 negotiation cases identified. We present this design-centered negotiation in its entirety to illustrate how each proposition in the model is representative of the interactions associated with the negotiation. The topic of the negotiation is regarding representative symbols in the 3-D Model (3DM) being discussed. The negotiation unfolded as follows:

> US1: "*That's a globe valve; the control valve is on the gate valve…*"
>
> IN1: "*It doesn't have a tag.*"
>
> US2: "*Which one … here?*" [Laser pointing to identify where in the 3DM]
>
> IN1: "*Yes but it doesn't have a tag.*"

In the above example we see how the 3DM functions as a boundary object by drawing the attention of US1, US2 and IN1 to the control type valve seen in the 3DM (P1 & P1.1).

> US1: "*So we need to tag it, and that needs to be a gate valve as well… it needs to be a gate type instead of a control type…*"
>
> IN4: "*No I think that in this bubble* [using the mouse to point out the symbol in the 3DM], *this is my instrument; you can see that … they are putting a bubble for annotation for their drawing so this is not actually showing the valve.*"
>
> US1: "*What do you mean?*"
>
> IN1: "*[The] piping group is modeling the control valve through [the] piping modular and [the] instrument [group] needs to tag this line and [so] they put a bubble, a small ball at the center of the control valve to get the tag number from that equipment model into their 2 D drawings. It takes data from that ball … to find out the location that's why they are putting that one* [highlights again with the mouse] *and [therefore] it's generating clashes.*"
>
> US4: "*It's too bad that you can't model this so it looks like what it represents. You could still have the ball in there but…*"
>
> US1: "*On our PNID, the first thing you look at is the symbology. That's a gate. Our symbology…* [flipping through the PNID in front of him to show the symbol] *and that's a globe* [pointing to the symbol in the PNID]*.*"

IN4: "*No. You can see this is a globe* [using the mouse to highlight the globe in the 3DM]. *This is gate modeled by piping. And this is I-5"*

US1: "*So it's separate…"*

IN1: "*Right this is a separate model by the instrument group."*

The US1 and US4 are clearly perturbed by the symbol presented in the 3DM to represent gate-type valves, since to them this symbol resembles that of a control type valve, which would require IN1 to agree to a design change. By drawing attention to the control valve representation, the 3DM boundary object enables the U.S. engineers and Indian engineers to acknowledge their dispersed knowledge and begin engaging in a cross-boundary negotiation as to how to proceed with clarifying this symbol. In this case each side presents their local knowledge: the U.S. engineers' knowledge of their customary symbols, those that are seen in the PNID and the Indian engineers' knowledge of why the symbols are as they are (based on directives, DI) (P2 & P2.1).

US2: "*Ok we need to get the right information in there right… we need to tag it* [referring to the 3DM] *and make sure it's right.*"

IN1: "*Right, I will verify from piping standpoint to verify* [IN1 leaves the room to get the DI]*."*

US1: "*If that's the case, then we need to make sure it's a globe; so we ought to have a standard note... Because you'll see it as a globe on the PNID* [still holding the PNID in his hand]*."*

US4: "*Well the graphics on the screen should represent just as the PNIDs… and this doesn't do that. This leads you to believe that that's a ball."*

IN1: "*Right, yes…*[upon arriving back into the room with the DI and handing it to IN2]*"*

US1: "*That's what I am saying. That PNID…"*

US2: "*Let's make a note for instruments to check it because the graphics are not…*[IN1 begins to type a note in the 3DM] *there you go…*"

> IN2: "*There was a single option,* [reading from the DI] *in order to get their instrument tag and the JV number on the instrumentation plan, the direction was very clear. That for outline instruments it would be a 1 foot by 1 foot by 1 foot cube… and the inline instruments there would be this* ... [gesturing to the globe in the 3DM] *what you are calling a bubble or a ball, a sphere with no particular space or size that will represent the location so that it can provide details so that the data that we pull from the model into the instrumentation plan can be used."*

At this point the 3DM, the PNID and the DI are boundary objects that enable clarifications of both parties' local knowledge. US4 and US1 present their knowledge based on the PNID and IN2 then presents the DI from the home office. Once the Indian engineers present their local knowledge by showing the U.S. engineers the DI and the 3DM, it is clarified to the U.S. engineers:

> US1: "*And I hear that. We've looked at a lot of control valves that were gates without that ball; that were represented as gates on the PNID."*

Since US1 agrees and acknowledges the exact DI they received, the global engineering services project network is able to create common knowledge in order to justify the outcome:

> US3: "*We've only looked at globe type control valves; this is a gate type control valve* [highlighting the globe with the mouse again in the 3DM]*"*

US3 in this case understands why they had not seen this symbol until now, and based on the DI revealed by IN1, common knowledge is established in order to reach an outcome (P3 & P.3.1). Figure 10 is a visualization of the network interactions of this particular negotiation. The network diagram demonstrates, as observed in the earlier boundary object specific network diagrams and the network diagram for all interactions observed, that boundary objects played a salient role in the design-centered negotiation of this project network. This provides face and pattern validity for the propositional model developed in this paper.

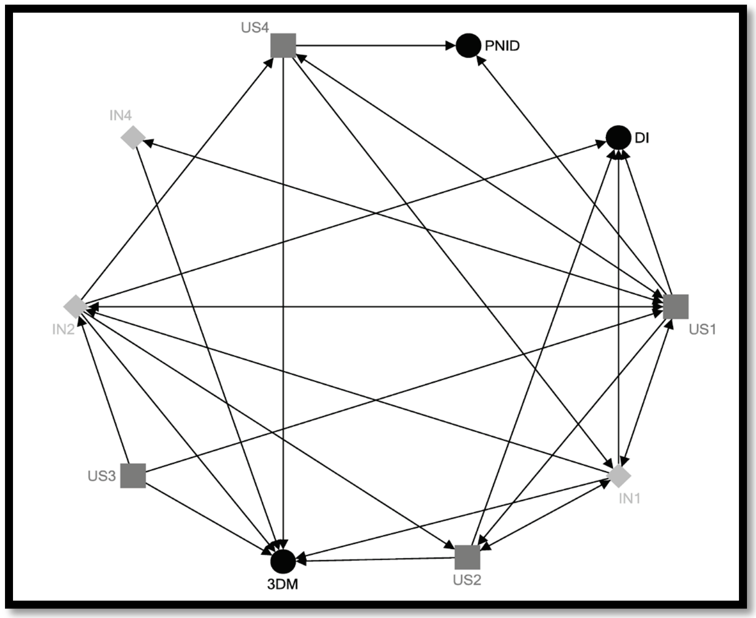

Figure 10: Negotiation Network for Representative Design-Centered Negotiation Case

LIMITATIONS AND FUTURE RESEARCH

Limitations for this research should be noted along with some suggestions for future research. The results of this study offer an indication of how boundary objects are used in cross-boundary negotiations by global engineering project networks. However this study was conducted with a network of firms from the United States and India, which may not be the same as other national cultural interactions. Further research involving other national cultural boundaries should be conducted in order to understand the possible influences of country context on the roles, relations, and outcomes of boundary object mediated negotiation in global project networks. Future research should consider varying both participants (testing the results with various national cultural boundaries and organizational cultural boundaries) and boundary objects (technological, practical, and institutional). With these additional dimensions, the reciprocal and transitive relations between egos and alters may differ and by expanding the types of interactions studied we can develop a more comprehensive understanding of the role of boundary objects in design-centered negotiations. Similarly, firms within different industries in global project networks may also demonstrate different relations between egos and alters. For instance, architectural firms often utilize both formal and non-formal boundary objects during the critical planning stages of design and as a result may generate a different response to cross-boundary negotiations at the preliminary stages.

Another limitation exists in that the findings presented in this manuscript arise through an analysis process that is based on a 'bottom up' inductive research approach; therefore the conclusions presented are based on the observations of the specific case studied. It should be noted that boundary objects can be dynamic, as suggested by Carlile (2002), and that not all objects present in cross-boundary negotiations are useful boundary objects. As contexts change, so can the roles of boundary objects along with their impacts on the network participants associated with them. Future research should aim to triangulate these findings with other research settings in order to capture roles, relations and outcomes across different global project network contexts. Notwithstanding these limitations, we hope the research presented in this paper can stimulate a dialogue on the important role boundary objects play in design-centered negotiations in project networks where national, cultural, organizational, or other salient boundaries are present.

Di Marco and colleagues (2010) identified that cross-national cultural collaborations resulted in an increase in knowledge system conflicts in global project networks; however a majority of the negotiations identified in the design-centered negotiations we studied involved work practice issues. The fact that the conflicts being negotiated in our boundary object rich setting versus were less attributable to cultural issues than the conflicts observed by Di Marco and colleagues may suggest that the salient national cultural boundary previously identified by research (Levina and Vaast 2008, Di Marco et al 2010) may not be as salient when boundary objects are present. The ego-centric network figures presented in this research could potentially be capturing the confounding role of boundary objects in focusing cross-national cultural participants on the task at hand versus their cultural and geographical differences. With this possibility, future researchers might productively investigate the role of boundary objects as "cultural boundary spanners" that can act to facilitate communication and hence reduce knowledge system conflicts.

CONCLUSIONS AND IMPLICATIONS

This study focused on boundary object use in negotiations across national cultural boundaries in global engineering services project networks. The purpose of this empirical investigation was to examine the link between effective boundary object use in negotiations and negotiation outcomes between network participants in a global project network setting. This paper drew from previous research on national boundaries and the use of boundary objects in design-centered negotiations. Previous literature has argued that boundary objects work by assisting individuals in representing dispersed knowledge at the boundary (Carlile 2002), enabling the creation of local knowledge (Okhuysen and Bechky 2009) and as well as the creation of more widely held common knowledge (Carlile 2004) or shared understanding (Koskinen and Makinen 2009). Our research contributes to this literature on boundary objects by specifying the crucial role boundary objects play in network participants' negotiations, enabling dispersed knowledge in global engineering services project networks towards common knowledge in project design. We demonstrated how the use of boundary objects in global project networks facilitates the participating individuals to resolve design issues in design-centered negotiations.

The number of design and engineering services projects with global participation is increasing, and therefore there is a need to better understand how both cross-national relationships and knowledge are developed. In practice, negotiations are an integral part of decision making and coordination within dispersed global project networks. Achieving outcomes that benefit all parties are sometimes infeasible due to the lack of balanced cross-national relationships and the dispersed knowledge each participant possesses. Research has shown that balanced relationships in interorganizational collaborations fosters learning and innovation in networks (Powell et al 1996), where in the case of cross-national negotiations both learning and innovation can lead to attaining common knowledge. In order to negotiate knowledge successfully in global engineering services project networks, participants cannot solely consider the types of boundary objects that are available to them; they must both acknowledge and exploit these objects in practice. Our research posits that the role of boundary objects within global project network negotiations is neither explicit nor obvious. Boundary objects are shown to elicit both reciprocal and transitive relationships that play an integral part in creating common knowledge among global participants separated by salient national, cultural and organizational boundaries.

Chapter 5

CONTRIBUTIONS

In the chapters of this dissertation I investigated the boundary spanning capabilities, the roles and impacts, of both individuals and objects in global project networks. The third chapter is a direct continuation of the second, as it investigates a step beyond the empirical contribution of team effectiveness; its unique contribution is the performance implications of cultural boundary spanners. The fourth chapter, once more contributes to boundary spanning research; however as objects as opposed to individuals and takes a purely industry based look at the boundary spanning capabilities as objects in global engineering project networks.

In its entirety, the contributions of this research develop a deeper understanding and build theory into the overall dynamics of global project networks. As an industry specific contribution, global project networks are an organizational structure that is quickly being adopted by AEC firms in order to better conduct its growing global ventures. Therefore, the findings presented in this dissertation include potential best practices such as the implementation of cultural boundary spanners, maintaining a better grasp of the knowledge system conflicts expected, refining global negotiation techniques and adopting adequate utilization of boundary objects. A further discussion as to the theoretical and academic contributions of chapters 2 to 4 can be found in the individual contributions section, however holistically the findings from this research allow for a deeper understanding of the global trends in the AEC research fields. In the next section of the contributions I discuss the various levels of integration for each of the global project networks observed. This concept is particularly important in order to understand how the concepts presented in this dissertation can span multiple levels of integration in order for networks to obtain an improved integration level along with an optimal performance.

GLOBAL PROJECT NETWORK LEVEL OF INTEGRATION

Global project networks cover a broad range of project stages from pre-planning to close-out; therefore it is important to note the stages of collaboration of each of the global project networks studied in this research in order to fully understand their contribution to project organization research. The People Capability Maturity Model (PCMM) developed by Curtis and colleagues (1995) is a useful process driven tool developed to aid organizations to develop their workforce performance based on subsequent levels of collaboration. Organizations that adhere to this process can experience less variability to their performance as well as an increase in collaboration effectiveness. As performance and collaboration effectiveness lie central to the theoretical contributions presented in this research, the PCMM framework is well suited to discuss which level of global project network collaboration would benefit most from boundary spanning capabilities. The five levels presented by the PCMM framework include: 1) Initial, representing a somewhat new or ad hoc collaboration; 2) Managed, represented processes that are managed to a certain approved standard; 3) Defined, representing work processes that are defined; 4)

Quantitatively Managed, representing an organization where growth in quantitatively managed; and 5) Optimizing, representing processes that are continuously being optimized.

In the second chapter, the first global project networks presented, observing the emergence and role of a cultural boundary spanner, falls within maturity levels 2, managed, and 3, defined. The global project networks worked together for months prior to the face to face portion of collaboration. From their prior experience together, management processes and standards for their performance emerged and were established at the early stages. Participation in the graduate class as well enabled their work processes to also be established at the beginning and during the length of the project. This level allowed for an adequate quantitative observation of cultural boundary spanner emergence and role because the network itself was in the early stages of collaboration and therefore allowed for the researchers to observe this phenomenon in real time. Had the global project network arrived at a higher level of integration before the observations began, the cultural boundary spanner emergence may have already occurred, therefore not allowing the researchers to adequately understand the network's growth. In the third chapter, the global project networks observed, in order to distinguish the performance implications of cultural boundary spanners, fall within maturity levels 1, initial and 2, managed. Though these networks had no prior experience working together, which classified them as ad hoc collaborations, the rules and guidelines given to each of the participants adhered to the experimental process of the research. All of the networks in this chapter were also managed by the observing researchers. The preliminary level established for each of the networks was imperative in order for the comparison to be adequate across global project networks. Finally in chapter 4 the global project network observed falls within levels 4, quantitatively managed, and 5, optimizing. The industry based global project network in this case has highly sophisticated management processes in placed that involved multiple staged of quality assurance and quality controls. They also maintained real-time lessons learnt processes in order to constantly optimize their organization. This higher integration level is important for inductive research purposes as the processes had already been in place allowing for the researchers to observe them as they occur.

INDIVIDUAL CONTRIBUTIONS

The following sections discuss in further detail the contributions of each chapter.

Chapter 2: The Emergence and Role of Cultural Boundary Spanners in Global Engineering Project Networks

Earlier research suggests that boundary spanners can play important roles in interorganizational collaborations. Cross and Prusak (2002) found that boundary spanners can link internal networks with networks in other organizations, therefore playing a critical role in increasing the efficiency of knowledge exchange between organizations. In networks of organizations, such as global project networks, that are susceptible to boundary formation between organizations, boundary spanners can overcome these boundaries and create team dynamics that may otherwise not be possible. Levina and Vaast (2008) took a global perspective and found boundary spanning potential in offshore outsourcing of information technology. Emergent managerial practice due to geographic and time differences, allowed for the lessening of social boundaries to facilitate collaboration effectiveness. However, past research fails to investigate how boundary spanning emerges at the national-cultural boundary in global project networks.

In Chapter 2, I extend the findings of Levina and Vaast (2008) to global engineering project networks by showing that cultural boundary spanners emerge as central participants when cultural boundaries are spanned. Though this central role diminishes over time, the project network over time can become a uniformly integrated collaborating team. Cultural boundary spanner emergence can positively impact collaboration effectiveness by not only spanning the national-cultural boundaries within the distributed network; they also contribute to resolving knowledge system conflicts and by triggering emergent cultural boundary spanners-in-practice. It is also in chapter 2 that I define the term ‘cultural boundary spanner’. There is no consistent use of this term in organization literature, but researchers generally refer to culturally-intelligent participants as mediators in global business environments. In negotiating national-cultural boundaries, cultural boundary spanners can form new joint fields that enable participants from different organizations, and particularly from distinct national backgrounds, to pursue a common goal. The overall aim of this chapter was to shift the extensive research on the pitfalls and conflicts within distributed culturally distinct networks, to a micro-analysis research of the boundary spanning potential of individuals within these global project networks that can lead to success.

Chapter 3: The Impact of Cultural Boundary Spanners on Global Project Network Performance

In Chapter 3, I recreated, through a controlled experimental process, the interdependent task observed in global AEC projects. My first goal was to validate the findings in the second chapter as collaboration effectiveness, in-practice (i.e. in the 'real world'), might not always lead to a benefit to team performance. As the empirical analysis in the second chapter predicted, cultural boundary spanned multi-cultural networks positively impacted team performance when compared to purely multi-cultural and mono-cultural project networks. The most significant contribution of this chapter is that it shows the initial performance liability of global project network collaborations lessened to that of mono-cultural networks due to cultural boundary spanners. Although research has identified the subjective nature of evaluating project performance, the experimental process in this chapter allows for a validating quantitative measure to the collaboration effectiveness of the global engineering project network found in Chapter 2. The findings show further evidence of the boundary spanning potential of individuals in global project networks. The results have significant implications for industry. Networks aiming to bridge the cultural and linguistic differences from the beginning of a global collaboration can tap into the boundary spanning potential of their employees (or seek them out externally). Cultural boundary spanners can provide a common ground for mutual understanding to be established between diverse organization participants in multi-cultural business networks.

Chapter 4: Negotiating Through Boundary Objects in Global Design Project Networks

Though socio-centric network analysis is often used in many fields of organization research in order to explain the dynamics within organizations and identify the roles played by employees, ego-centric network analysis remains seldom applied. In Chapter 4, I observe the boundary spanning potential of global design project networks from a different angle, by analyzing the ego-centric networks that surround boundary objects. As negotiations play a central role in the decision making process of global engineering design project networks, by observing the boundary spanning capability of objects used in negotiations we better understand global project networks themselves. I extend the important role identified by Koskinen and Makinen (2009) of boundary objects application in a project context, by contributing to a shared understanding during negotiations. Though research has observed both boundary objects in design and negotiations, an industry approach to the boundary spanning potential of objects at the national-cultural boundary have yet to be discussed.

Firstly, in Chapter 4 I found that in a global project network negotiation context, balance theory shows how boundary objects played an important role in generating reciprocal and transitive collaborative relationships among global engineering design project network participants. Secondly, boundary objects promoting collaborative relationship in cross-boundary negotiations plays a salient role in transforming dispersed knowledge during negotiations to common knowledge leading to negotiation outcomes. Where organizations within distributed culturally distinct networks face boundaries prohibiting successful collaboration, I show how boundary objects can aid in mediating knowledge in order to reach common knowledge among cross-boundary network participants.

The findings of these three chapters have significant implications for the organizations that are or aim to participate in global project network collaborations. Achieving a higher potential for collaboration efficiency and improved performance will require organizations to seek out the boundary spanning capabilities of their employees or the technologies they use. In revealing the key dynamics of cultural boundary spanner and boundary objects that leads to successful interorganizational collaboration, I hope this dissertation will contribute to the global organizations managerial process and strategy.

Chapter 6

LIMITATIONS AND SUGGESTED DIRECTIONS FOR FUTURE RESEARCH

The focus of this research is on the cross-boundary collaboration in project networks. I aimed to use empirically based research techniques in order to investigate the boundary spanning capabilities within global project networks. Although such inductive research is beneficial in understanding the dynamics in organization settings, it is not without its shortcomings.

In order to maintain a controlled observable environment, some of the observations are based on non-industry research settings. For example, the ethnographic research setting in Chapter 2 observes a graduate course where engineering project management graduate students are involved in cross-cultural and cross-boundary project collaborations. In quantitative analysis of Chapter 3, the research setting involves a highly controlled experiment, strictly for comparison purposes, also involving university students in this case simulating the AEC industry network task interdependence. However, the objective of these chapters is to explain, through theoretic observation, the potential benefits of cultural boundary spanners on collaboration effectiveness and impact on team performance. The findings in Chapter 2 and 3 provide strong theoretical support for these findings. Therefore the validity of the arguments is more important that the exact context of which the observations took place. The reader can refer to the limitations in Chapters 2 and 3 for a detailed discussion of how the research methods I used have benefits towards theoretical contributions.

In order to minimize the national cultural boundaries in cross-cultural collaborations, in Chapters 2 and 3 I propose the concepts of cultural boundary spanners and knowledge system conflicts. These concepts can be further developed in order to establish them as possible avenues for developing cross-cultural protocols for collaboration. Limitations exist however to simply applying these concepts to decrease the impact of national cultural boundaries on collaboration effectiveness as well as improve the performance during the initial stages of global project network collaborations. Protocols and processes for successful cross-cultural interactions should in this case be investigated further. In order to first establish a standard of best practice further research should tap into other avenues of global collaborations such as international joint ventures and global partnerships in order to determine successful practices already identified in literature. Finally, by testing these various practices, also including the cross-cultural concepts presented in this research such as cultural boundary spanners, towards global project networks setting standard protocols for cross-cultural interaction could begin to emerge as successful (or not).

Another limitation lies in the grounded data analysis approach I took in Chapter 2 and Chapter 4. Corbin and Strauss (1990) outline the specifics for following grounded theory research, where theories are established from the ground up. The findings in these studies are representative of the concepts within global engineering project networks and not of the persons involved in the study. The approach I took in these studies was to develop a theoretical explanation for the phenomena of collaboration effectiveness as well as the reciprocal and transitive relationships observed through the social network graphs in chapters 2 and 4 respectively. The conditions that give rise to these phenomena in global engineering project networks are the boundary spanning capabilities of cultural boundary spanners and boundary objects alike. There are many other possibilities of boundaries in project networks that include: cross-organizational boundaries of non-dispersed networks, cross-industry boundaries, and cross-discipline boundaries etc. all of which have potential for future research to examine further. As for the quantitative network analysis approach taken in Chapters 2 and 4, it is important to note that the methods used were appropriate for the data at hand. Should the global project network data become expanded and vaster, network analysis techniques need to adapt to this change and slightly more sophisticated processes be used. In the case of larger networks, probability methods in network analysis are much better suited to analyze network trends and participant roles.

In this dissertation, I draw upon past organization research that observers cross-boundary collaborations and boundary spanning capabilities in organizations. I observe beyond the macro-analysis of organizational or interorganizational structures of global project networks to make a more specified micro-analysis of the actors involved. Future research should take the findings I present in this dissertation and extend them in order for there to be a greater understanding of global project networks and the capabilities that sustain or protract their success or lack thereof. In the previous section I briefly discuss the various levels of integration, presented in Curtis and colleagues' (1995) research on the People Capability Maturity Model (PCMM), of the global project networks presented in the research. Future research can observe more specifically how and if the boundary spanning concepts presented in this research can also span multiple levels of integration in order for networks to reach a greater degree of collaboration effectiveness and performance.

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