

Knowledge-sharing connections across geographical boundaries in global intra-firm networks

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To boost project performance, managers of engineering and construction organizations are interested in sharing knowledge between employees across the organization. Global project-based organizations that operate in diverse markets are particularly keen to share knowledge collectively across projects and regions to gain a competitive advantage. Unfortunately, creating knowledge-sharing connections (KSCs) and knowledge-sharing networks (KSNs) can be particularly challenging for global project-based organizations. They face not only typical knowledge-sharing barriers of resources, organizational structures and individual motivations, but also physical and cultural barriers due to geographical distance. Although the benefits of global knowledge sharing are established, little is known about how KSCs and KSNs are established and maintained. In order to better understand the network structure and the formation of KSCs within these global organizations, the research analysed the KSC within a KSN focused on sustainability in one large multinational engineering organization. This paper analyses KSCs that span geographical boundaries to determine regional knowledge exchange patterns within the KSN, why KSCs across geographical boundaries are formed and maintained and the barriers to establish these KSCs. To meet these objectives, a mixed research method was employed, including quantitative and qualitative analyses. Social network questionnaires and analysis determined the mechanics and dynamics of knowledge sharing within the KSN, including knowledge exchange patterns and metrics. Code was developed to determine the influence of geographical location on KSC within the network, which revealed a propensity for intra-regional knowledge exchange, particularly at a weekly knowledge exchange frequency. However, geographical proximity was found to be less important in inter-regional knowledge exchange patterns. Instead, despite location or economic indicators, regions exchange knowledge most frequently with the corporate headquarters. To better understand why and how knowledge connections across geographical boundaries were formed, approximately 5% of network members were interviewed using a semi-structured format and ethnographic techniques. The results indicate that engineering organizations must strategically focus on knowledge exchange by identifying technical experts and centres of excellence that consult across the organization, supporting an organizational structure and controls that encourage collaboration across borders, and creating resources to facilitate face-to-face meetings, training sessions or internal organizational projects with global KSN members.

Keywords: Globalization, knowledge, networks, organizational issues, social network analysis.

Introduction

Globalization has impacted the architecture, engineering and construction (AEC) industry tremendously. Organizations are expanding their geographical reach to meet the tremendous demand for infrastructure worldwide. As a result, AEC organizations have distributed projects and regional offices scattered across the

globe. In order to gain a competitive advantage, these multinational organizations desire to gain knowledge from each market (Miller and Chen, 1996) and to share this knowledge collectively (Ghoshal, 1987). In fact, today there is consensus that a multinational organization is ‘an international network that creates, accesses, integrates and applies knowledge in multiple locations’ (Almeida *et al.*, 2002, p. 148). Although

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difficult, integration of the knowledge held by employees across the world enables multinational organizations to add value (Kogut, 1989). Specifically, research has found that connections between people that span physical barriers can increase opportunities to access information and to improve performance (DeSanctis and Monge, 1999) and that task-relevant knowledge sharing between people in different geographical regions can boost performance at the project level (Cummings, 2004) and at the individual level (Cross and Cummings, 2004). Creating knowledge-sharing connections (KSCs) among employees in diverse geographical regions must, therefore, be a focus for managers of global organizations.

Although the consequences of diversity have been studied, little attention has been paid to the theoretically important features of connections within the networks (Monge and Contractor, 2001; Adler and Kwon, 2002; Cummings, 2004). In addition, little is known about how these boundary-spanning KSCs are formed between geographical regions. As a result, this paper seeks to increase our understanding of intra-firm knowledge exchange patterns and connections within a knowledge-sharing network (KSN) focused on sustainability in a multinational AEC organization headquartered in the UK, including how and why geographical boundary-spanning KSCs were established.

Theoretical points of departure

Theoretically, this work is derived from branches of organizational theory, including the knowledge-based view of the firm and network theory. Project-based organizational theory and the global business literature also underpin the research.

Organizational knowledge

The knowledge-based theory of the firm has wide acceptance and support. The theory indicates that organizational knowledge has the same level of importance as capital (Grant, 1996) and is critical for sustaining a competitive advantage (Spender, 1996). In order for an organization's collective knowledge to add value, however, the knowledge needs to be accessible when and where it is needed. Unfortunately, most organizations 'don't know what they know' and all organizations 'know more than they can tell' (Polanyi, 1967). A lack of knowledge sharing across the organization can cost time and resources spent on repeating the same mistakes, 'reinventing the wheel', or even employing redundant resources that could be better utilized pursuing other strategic objectives.

The AEC industry, where teams are project-based and temporary in nature (Whitley, 2006), faces additional hurdles to share knowledge. The autonomy of projects can cause project teams to become siloed, making organizational knowledge sharing challenging across projects (Sydow *et al.*, 2004). This is further exacerbated by global AEC organizations, which face the added hurdle of geographical distribution.

Global intra-organizational knowledge exchange

Despite the challenges of global knowledge sharing, multinational organizations are particularly keen to learn from each market they operate in to gain collective organizational knowledge across geographical regions (Miller and Chen, 1996) and to use this knowledge to achieve better performance (Ghoshal, 1987; Zahra, 2000). As a result, multinational organizations spend tremendous resources creating KSN and communities of practice (CoPs) that connect employees aligned in either interest or task across geographical boundaries and attempt to collect and make knowledge and information available across the organization. These connections can open up new opportunities for knowledge sharing by having access to a greater variety of task-related information (Monge *et al.*, 1985), which can improve performance (DeSanctis and Monge, 1999). Studies of the consequences of diversity have found that task-relevant knowledge sharing between people in different geographical regions can boost performance at the project level (Cummings, 2004) and at the individual level (Cross and Cummings, 2004). This is particularly important within the AEC industry, where the fragmented nature of tasks requires coordination and sharing of knowledge for projects (Jin and Levitt, 1996) and innovations (Taylor and Levitt, 2007).

Although communication and knowledge management technologies were developed to connect employees across physical distances (Cramton, 2001), many hurdles still remain. In addition to the challenges of physical separation, which can limit spontaneous interaction and cause difficulty in knowledge interpretation (DeSanctis and Monge, 1999), research on global project teams and organizations in the AEC industry has found that misunderstandings and conflicts result when team members from different national backgrounds work together (Mahalingam and Levitt, 2007; Orr and Scott, 2008). These differences can detract from effective communication (Watson *et al.*, 1993). These members are embedded in different external contexts with less mutual contextual knowledge (Gluesing *et al.*, 2003) or knowledge of each other's situations (Cramton, 2001), making knowledge transfer difficult. To reduce these conflicts, research findings highlight

the importance of individuals within project teams or organizations, including expatriates (Yates, 1989; Mahalingam and Levitt, 2005), cultural boundary spanners (Di Marco *et al.*, 2010; Di Marco and Taylor, 2011) and cosmopolitans (Haas, 2006).

Social networks in construction

To better understand how knowledge transfer occurs within global organizations, we must examine both the individual connections and the networks of participants. Recently, social network analysis has enjoyed prolific success in construction engineering and management (CEM) research to study projects and intra-firm networks. Primarily, CEM scholars have utilized network analysis within project teams or inter-firm networks (Pryke, 2010; Taylor and Bernstein, 2009; Chinowsky *et al.*, 2010; Comu *et al.*, 2010; Di Marco *et al.*, 2010; Nayak and Taylor, 2009; Wong *et al.*, 2010; Di Marco and Taylor, 2011; Park *et al.*, 2011; Unsal and Taylor, 2011), with minimal studies of intra-firm networks (for example, see Chinowsky *et al.*, 2008). To address knowledge sharing within a global organization, this study will focus on intra-firm networks.

Studies of global construction networks have examined how perspectives that differ between teams from different countries may inhibit effective knowledge sharing, including cultural barriers, design practice norms and role redundancy (Nayak and Taylor, 2009). A subsequent study found that once members of multicultural networks identified ways to overcome cultural and linguistic difficulties, they were able to introduce new approaches and tactics that improved their performance over time (Comu *et al.*, 2010). The insights from these findings led to a simulation experiment, which found that robust network designs differ for global versus domestic project environments (Wong *et al.*, 2010). In addition, network structures are also contingent on the size of the company, with significant differences observed between network structures of large versus small-to-medium-sized companies for overseas construction projects (Park *et al.*, 2011).

Although there are an increasing number of network studies, little attention has been paid to features of individual connections within networks (Monge and Contractor, 2001; Adler and Kwon, 2002; Cummings, 2004) and the emergence of connections and networks (Monge and Contractor, 2001, 2003). Given the importance of global knowledge sharing and the dearth of studies related to intra-firm KSCs and KSNs within the AEC industry, specifically the emergence of connections across geographical boundaries, this research will fill an important gap by addressing the following questions.

- (1) What knowledge exchange patterns between geographical regions exist in a multinational engineering organization's KSN?
- (2) Why are inter-regional KSCs established in a global KSN in a multinational engineering organization? If not, why are they not?

The paper will describe the research method employed, followed by a presentation and discussion of the results.

Research method

This research utilized a mixed method that included quantitative and qualitative approaches to gather and analyse KSCs between employees within a globally distributed intra-firm KSN.

Research setting

The multinational organization studied has been offering a diverse range of engineering consulting services for over 60 years. The organization is headquartered in the UK, but is globally distributed with offices in 33 countries serving 18 markets. Working together with the organization, an existing, inter-disciplinary and globally distributed KSN, the 'sustainability CoP' was selected. The organization established CoPs to enable connections to be formed within a network and to increase knowledge sharing on a global basis. Specifically, the sustainability CoP aims to develop and share sustainability knowledge and tools across the multinational organization. Because 'sustainability' is a broad topic involving multiple disciplines, the KSN has over 1300 members, including mechanical engineers, civil engineers, environmental engineers, environmental science practitioners, etc., who are globally distributed across the organization's offices. Due to the size of the network, the organization selected employees that represented the major regions and countries in which the organization has a permanent office to participate in the research. This geographical distribution ensured that the global network was represented to determine knowledge-sharing relationships across geographical boundaries.

Social network analysis

To determine KSCs and patterns, 37 employees of the sustainability KSN responded to an ego-centric social network questionnaire delivered through *Network Genie*, an online survey system designed specifically for managing social network analysis (SNA) surveys (Hansen *et al.*, 2008). Table 1 provides information on the geographical location of the respondents. SNA

Table 1 Geographical location of network egos and alters

	Egos	Alters
Africa	4	16
Asia	7	28
Australia	3	41
Eastern Continental Europe	4	4
Middle East	1	5
North America	6	69
UK	9	88
Unknown	0	27
Western Continental Europe	3	5
Total	37	283

is a quantitative research method that can map connections and knowledge flow graphically (Moreno, 1960; Borgatti and Cross, 2003; Cross *et al.*, 2004) and provide a set of mathematical measurements about the network (Wasserman and Faust, 1994). Ego-centric SNA surveys ask respondents to manually enter and report connections that they have with others. Conversely, SNA surveys using complete networks ask respondents to select from a pre-defined list of names. In either case, the respondent answering the survey is referred to as the 'ego' and the connections egos report are referred to as 'alters'.

Thirty-seven employees responding to the survey represented 32 different offices within 19 different countries. The questionnaire employed had three categories of questions, including mechanics and dynamics questions developed from the social network model for construction (Chinowsky *et al.*, 2008), and a newly developed section regarding node attributes. On the mechanics side, the survey included questions on information and knowledge exchange. For example, respondents were asked: 'what individuals have you exchanged job-related (project or organization) sustainability knowledge or information within the last 12 months?' Subsequent questions ascertained the knowledge exchange frequency (semi-annual, monthly, etc.) and directional flow of knowledge for each of these connections. An additional mechanics question was added to determine the method of knowledge exchange. On the dynamics side, the survey elicited responses to questions asking respondents to rate the amount of reliance they have on each individual to complete their sustainability-related job tasks. In addition to the prior questions developed from the social network model for construction, we asked additional questions related to individual attributes that may influence the mechanics and dynamics of the network. These questions included the respondent's current office location, professional discipline, location of birth, business practice, generation, level within the organization, number of years

employed in the organization and prior physical locations worked. For the purpose of this article, we will focus exclusively on geographical office locations.

'Egos', or the employees responding to the survey, reported 412 KSCs across a network of 320 individuals, which included both the 'egos' and 'alters', or people who did not respond directly to the questionnaire but to whom 'egos' reported KSCs with (refer to Table 1 for geographical location of individuals within the network). In order to test the influence of attributes on the KSCs, attribute data for alters were provided by the organization. Data collected from the survey were used to identify and analyse the global KSN and KSCs within each organization using the UCINET Social Network Analysis (SNA) software (Borgatti *et al.*, 2002). The UCINET software provides the mathematical measurements for network indicators and graphical representations (Borgatti, 2002) provided in the social network analysis section. In addition to the analysis with UCINET, the research team developed a code in Microsoft Excel that analysed the relative frequency of attributes between connections for each network question.

Qualitative analysis

To better understand how and why KSCs were created and maintained and to uncover factors that impact the creation and maintenance of these connections, approximately 5% of KSN members were interviewed regarding their specific network connections (or lack thereof). Interviews and case studies are fitting for this portion of the research because they respond to questions of 'how' and 'why' (Yin, 2003; Eisenhardt 1989). Interviewees were chosen due to their KSCs that spanned or did not span boundaries. In particular, we aimed to interview respondents who had a variety of intra-regional connections as well as inter-regional connections across the globe to discern differences in establishing and maintaining these connections. We ensured that we had representation from each region, with the number of interviews roughly corresponding to 5% of the total number of connections in each region on an annual basis. Using ethnographic interviewing techniques proposed by Spradley (1979), these interviews were semi-structured using theoretical observations derived from the SNA, but open-ended to allow new insights that could explain or uncover additional factors important for establishing boundary spanning connections across geographies. The interviews had three semi-structured sections. The first addressed questions about the interviewee's background and role within the sustainability CoP. The second section focused on specific inter- and intra-regional KSCs reported from the SNA. It addressed the types of

knowledge provided and received across the connection, the frequency of knowledge exchange (for validation purposes), why and how they created the KSC and any advantages or difficulties with exchanging knowledge with the connection, particularly due to geographical location. Finally, the third section asked open-ended questions regarding the advantages and difficulties of knowledge sharing across geographical boundaries as well as the barriers and facilitators for creating and maintaining KSCs.

The interviews were recorded, transcribed and imported as transcriptions into qualitative coding software, QSR NVivo 8®. NVivo allows researchers to manage data and ideas and to query the data to report results (Bazeley and Richards, 2000). The data were analysed to discern emergent patterns from the responses (Glaser and Strauss, 1967) using the line-by-line microanalysis technique (Strauss and Corbin, 1990). To focus on how and why network connections existed, the responses were coded into categories of 'connections across boundaries', where participants described specific inter-regional KSC; 'reasons for connection', which addressed why the KSC was established; 'difficulties resulting from inter-regional KSC', which addressed reasons why inter-regional KSCs were not established and 'facilitators of knowledge connections'. Additional information was categorized into free nodes for future analysis. The results from each of the analysis method are presented in the following section.

Results

To understand the global distribution of knowledge sharing, the sustainability KSN was analysed based on connections within and across geographies for various knowledge exchange frequencies.

Social network analysis

About 412 KSCs were reported on an annual basis. The graphical representation of this annual KSN for the sustainability CoP is shown in Figure 1. Within the network figures depicted, a shape (or node) represents each individual, whereas the KSCs are displayed as lines connecting the nodes. The figure groups nodes according to the region (Asia, Australia, Africa, Middle East, UK, Eastern Europe, Europe-Other and North America). The black nodes represent individuals whose information is not known, either because they left the company or could not be identified from the survey.

Mechanics

Although the graphical network provides visual cues regarding knowledge-sharing patterns, the size of the network necessitated further analysis to determine the relative frequency of intra- and inter-attribute KSCs. A macro-script developed by the research team helped us to analyse the frequency of connections within the matrices for responses based on attributes (in this case, geographical work location) of each employee within the connection. This enabled the analysis of knowledge-sharing patterns within the organization. Table 2 provides the annual KSCs based on geographical working location (Africa, Asia, Australia, Eastern Continental Europe, Western Continental Europe, Middle East, North America and UK) of egos and alters. On an annual basis, the majority of KSCs occur between people within the same region (e.g. an employee from the San Francisco office sharing knowledge with another employee from the San Francisco office, or an employee from the New York office sharing knowledge with an employee from the Chicago office). Of the 412 annual KSCs, 62% are intra-regional KSCs, 29% are inter-regional KSCs and 9% are unknown. All regions exhibit the same knowledge-sharing patterns based on primary and secondary regional connections. For example, every region exhibits a propensity to share knowledge with others in the same region (e.g. 89% of Australian employees' sustainability KSCs are with other employees located in Australia). In addition, the majority of every region's external KSCs are with employees from the UK, the organization's home country.

These knowledge exchange patterns were analysed further to determine the influence of geographical location on knowledge exchange frequency. Figure 2 depicts the KSN for KSCs that occur at least quarterly. Of the 181 KSCs that occur quarterly, 80% are intra-regional KSCs, 14% are inter-regional and 6% are with an alter whose location is unknown. Table 3 provides relative frequencies of KSCs within each region for quarterly knowledge exchange. From Table 3, we witness increased frequencies of intra-regional KSCs for every region as knowledge exchange increases in regularity from annual to weekly exchanges. However, the importance of the home country region decreases from annual to quarterly knowledge exchanges. Specifically, three regions (Africa, Australia and Eastern Europe) maintain no KSCs with employees from the home country; the other regions still maintain the majority of their external KSCs with the UK.

Research on group communication emphasizes the need for frequent knowledge exchange to ensure the transfer of ideas between participants (Fisher, 1974). As a result, the KSN was analysed for KSCs that

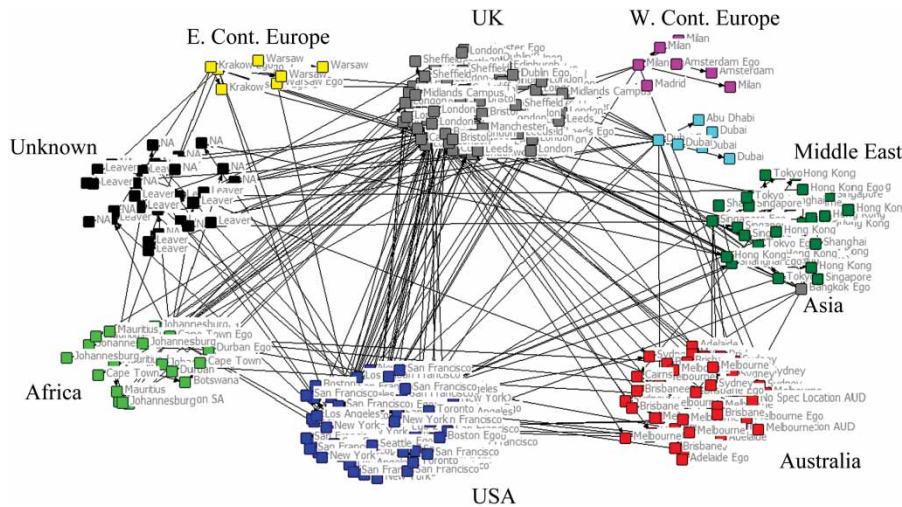


Figure 1 Annual KSCs

exchange knowledge at least monthly (Table 4) and at least weekly (Figure 3 and Table 5). These figures depict islands of knowledge sharing with weak inter-regional KSCs. Table 6 provides descriptive statistics regarding the intra- and inter-regional KSCs according to the frequency of knowledge exchange. From Table 6, we witness an increasing relative frequency of intra-regional KSCs as knowledge exchange becomes more regular. Specifically, the relative frequency of intra-regional KSCs increases from 62% of yearly KSCs to 93% of weekly KSCs. As a result, global knowledge exchange occurs on a less frequent basis than intra-regional knowledge exchange within the KSN.

Dynamics

In addition to the mechanics, dynamics related to reciprocity of knowledge exchange and reliance on the

knowledge to perform job-related duties was analysed for each KSC. For each KSC that exchanged knowledge at least quarterly, two questions were asked pertaining to the directional flow of knowledge. The first question asked was whether they provided knowledge to their KSC. The second question asked was whether they received knowledge from the KSC. Responses were combined to determine whether they provided, received or both provided and received knowledge for each KSC. Of the 148 total reported KSCs, 35% were unidirectional, meaning that they only gave or received knowledge, and 65% were bidirectional, meaning that they both gave and received knowledge with their connection. The bidirectional KSCs are positive for the global KSN, as reciprocity is important for maintaining long-lasting KSCs. The interdependent exchanges in reciprocal relationships can lessen opportunistic behaviour by providing a foreshadow where the provider of

Table 2 Relative frequency of annual KSCs by ego’s geographical region

		Ego location							
		Africa (%)	Asia (%)	Australia (%)	Eastern Continental Europe (%)	Western Continental Europe (%)	Middle East (%)	North America (%)	UK (%)
Alter location	Africa	48							5
	Asia		55					3	3
	Australia	9	13	89				6	10
	Eastern Continental Europe				28				
	Western Continental Europe				6	50			1
	Middle East						29		
	North America	5	6		17	13		70	13
	UK	25	19	7	28	13	29	16	59
	NA	14	6	4	22	13	12	5	9
	Total KSCs per region		44	47	27	18	8	17	136

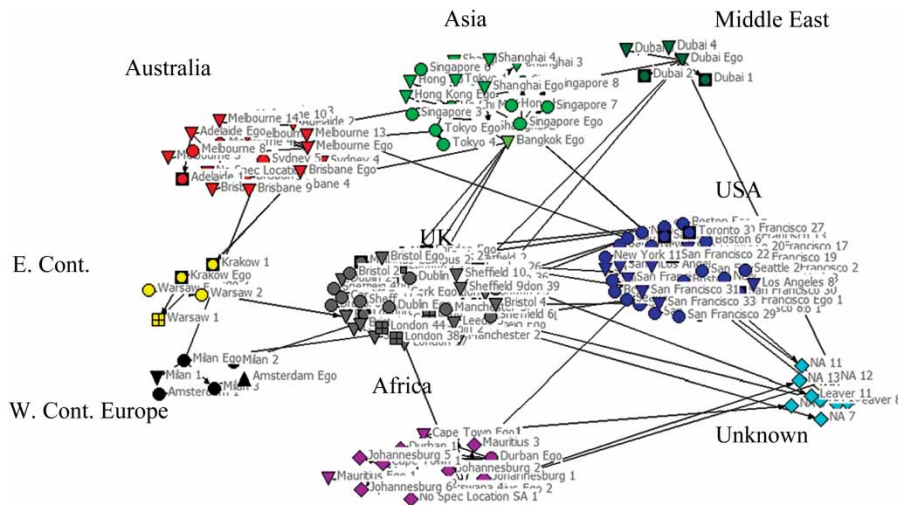


Figure 2 Quarterly KSCs

knowledge in one exchange will become the seeker of knowledge in the future. This will increase the likelihood that the knowledge provider will give the seeker the needed knowledge.

The total KSCs were analysed further to determine whether the geographical region impacts bidirectional versus unidirectional knowledge exchanges. Although the relative frequency of bidirectional versus unidirectional knowledge exchange was fairly balanced for inter-regional knowledge exchange, bidirectional knowledge exchange was almost double for intra-regional knowledge sharing when compared with unidirectional knowledge exchange (Table 7). One interviewee explained her preference for maintaining bidirectional knowledge sharing exchanges with intra-regional

colleagues and unidirectional exchanges inter-regionally: ‘across countries, knowledge exchange may be difficult for a variety of reasons, including language and time zones. However, although two-way conversations are difficult, one-way monologues are not’. Additional difficulties associated with maintaining inter-regional KSCs are described in the Qualitative analysis section.

An additional dynamics question focused on the amount of reliance an ego had on their KSCs to exchange job-related sustainability knowledge, so that they could complete their job tasks. Of the 300 KSCs whose geographical attributes are known, 68% had little-to-moderate reliance on their KSCs and 32% had above-average-to-strong reliance on their KSCs (refer to Table 8). Although the majority of connections

Table 3 Relative frequency of quarterly KSCs by ego’s geographical region

		Ego location							UK	
		Africa (%)	Asia (%)	Australia (%)	Eastern Continental Europe (%)	Western Continental Europe (%)	Middle East (%)	North America (%)		
Alter location	Africa	83							1	2
	Asia		81	5						
	Australia		6	71		20	13	1		
	Eastern Continental Europe			10	75					
	Western Continental Europe					60		1		
	Middle East						50			
	North America		6			20		84	7	
	UK			14	25			25	9	84
	NA	17	6					13	3	7
	Total KSCs per region		18	16	21	4	5	8	69	43

Table 4 Relative frequency of monthly KSCs by ego’s geographical region

		Ego location							
		Africa (%)	Asia (%)	Australia (%)	Eastern Continental Europe (%)	Western Continental Europe (%)	Middle East (%)	North America (%)	UK (%)
Alter location	Africa	80							
	Asia		79						
	Australia			100		20		2	
	Eastern Continental Europe				100				
	Western Continental Europe					80			
	Middle East						80		
	North America							91	6
	UK							5	84
	NA	20	7				20	2	9
Total KSCs per region		15	14	10	2	5	5	56	32

had little-to-moderate reliance on the KSCs, the amount of reliance was significantly less for inter-regional KSCs compared with intra-regional KSCs (80% of inter-regional KSCs had little-to-moderate reliance). A lack of reliance on another for job-related tasks will reduce the desire and effort exerted to create and maintain KSCs.

The mechanics and dynamics of the global KSN for a multinational engineering organization reveal a propensity for intra-regional KSCs. As knowledge exchange between KSCs occurs on a more regular basis, KSCs become increasingly intra-regional. Survey responses to dynamics question revealed some of the reasons for these patterns, including difficulty in establishing reciprocal ties and a lack of reliance within the KSC to complete job-related tasks. However, building from prior work and theory that highlights the importance of

inter-regional knowledge-sharing ties, the research aimed to uncover why some inter-regional KSCs were established (and why others were not). To determine these reasons and to add depth to the survey responses, approximately 5% of the egos and alters within the network were interviewed. These individuals were chosen based on their inter- and intra-regional KSCs within the network as well as ensuring representation from every region within the network.

Qualitative analysis

Interviewees were asked open-ended but semi-structured questions about their KSCs. The questions focused on why inter-regional KSCs are sparse (difficulties of inter-regional KSCs) and why inter-regional KSCs were established (reasons for inter-regional KSCs).

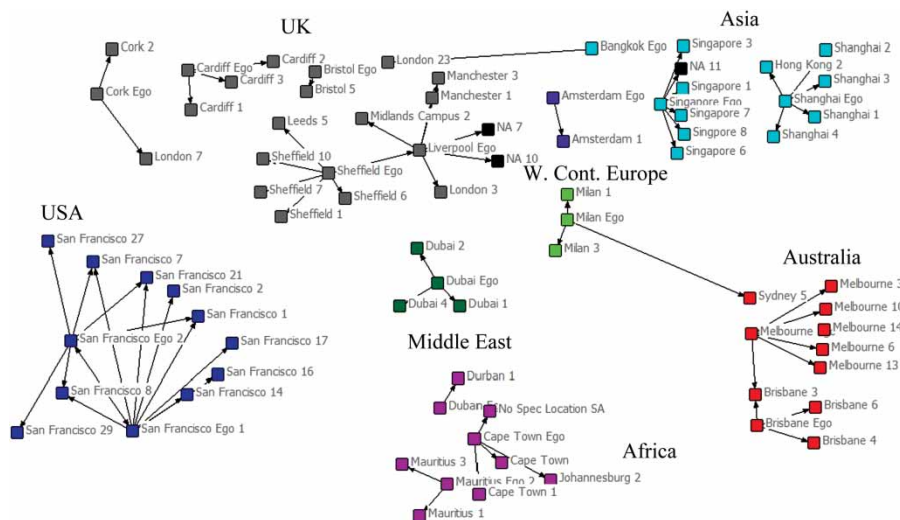


Figure 3 Weekly KSCs

Table 5 Relative frequency of weekly KSCs by ego’s geographical region

		Ego location							
		Africa (%)	Asia (%)	Australia (%)	Eastern Continental Europe (%)	Western Continental Europe (%)	Middle East (%)	North America (%)	UK (%)
Alter location	Africa	100							
	Asia		83						
	Australia			100		25			
	Eastern Continental Europe								
	Western Continental Europe					75			
	Middle East						100		
	North America							100	
	UK		8						89
	NA		8						11
	Total KSCs per region		7	12	9	0	4	3	16

Difficulties of inter-regional KSCs

Responses regarding difficulties with creating and maintaining global KSCs were grouped into three primary categories: institutional, organizational and personal. Institutional challenges included language, local contextual requirements of projects and differing institutional approaches of offices. Numerous scholars have observed challenges associated with institutional differences (e.g. see Javernick-Will and Scott (2010) for a list of institutional differences experienced in the AEC industry). As one individual summarized, ‘it gets really complicated because of time zones and language differences ... the other big aspect is that there is no singular approach to what we do—each region approaches sustainability and design differently ... this makes sharing knowledge difficult, but also very valuable’. Previous work has validated the difficulty of knowledge sharing across contexts. Gluesing *et al.* (2003) found that members gave a much greater understanding of their own context and, therefore, had less shared contextual knowledge. Because global KSNs

have differing institutional approaches according to their region and context, there are difficulties in sharing knowledge across boundaries, with conceptual misunderstandings resulting from a lack of shared experience. In contrast, members who are co-located generate greater understanding of local context and experience an easier time facilitating knowledge exchange (Tyre and Von Hippel, 1997).

Organizational hurdles included the organizational structure of business groups, the project focus within offices and resource funding, including time and rate differences between regions. Organizational structure can be a barrier in all organizations, whether national or global. As one respondent indicated, ‘There are some internal barriers to break down ... the biggest challenges are trying to get across the silos [of business practices]’. Other respondents indicated that different regional offices focus on specific project types, limiting their desire to engage in knowledge sharing with other regions. Finally, many respondents indicated a reluctance to share their knowledge across regions due to time and resource constraints. The organizational controls dictate that employees must charge a certain number of hours to projects, and within the sustainability network in particular, employees feel overly

Table 6 Relative frequency of KSCs according to knowledge exchange frequency

	Frequency of knowledge exchange			
	Yearly (%)	Quarterly (%)	Monthly (%)	Weekly (%)
Intra-region	62	84	87	93
Inter-region	29	10	11	3
NA	9	6	2	3
Total KSCs	<i>n</i> = 412	<i>n</i> = 181	<i>n</i> = 139	<i>n</i> = 69

Table 7 Relative frequency of reciprocal KSCs

	Intra-regional (%)	Inter-regional (%)
Unidirectional	34	46
Bidirectional	66	54
Total KSCs	135	13

Table 8 Relative frequency of reliance ratings within KSCs

	Intra-regional (%)	Inter-regional (%)
Little to moderate	64	80
Above-average to strong	36	20
Total KSCs	220	80

burdened as a 'free' internal resource to other teams. Ultimately, as one respondent put it, 'they [other employees] say they need a little bit of help with this and that ... but sometimes it becomes a black hole without a charging number so we end up killing ourselves and working tons of extra hours to meet our bill-ability'. Others commented that they chose not to seek the most knowledgeable people within the network because the hourly billing rate is cost prohibitive for their region and would not be accepted locally. When asked why a region exhibited intra-regional knowledge-sharing patterns, one respondent from Africa stated that 'everyone wants to charge a job number, and our rates cannot support people from expensive areas such as the UK'. According to the information processing view of organization design (Galbraith, 1974, 1977), organizations can cope with increasing complexity and uncertainty in one of the two ways. The first, reducing information processing needs by creating slack resources or eliminating interdependencies, is a limited option for multinational organizations (Ghoshal *et al.*, 1994) and does not enable the benefits of global knowledge sharing described above. The second, increasing information processing capacity through investment in the creation of lateral relations or vertical information systems, deserves more attention. Specifically, organizations might consider creating overhead codes intended to foster intra-regional knowledge-sharing ties, particularly KSCs between employees in emerging markets, with billing constraints, and experts in developed countries.

Finally, respondents indicated that personal and physical barriers hinder knowledge sharing, including reaching outside of a comfort zone, challenges finding the right people and having issues getting people to complete a task. A few respondents indicated that they observed a reluctance to create KSCs outside of a region due to the employees' concern over their English skills or simply their lack of comfort contacting someone via email, the intranet or phone whom they had not met personally. Finally, there were multiple responses regarding the difficulty of getting people to respond and complete tasks when they were located in a different region. As one respondent indicated, 'once

people get busy, then they have to start letting people down and if you are however many thousands of miles away, then you are all too easy to ignore. Especially if you get a time zone [that is so different] where realistically you can only ever e-mail them and once people know that [you can only email them], it is all too easy for them to just not take notice of your request'. The same respondent elaborated further, outlining the importance of method of interaction for maintaining a KSC, 'it is slightly easier if you are in the same time zone as a person and can give the person a call and establish a relationship ... then you can bond with them slightly which makes them more likely to feel obligated to help you out and get your project done'. Previous research finds that physical separation may increase free riding among coworkers (Kiesler and Cummings, 2002). This research has similar findings, but indicates priority-based responses to knowledge requests based on physical location. Although many people do not intend to be malicious, physical proximity to others seems to indicate an order of priority for completing tasks and sharing knowledge. This may also be attributed to the organizational structure and controls, as promotional reviews are often conducted intra-regionally with little input from other regions in the global organization.

Reasons for inter-regional KSCs

Despite the difficulties in establishing inter-regional KSCs, these connections have been shown to increase performance. As a result, respondents were also asked about their specific inter-regional KSCs to understand why these connections were formed. The responses were analysed and grouped into two primary categories: project-based reasons, including the need for technical expertise, client-based requirements or geography-based requirements; or familiarity-based reasons, meaning that they had met physically through travel or rotational assignments or belonged to a specialized group and continued to exchange knowledge within the KSN.

Project-based reasons were provided abundantly for reasons KSCs existed. Often, respondents indicated that they established an inter-regional KSC because the person was an expert in a particular area, such as climate change adaptation, or the person had developed a sustainability tool they intended to use. Sometimes, the individual had expertise in a certain market or geography. In many cases, the KSCs originated from a client-based requirement; for instance, a respondent from Africa indicated that her US-based client wanted a project she was designing to be LEED certified. Due to her unfamiliarity with LEED, she developed a KSC with a woman in the USA who shared knowledge regarding LEED and the certification process and performed a

feasibility study for the project. Other projects require specific technical expertise that is difficult for the organization to maintain within each region. Many respondents recognized that the value of the multinational organization was being able to have a diverse set of specialist experts available for global work. One employee from the UK said that ‘sustainability and many other disciplines is very broad and no one person can be an expert in every aspect... so... it is important to have a network of people who know more than you about a specific area that you can contact when needed’. In these instances, people are forced to search within the existing intra-organizational KSN to locate an expert with specific knowledge required for the project and to establish a KSC. Establishing these KSCs follows the process of ‘problemistic search’ within the behavioural theory of the firm, whereby ‘search is stimulated by a problem and is directed toward finding a solution to that problem’ (Cyert and March, 1963, p. 121). Therefore, it is expected that KSCs between employees and identified experts in the organization would increase when project- and problem-driven needs arise. Due to the propensity for KSC to be established based on project needs, it is important that the organization identifies intra-organizational experts and centres of excellence to facilitate the search process.

Organizations may also be able to increase these KSCs through internally funded projects. For instance, one of the most central employees within the network worked on a project sponsored by the organization that identified sustainability tools and processes developed in each region and shared them on the organizational platform. He travelled around the globe to collect these processes and tools from various offices and, as a result, gained tremendous knowledge, not only of the tools but also referential knowledge of ‘who knows what’. He was, therefore, able to not only make the knowledge collected regarding tools and processes available to the organization on the intranet, but also connect people together who had a common interest or need. Numerous people discussed the role he played in connecting people who would not have known about each other’s work. In this case, the organization created an internal project that necessitated a problemistic search, resulting in the creation of inter-regional KSCs with minimal organizational investment (approximately half a year of a young employee’s time).

Respondents also indicated that inter-regional KSCs were established based on familiarity with the person from prior physical proximity in an office, on a travelling assignment or due to membership in a smaller specialty group. In these cases, the person had established a KSC with an individual because they had been co-located, attended an internal project review or training session together or belonged to the same specialty group.

These opportunities for collaboration and spontaneous interaction enabled them to develop a shared history and understanding of each other’s expertise and experience. Later, they would call on these established relationships to address project needs or just to ‘have a chat to brainstorm new directions and innovations’. These KSCs were developed through shared experiences and ended up developing into long-term, sustainable KSCs over time.

Discussion

Through the examination of the data collected from the global KSN, there is a propensity for intra-regional knowledge sharing, particularly for knowledge exchange occurring on at least a monthly basis. Given the positive consequences for global knowledge sharing (Cross and Cummings, 2004; Cummings, 2004), the research aimed to better understand why inter-regional KSCs were established and why they were not established. In addition, given the need for frequent knowledge exchange to ensure continuous knowledge transfer (Fisher, 1974), the research aimed to understand why inter-regional KSCs exchanged knowledge less frequently within this network. To understand the reasons for KSC patterns, the process of KSC creation needed to be identified.

The results indicated that establishing KSCs begins with a project-based need for knowledge or expertise that requires external knowledge. Employees then engage in a search for this knowledge. They will first search within their existing known network to address these needs. This research classifies these connections as ‘stable KSC’ due to the ease of exchanging knowledge between people with a shared history and contextual understanding. In addition, existing KSCs eliminate a lengthy search process. If the employees’ existing network does not contain the adequate expertise, employees will reach outside of their comfort zone to locate the knowledge within the global KSN. These new KSCs are classified as ‘turbulent KSC’ as they require additional time to establish and face many challenges, both in establishing a new relationship and in crossing geographical boundaries, whether due to time zones, differing institutions and approaches or organizational constraints. Although boundaries may be difficult, this search process can lead to the identification of the best expert or specialist and may provide the optimal solution to address the problem. In addition, it can enable knowledge sharing across regions, cause organizational memory to develop and boost individual, project and organizational performance. However, if the problem-based need is addressed quickly, the KSC may not develop into a reciprocal KSC with frequent knowledge sharing and reliance, but rather a ‘one-off’

contractual knowledge exchange occurs on an infrequent basis. In these instances, the contractual need can be addressed quickly by providing the necessary information without necessitating the reliance and reciprocal knowledge exchange for a sustained KSC. As one respondent described a KSC within infrequent knowledge exchanges, 'that was 1 year ago... I only provided a singular piece of support and haven't been needed again'. These quick, one-off KSCs are often unilateral, providing knowledge via email or posting a response via intranet. Moreover, the reason that the majority of these inter-regional KSCs are established is to respond to a project-specific problem or need that requires specialty knowledge. Once the need is addressed, the effort required to sustain the KSC may not be warranted. Conversely, KSCs established due to familiarity may be more likely to sustain. People who interact at a meeting or in an office and develop familiarity with one another are more likely to exchange generalized knowledge that is not problem- or project-specific. As a result, relationships and knowledge exchange extend beyond a specialty need and may involve reciprocal KSC with more frequent knowledge exchanges.

Sometimes, infrequent exchanges of knowledge may be warranted. In other instances, the organization may wish to facilitate long-term relationships to discuss strategy and future directions. Once again, the responses indicated that facilitating KSC with more frequent knowledge exchanges that develop a stable KSC requires in-person meetings: 'I only feel like I have a good connection with someone or an understanding of an office if I am able to go and actually meet people or if they come to meet me. Without an in-person meeting, it is difficult to establish a relationship that can later be carried out via phone and email'. Creating a KSC by meeting in person enables a deeper level of understanding and trust between the employees and may more easily enable 'stable' versus 'turbulent' KSC to develop. This helps to facilitate the power of reciprocity and helps to prevent people from ignoring the request due to not wanting to let the person down. As a result, to spur inter-regional KSC and transition KSC from 'turbulent' to 'stable', an organization can facilitate in-person geographical transfers or sponsor inter-regional, task-specific meetings. However, almost all respondents indicated that after an initial face-to-face meeting, the method of communication for knowledge exchange (email, phone, etc.) becomes less important. Furthermore, knowledge exchange that is reciprocal and frequent, even over the course of a project, develops more 'stable' KSCs whereby the connected individuals can discuss multiple topics, including not only immediate project-based concerns but also long-term organizational strategies and goals.

Conclusion

To better understand the knowledge exchange patterns between and within geographical regions in a multinational engineering organization's KSN, the research employed social network questionnaires and analysis. Using an embedded unit of analysis of KSC, an intra-organizational network was analysed that focused on sustainability. Specifically, the mechanics and dynamics of job-related sustainability KSC were analysed within the network to discern patterns of knowledge sharing based on the geographical location of employees. The results indicated a propensity for intra-regional KSC, especially for knowledge exchanges that occur frequently on a monthly or weekly basis. The frequency of knowledge exchange has been commonly used to operationalize the 'strength' of the tie between two people (Granovetter, 1973; Hansen, 1999) and has been found to have a positive and statistically significant effect on the perceived receipt of useful knowledge (Levin and Cross, 2004). As a result, this trend for intra-regional knowledge sharing is concerned from a performance perspective. In addition, the inter-regional KSCs, as compared to the intra-regional KSCs, exhibit a tendency to be unidirectional versus bidirectional reciprocal exchanges and demonstrate a lower level of reliance within the KSC.

To better understand the reasons for these patterns and how inter-regional KSCs were established, approximately 5% of people within the KSN were interviewed. Their interviews were transcribed, imported and analysed using QSR NVivo. Respondents indicated that establishing inter-regional KSCs required a project- or problem-based need. This was especially true when effort had to be exerted to reach outside of their established knowledge networks with people external to their operating region. Difficulties of locating the appropriate person, crossing time zones and working across differing approaches, contexts and languages hindered the desire to create and maintain these KSCs—in other words, they resulted in 'turbulent' KSC. As a result, creating inter-regional KSCs would occur if people had prior familiarity with each other ('stable' KSC) or if a project-based requirement necessitated expertise outside of the region, requiring the employee to establish a KSC that crosses boundaries or a 'turbulent' KSC. These turbulent KSCs are difficult to establish and maintain due to different institutional contexts: a lack of shared experience, a lack of commitment and obligation to provide the knowledge, personal intimidation to cross boundaries and organizational constraints. Because many of these inter-regional KSCs are established due to a project-based need, they may result in 'one-off' unidirectional knowledge exchanges that are

not sustained with more frequent knowledge sharing, resulting in the trend of intra-regional KSC for frequent, reciprocal knowledge exchanges.

Because knowledge sharing between people from different geographical regions can boost performance at project and individual levels (Cummings, 2004), creating inter-regional KSCs is fundamentally important. In addition, these connections can help organizations retain the competitive advantages of a global organization. Specifically, creating lateral relations helps the organization to employ the organization's collective knowledge by making experts available across the organization's geographical reach. In turn, this avoids over-investment in slack resources, which is a strategic benefit in today's economy. Creating 'stable' KSCs is particularly relevant, as knowledge exchange extends beyond a project-specific need to enable strategic longitudinal knowledge exchange.

In order to enable the creation of KSCs across geographical boundaries and to encourage intra-regional KSCs, organizations must facilitate an understanding of 'who knows what'. For newly hired employees, a virtual 'yellow pages' is important to assist in KSC formation. Because many employees establish KSCs based on a project-specific need, organizations should also identify experts and centres of excellence to ease the search process. Many employees indicated the importance of an intranet for the search process of locating an expert with specialized knowledge of a project type, region or technical specialty. However, this research found that virtual platforms do not foster 'stable' KSC alone.

Rather, to transition KSCs between 'turbulent' and 'stable', organizations must devote resources that enable people with a common organizational goal (such as sustainability) to meet in person or to work on an external or internal project together. For instance, the organization studied created an internal project that mapped existing sustainability tools used in various regions. This helped develop an intranet reference for existing tools and a 'how to guide' regarding use of the tools. In addition, it increased referential knowledge of 'who knows what' as the researcher was able to connect people from diverse networks together and to identify experts for various tools and specialty needs on the intranet. These interactions encourage familiarity within the KSN and help to ease the hurdles associated with finding and establishing inter-regional KSCs. The organization can focus on strategically bridging network gaps by mapping employees' personal KSNs to focus on creating connections between people that can expand the networks and referential knowledge of both employees involved. This is particularly helpful when these projects or meetings include employees from various geographical locations. To create these opportunities outside of contractual projects,

organizations can provide resources to fund internal projects that strategically help identify and collect knowledge into an organizational memory and establish boundary-spanning KSC. Finally, due to the frequent mention of resource constraints and billability, organizations can reduce barriers for KSC creation by establishing overhead accounts to encourage inter-regional KSC, particularly with regions that have substantially different billing rates, such as Africa and the UK.

This work was validated using a mixed method approach including SNA, interviews and relative frequency. However, certain limitations are inherent in a network of this size. Specifically, it was impossible to survey the entire network. As a result, an ego-centric network was used with representation from all primary operating regions within the network. This limits the knowledge of the complete network and the KSC identified to the responses of the individuals completing the questionnaire. However, interviews conducted with the alters confirmed the KSC reported with them by responding egos. Furthermore, the research relied on respondents to remember and answer questions regarding with whom they exchanged job- or organization-related sustainability knowledge and how frequent these knowledge exchanges occurred. Although interviews indicated that this knowledge was often actionable, distinguishing it from information, the exact frequency of knowledge exchange and method rely on the participants' memory and accuracy of reporting. In addition, data were elicited from respondents regarding the frequency and method of knowledge exchange as well as the reliance to complete job-related tasks; however, the complexity of the knowledge exchanged was not captured. Future research may be able to collect longitudinal data through virtual platforms to validate these responses and results. In addition, future work can extend and generalize the findings by studying KSN in additional multinational organizations. Finally, research should expand attention to the influence of additional attributes, including discipline, intra-organizational groups and generations, on knowledge sharing.

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