

How Intra-firm Networks Facilitate Knowledge Flows in MNEs: Evidence from Global Virtual Teams

Abstract

Multinational companies increasingly rely on flexible organizational structures which emphasize knowledge networks spanning across national borders. We analyse two key intra-firm knowledge dimensions: (i) availability, and (ii) complementarity within global virtual teams. We draw from network theory to develop and test a conceptual framework where knowledge accumulation is revealed to be influenced by tie content (multiplexity), coordination (geographical and cultural distance), and motivation (reciprocity). Our study extends current conceptualizations of knowledge-based global virtual teams by identifying (i) structural and (ii) relational antecedents under which intra-firm information and knowledge flows are maximized. Our findings have theoretical and practical implications on effectiveness of transnational forms of organizations and the role that social networks play within them.

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INTRODUCTION

Multinational enterprises (MNEs) have become increasingly embedded within international knowledge networks, where a high degree of emphasis is placed on innovation and knowledge intensity (Mudambi and Navarra, 2004). MNE strategies consequently revolve around subdividing various economic activities to optimal geographic locations (Buckley and Ghauri, 2004, Buckley, 2009). These have simultaneously created a need towards increasingly flexible organizational structures which rely heavily on 1) non-hierarchical communication patterns, 2) reliable information, and 3) specialization of activities (Buckley, 2010; Mudambi and Navarra, 2004). Strengthened global competition thus necessitates dynamic organizational forms which are able to respond rapidly to changing economic landscapes. One response to these requirements is the global virtual team (GVT). These teams consist of two or more individuals working towards long-term common goals across geographical, cultural, and linguistic boundaries, and who interact mainly through computer-aided communications.

Improving absorptive and productive capabilities through the deployment of virtual teams and collaboration across geographical, cultural, linguistic, and temporal zones has been made possible by the internet revolution and the near universal availability of digital and computer-based applications (UNCTAD, 2005, Benkler, 2006). As a consequence, the number of GVTs has been rapidly growing over the past two decade (McDonough *et al.*, 2001; Sidhu and Volberda, 2011). Indeed, Maznevski and Athanassiou (2006) found that 85 per cent of international managers conducted more than half of their work through such teams. Within these environments, knowledge transfer through organizational social networks

underpins cooperation and provides learning opportunities, which in turn facilitate the creation of new knowledge and innovations (Kogut and Zander, 1992; Tsai, 2001). However, much of the previous research on social capital and network ties is based upon the premise that relationships are bounded by geography and national borders (i.e. Putnam, Leonardi, and Nanetti, 1993; Laursen *et al.*, 2012); an assumption which effectively overlooks MNEs pursuing global strategies by organizing work through GVTs. At the same time, it has been argued that integrating various tasks and functions in GVTs requires extensive internal networks and social capital (Gibson and Cohen, 2002; Tsai and Ghoshal, 1998) in order to overcome issues such as technological failures, communication problems, conflicts, and inefficiencies in the coordination of work flows. There are strong arguments claiming that relationships and interpersonal interactions are at the core of successful GVTs (for reviews, see Martin *et al.*, 2004 and Zimmerman, 2011). However, studies to date provide only anecdotal evidence to support these arguments. For instance, we know that strategic actions are strongly influenced by the social structure within which actors are embedded (i.e. Burt, 1982; Granovetter, 1985). But we know less about what network mechanisms may affect knowledge flows within GVTs specifically. This may be in part due to difficulties in obtaining primary data on virtual teams (Martin *et al.* 2004) as well as about individual-level knowledge exchanges (Levine and Prietula, 2012). This has often resulted in laboratory studies and use of student samples (Mortensen, 2009). Consequently, Ebrahim *et al.* (2009) note that future studies on GVTs should focus on providing empirical analyses of MNEs, assessment of patterns, and process structures. Moreover, there have been numerous calls for research that takes into account structural and relational configurations within global and virtual team settings (Martins *et al.*, 2004; Maznevski and Athanassiou, 2004; Mortensen *et al.*, 2009; Zimmerman, 2011). To the extent that MNEs utilize informal intra-firm networks for transferring information and resources, we need to understand better these *specific* structural

and relational antecedents which underpin real-life knowledge flows within transnational teams.

We posit that it is important to examine knowledge networks from both a theoretical as well as an empirical perspective. From a theoretical perspective, analysing how globally spanning networks facilitate knowledge flows between team members represents an important but under researched contingency. At the same time, current economic trends emphasize the need for flexible and dynamic structures which allow for the completion of tasks across time and distance, and the internalization of activities which were previously bound by geographical location (Buckley and Ghauri, 2004). Simultaneously, knowledge can be “sticky” and difficult to diffuse to distant units (Szulansky, 1996). By drawing from social network theory and the knowledge-based view of the firm, we develop in this paper a distinctive individual-level conceptual model which explores the network factors that facilitate: 1) the knowledge availability, and 2) complementarity of information in global virtual teams. As noted by Levine and Prietula (2012, p. 1761) analysing knowledge at the individual-level is difficult because previous research has tended to examine this mainly at an aggregate level (i.e. between firms or teams). Instead, we adopt here the view (similarly to Wu, 1989; Buckley and Casson; 1998, Buckley and Carter, 2004) that a firm consists of a coalition of active agents (actors) who respond to changing environmental situations according to their individual motivations, goals, and biases. We complement this view of the MNE by *specifically* focusing attention on the role that the interconnectedness of actors plays in the knowledge flows within GVTs. Our study thus contributes towards expanding an understanding of the network drivers of intra-firm knowledge flows at the level of the individual. This provides a unique perspective for analysing knowledge sharing among team-members who are embedded within larger formal, *as well as* informal, organizational structures.

The remainder of this paper is organized as follows. First, we analyse the role of networks and interpersonal interaction within GVTs. Second, we explore the nature of knowledge flows in terms of (i) knowledge availability, and (ii) complementarity of information. We define *availability of knowledge* as the extent to which team members are able to access information, ideas, and opportunities from their networks. *Complementarity of information* on the other hand refers to the extent to which actors are embedded within network structures that underpin likelihood of obtaining diverse and non-redundant information (Burt, 1992). We then present the conceptual framework which draws from social network theory and the knowledge-based view of the firm. The hypotheses, context of the study, and the data collection procedures are then presented. Finally, we report the research findings and contributions, discuss the limitations of the study, and suggest directions for future research.

DEVELOPMENT OF HYPOTHESES

Global virtual team

Extant research has focused on exploring the key underlying differences between distributed and virtual teams in comparison to traditional co-located organizational forms (Gibson and Cohen, 2003; Mortensen *et al.*, 2009; Sidhu and Volberda, 2011). While the GVT provides superior flexibility in terms of tapping into different pools of knowledge and expertise across geographical and national boundaries, many of the issues that co-located teams experience are further amplified in virtual and global business environments (Gibson and Cohen, 2003). For instance, virtual teams are hindered by the absence of face-to-face communication, lower familiarity with team members, and linguistic and temporal issues. (Martin *et al.*, 2004). These can become serious obstacles to the effectiveness of the GVT because establishing common understanding and shared language are key elements in ensuring effective

knowledge sharing among team members (Levine and Prietula, 2012). Perhaps not surprisingly, extant research has also found that cultural differences in GVTs manifest as interaction problems (Maznevski and Chudoba, 2001; Kayworth and Leidner, 2000) and coordination difficulties (Van Ryssen and Godar, 2000).

Communication has been regarded as a key factor in overcoming these difficulties. Interestingly, virtual teams tend to have higher degree of communication in comparison to co-located teams (Galagher and Kraut, 1994), which may indicate the need to compensate for inherent problems caused by virtuality and dispersion through extensive interaction. For example, Jarvenpaa and Leidner (1999) found a direct positive relationship between the amount of social communication and relational trust in virtual teams. The quantity of communication in virtual teams is also positively related to higher quality of relationships in terms of sociability and emotional loading (Robey *et al.*, 2000). However, authors have presented dissimilar views about the role of informal communications in GVTs versus co-located teams. To illustrate, Ahuja and Carley (1999, p.742) argue that a *high* degree of informal interaction is a defining key feature of virtual organizations because non-hierarchical network structures emphasize shared norms and procedures, and lack of formal rules. Similarly, Sole and Edmonson (2002) argue that information and situated knowledge can be informally exchanged just as effectively in virtual teams as co-located teams, but it requires more time and effort to do so. Gibson and Cohen (2003), on the other hand assert that technology-aided communication is by its very nature explicit and formal, and therefore leads (in combination with geographic dispersion) to decreased opportunities for informal and social interaction. These divergent views indicate that we do not have a clear understanding yet about the extent to which *informal* communications may influence knowledge exchanges within GVTs. This provides an avenue for developing our hypotheses.

Availability of knowledge

Previous studies of MNEs (i.e. Buckley and Carter, 1996; Mudambi and Navarra, 2004) have proposed that innovation occurs through synthesis of knowledge flows from various parts of the organization. These studies argue that the intra-firm pattern of knowledge determines the current and future potential sources of added value within the firm's network. Furthermore, access to a firm's knowledge and information stocks enhances flexibility because it facilitates forecasting and responding to internal and external changes (Buckley and Ghauri, 2004). Consequently, communication patterns within modern MNEs often tend towards networked and non-hierarchical forms as managers at different levels must be able to consult their peers and minimize the trade-off between strategic cohesion and local responsiveness (Buckley, 2010; Hedlund, 1993). However, knowledge transmission is riddled with difficulties. Tacit knowledge tends to remain localized due to its contextual nature, while codified knowledge transmits relatively easily across geographical locations and even across national borders (Mudambi and Navarra, 2004). Indeed, the availability of highly tacit knowledge is most often driven by either strong unique local competencies or specific networking capabilities (Cantwell and Santangelo, 1999). Innovation and knowledge in MNEs are centralized because of the advantages of physical co-location of R&D (Cohen, 1998), and the importance of the home market (Dunning, 1980; Cantwell, 1989). For knowledge-based GVTs, this is a detrimental scenario because their key function often is to share various types of knowledge (i.e. task-related, markets, opportunities etc.) among their team members. GVTs are especially vulnerable to the difficulties of knowledge sharing because recipients of information often tend to develop context-specific heuristics and cognitive schemas (i.e. about markets and customers) to apply the acquired knowledge (Dougherty, 1992).

Complementarity of information

Extant economic literature has long recognized the importance of bundling complementary factors together (Milgrom and Roberts, 1990, Roberts, 2004). Combining diverse knowledge resources is largely beneficial to an organisation because it increases the availability of know-how, creative capacity, and innovative capabilities which the firm can access through its networks (Glassman, 2001; Kotabe *et al.*, 2007). Previous research has provided insights into the characteristics of knowledge creation and sharing, and the necessity of interpersonal interaction in facilitating these processes (i.e. Birkinshaw, 2001; Soo *et al.*, 2002). The interplay between developing a mutual knowledge-base and an effective communication structure is a fundamental element of a successful team. For instance, Buckley and Carter (2004) argue that transmission of knowledge across national boundaries is most efficient when group members possess shared information and collective understanding. Similarly, Powell et al (2004) assert that a shared knowledge base can be established when all actors possess the same information, and when actors are aware of the knowledge which their co-workers possess. Consequently, teams will be able to avoid communication problems, misallocation of valuable information, difficulties in interpreting equivocal messages amongst other things.

The above arguments are only valid, however, when group members possess information and resources which are *complementary*, in the sense that they add value to the accumulated knowledge pool. Thus, when all team members possess the same knowledge, the information is likely to be redundant to the extent that the members may lack new insights or ideas to contribute towards common goals. This was empirically demonstrated by Maurer and Ebers (2006) who found that overly cohesive interactions led to similar information and resources among network partners, which in turn hindered firm growth. Raegans (2005) also

found that high communication frequency between people indicated high degree of knowledge overlap between the network actors. Reagans and Zuckerman (2008) argued that the ego (focal actor) wishes to maximize the amount of accessible knowledge through non-redundant information. Organizational clusters, such as different groups within virtual teams, tend to contain diverse information and expertise (Tortoriello, Reagans, and McEvily, 2012). Accessing these clusters in turn increases the amount of information and advice available to the ego. In contrast, redundancy is increased when the network contacts are contained within the same cluster and possess similar type of knowledge. Accordingly, Gibson and Cohen (2003) argued that the more diverse is the virtual team the more knowledge there is to be shared. Non-redundancy therefore depicts the actual realized information benefits in terms of complementarity of information. Thus, these network ties are additive instead of redundant (Burt, 1998), and add value to the larger context like pieces in a puzzle (Reagans and Zuckerman, 2008).

Tie content

Both knowledge availability and complementarity of information are likely to be influenced by various types of network ties (i.e. trust, like, and dislike) at the different levels of analysis (i.e. individual, team, organization). However, previous studies on the role of relationships in GVTs have overlooked the fact that individuals possess qualitatively different types of relationships which often overlap. For instance, employees may be connected by reporting relationship as well as by friendship ties. In this case, a workflow tie becomes intertwined with friendship, thus forming a “multiplex” tie, i.e. a relationship composed of two individuals sharing more than one type of network tie (Wasserman and Faust, 1994). This is an important feature of the social organization because previous studies have noted that the more that the actor dyads share overlapping relationships the further influence it has on

different attitudes (Ericsson, 1988). Multiplex relationships are often associated with both high degrees of trust and predictability because co-workers interact in different contexts (Ibarra, 1995). Friendship and social ties (i.e. interaction outside of work environment) have been noted to be especially relevant for knowledge sharing (Bell and Zaheer, 2007; Schrader, 1991) because they facilitate discussion (Ibarra and Andrews, 1993), mutual support and assistance (Heimer, 1992), and the development of a deep bond based on mutual affection and liking (Verbukke, 1979). These overlapping ties may be simultaneously difficult to develop in GVTs because of minimal face-to-face interaction and diversity of team members. Consequently, official reporting relationships might not be adequate for transferring complex and potentially context-dependent information across knowledge-based teams. We therefore postulate that a combination of friendship *as well as* workflow ties (task interdependence) is positively related to the knowledge availability and complementarity of information within GVTs. Thus, we hypothesise that:

Hypothesis 1a. Multiplex ties wherein individuals share workflow ties as well as friendship ties are positively related to knowledge availability within global virtual teams.

Hypothesis 1b. Multiplex ties wherein individuals share workflow ties as well as friendship ties are positively related to complementarity of information within global virtual teams.

Coordination

One of the key issues affecting the dynamics of GVTs is that team members are typically spread across wide geographical and cultural distances, and hence individuals experience different norms of behaviour and interpretations about how to manage their work

responsibilities. Thus, different geographical and cultural clusters are likely to greatly vary in their interpretations of issues such as responding to emails, quality and speed of communication and time-pressures, amongst other things. Tacit information has been noted to be especially difficult to successfully transmit without the medium of face-to-face interaction (Daft and Lengel, 1986). Accordingly, geographical distance between team members can have damaging consequences for successful knowledge flows (Owen-Smith and Powell, 2004). Not surprisingly, the chances of conflict in highly specialized knowledge-based teams may be greater when individuals share tasks and workflow but are separated by geographical distance (Cramton and Hinds, 2005). Conflicts arise in part because geographically dispersed individuals often assume that co-located members have more informal interaction and knowledge sharing about topics that is not being communicated to more distant members (Kayworth and Leidner, 2001). In contrast, individuals have been found to more readily share information with geographically close team members (Ingram and Roberts, 2000). At the same time, the knowledge embedded within distant parts of the network is likely to be diverse and non-redundant due to team members' dissimilar educational, social, and institutional backgrounds. Therefore:

Hypothesis 2a. Geographical distance is negatively related to knowledge availability within global virtual teams.

Hypothesis 2b. Geographical distance is positively related to complementarity of information within global virtual teams.

Differences in language, social norms, knowledge specialization, as well as professional and personal identities can hinder the flow of information and resources within MNEs (Buckley and Carter, 2004). More specifically, differences in developing shared understanding,

common expectations, and rules of behaviour. In turn, these are likely to induce feelings of discomfort and confusion (Gibson and Cohen, 2003). Similarly, lack of cultural skills and an inability to activate appropriate behavioural models when interacting with people from different cultural backgrounds can lead to performance anxiety (Stajkovic and Luthans, 1998; Wood and Bandura, 1989). An important variable in here is the degree of discrepancy between the norms the native culture and norms of related to foreign cultural interactions (i.e. Molinsky, 2007). In international business literature, this is most commonly referred to as cultural distance (i.e. Chapman *et al.*, 2008; Shenkar, 2001, 2012). Not surprisingly, both interpersonal and task-related conflict have been found to be most emphasized in interpersonal interactions which span across countries and cultures (Hinds and Mortenson, 2005). Cultural conflicts in turn have been found to hinder knowledge acquisition (Lyles and Salk, 2007). Thus, we hypothesize:

Hypothesis 3a. Cultural distance is negatively related to knowledge availability within global virtual teams.

Hypothesis 3b. Cultural distance is positively related to complementarity of information within global virtual teams.

Motivation

Motivation to share information and resources has been identified as a key factor in knowledge-based organizations (Cohen and Levinthal, 1990; Szulanski, 1996).

Contemporary learning in organizations in turn has been characterized to occur through the connectedness of motivated units within flexible organizational networks where learning is facilitated by non-hierarchical architecture (Huber, 1991; Tsai, 2001). Motivation of the group members to share knowledge may be promoted through the building of trust and

identification with the firm's goals (Casson, 1991). Extant international business literature has revealed that knowledge transfer can only be successful when both "transferors" as well as "receivers" of information are willing to participate (Oddou *et al.*, 2009). One of the key motivational factors underpinning the sharing of knowledge and information is reciprocity in interpersonal interactions; that is, the extent to which individuals promote coordination and cooperation (such as returning advice and favours) with their network contacts. Reciprocated relationships tend to be stronger by nature (Krackhardt, 1999), and non-reciprocal interactions are also often quickly noted by other group members, and explicit or implicit sanctions may follow (see Gouldner, 1960). Finally, solving complex problems and sharing tacit knowledge in organizations has been linked to the development of reciprocal norms of trust and disclosure (Mariotti and Delbridge, 2012). We therefore hypothesize that:

Hypothesis 4a. Reciprocal network interactions are positively related to the knowledge availability within global virtual teams.

Hypothesis 4b. Reciprocal network interactions are positively related to the complementarity of information within global virtual teams.

Hence we identify three distinct factors affecting intra-firm knowledge flows: (i) tie content (multiplexity), (ii) coordination (geographical and cultural distance), and (iv) motivation (reciprocity). These are summarized in the figure 1 below.

[Insert figure 1 here]

RESEARCH METHODS

Data were collected from 36 global virtual teams in three high-technology companies. Two companies were involved in providing high technology solutions to construction industry and

one firm specialized in telecommunications and professional electronics. All three companies were therefore connected by high degree of knowledge-intensity and an environment driven by global competition. Working titles such as development manager, product manager, application specialist, sourcing manager, component engineer, and customer service manager were all common in the participating teams. All 36 teams were therefore highly knowledge-based and drew their competitive advantage from effective transfer of knowledge resources and expertise of team members.

The survey administered to 160 employees received an average response rate of 82%, which is well within accepted boundaries when using a whole network approach (Wassermann and Faust, 1994; Kossinets, 2006). The teams were geographically dispersed across 19 countries and 50 geographical locations. A considerable amount of interaction and coordination between team-members therefore takes place through virtual and computer-aided systems. Before data were collected, interviews and discussions took place with the Chief Executive Officers and managers of the companies. The purpose was to establish a connection between scientific explanation and context, which has been suggested an especially important issue in cross-border settings (see Welch *et al.*, 2011). During internal discussions the managers stated that the formation of knowledge networks within their organization had previously been a topic of interest (and one of some concern). Preliminary stage of investigation led to the inclusion of coordination of exchanges between individuals and groups as a key focus of study. Initial interviews clarified that knowledge diffusion among team members was considered to be one important key to success, and that no single individual could be responsible for holding all of the firm's knowledge (see Buckley and Carter, 2004). Participating teams were relatively small and, it was possible therefore to use a whole-network approach. Name rosters helped to reduce measurement error, to assist with recall,

and to enhance overall measurement reliability (Mardsen, 1990). Variables are described in more detail in the table below.

[Insert Table 1 here]

ANALYTICAL PROCEDURES

We tested each of our hypotheses by conducting a node level quadratic assignment procedure (QAP) regression. The QAP approach provides a robust indicator of unbiased significance levels and standard errors because it preserves the dependence in both the dependent and independent variables. We started our analysis by examining the proportion of variance between formal and informal communication. *Informal* communication ties (“mutual dealings, exchanges, and communications”) were regressed with *formal* ties (workflow-based communication structures), and the variance explained was less than 8 per cent ($R^2 = 0.076$). Therefore, there is a significant discrepancy between informal and formal communication in GVTs, and a substantial amount of informal communication takes place outside the formal team structure. This gave us an indication that, even though communications in GVTs have been argued to be (i) direct and explicit, (ii) frequently documented through technology, and (iii) limited in non-verbal cues (Gibson and Cohen, 2003), only a minimal amount of interpersonal interaction occurs through officially structured work flows. We then continued to analyse the hypotheses.

RESULTS

First, correlations and descriptive statistics were generated (see table 1 below). This was followed by a regression analysis of the factors affecting the flow of information (information flow models) and knowledge redundancy (redundancy models) (table 2 below).

[Insert Tables 2 and 3 here]

Hypothesis 1a and 1b predicted that multiplex ties where actors shared a workflow tie as well as a friendship tie would be positively and significantly related to both knowledge availability and complementarity of information. The t-statistics were significant in models four and ten, and the R^2 values increased by six per cent and two per cent, respectively. Hence, hypotheses 1a and 1b were generally supported, despite a relatively weak effect in relation to H1b.

Hypotheses 2a predicted that geographical distance between actors decreases knowledge availability within the organisational network. This hypothesis was not supported, and surprisingly, the coefficients were significantly positive. Therefore, geographical distance, in fact, was found to *increase* the knowledge availability (R^2 change 0.18 from the baseline model). Correspondingly, hypothesis 2b was supported, and geographical distance between network members significantly increased information complementarity (R^2 change 0.12 from the baseline model). Thus, physical distance between actors had considerable beneficial effect in terms of knowledge flows in GVTs. Hypotheses 3a and 3b followed a similar pattern. The effect of cultural distance on knowledge availability was unexpectedly positive, and complementarity of information also increased with a higher degree of cultural distance. Cultural distance variables improved the explanatory power of our model in terms of R^2 changes of 0.08 and 0.06 (knowledge availability and information complementarity, respectively). Finally, hypotheses 5a and 5b predicted that reciprocal network interactions will be positively related to both knowledge availability and complementarity of information. Both hypotheses were supported. Reciprocity variables in both models had positive and significant t-values (models five and eleven). These increased the R^2 values in knowledge availability models by eight per cent and complementarity of information models by nine per cent.

DISCUSSION

Extant research has increasingly noted that organization's ability to access and transfer knowledge has a significant impact on innovation, creativity and product development (Carlile, 2004; Tortoriello, Reagans, and McEvily, 2012). Even though organizational networks are critical for this process, we still have a limited understanding on *specific* intra-firm network mechanisms which contribute to knowledge flows on a global scale. We set out to analyse networks within global virtual teams to unpack the factors which facilitate (i) knowledge availability and (ii) complementarity of information within these teams. As we hypothesized, organizational knowledge flows were significantly influenced by tie content (multiplexity), coordination (geographical and cultural distance), and motivation (reciprocity).

Various types of ties and multiplexity have been previously found to promote information flows in domestic settings (Heimer, 1992; Bell and Zaheer, 2007). However, we demonstrate in this study that the overlap between friendship and workflow ties helps in overcoming some of the inherent difficulties (i.e. language differences, technology-based communication, context-dependent nature of information) regarding knowledge availability and complementarity of information in GVTs. The result that overlapping workflow ties and friendship ties provided a superior platform for accessing knowledge is in line with previous studies showing that informal ties are more resilient to geographical dispersion than are formal ties (Hansen and Lovas, 2004). Thus, it could be that the friendship component of the relationship in, combination with workflow, facilitates information flow through beneficial mechanisms such as affection, helping, predictability, and trust (Schrader, 1991; Ibarra, 1995). At the same time, friends may over time develop a shared knowledge base through sustained information exchanges. This may explain partly why we found only minor support for an argument that friendship would increase complementarity of information. In other words,

while friendship may be effective for sharing information across teams globally, it may over time become increasingly redundant as people learn more and more from each other.

Friendship ties may also help to reduce the effect of geographical and cultural distance between actor dyads. Previously, Bell and Zaheer (2007) found that friendship ties actually increases knowledge-seeking behaviour as firms become increasingly geographically dispersed. While they drew from a sample of Canadian firms, we extend the observed positive effects of geographical dispersion and cultural distance on availability of knowledge and complementarity of information to *globally* distributed teams. Considering these findings, it is not surprising that geographical and cultural distance variables have a reverse effect within the hypothesized model. Knowledge availability and complementarity of information should increase along with the heterogeneity of the contexts (i.e. cultural, institutional, and markets) from which the knowledge is extracted. Finally, technology-aided communication may mitigate some of the pitfalls associated with cross-cultural interaction in GVTs. Interpreting ambiguous messages may become easier through technologically aided communications as the recipient has more time to cognitively unpack the message and formulate an appropriate reply. Consequently, uncertainty reductions observed in computer-mediated communications (Tidwell and Walther, 2002) may mitigate conflicts and miscommunications often observed in international business environments (i.e. Shenkar and Zeira, 1992; Leung et al., 2005).

Finally, the motivation to reciprocate in knowledge sharing activities has been found to significantly contribute to effective information flows. This finding is in line with those of Oddou *et al.* (2009) in that both transferors as well as receivers are needed for successful knowledge and information flows. Further, social sanctions may be applied to individuals who do not follow reciprocity norms relating to knowledge sharing (Gouldner, 1960).

Interpreting such implicit social norms should be relatively intuitive even for culturally and geographically distant actors, as the reciprocity has been argued to be a universally applicable principle that permeates all human interactions (Thurnwald, 1932; Gouldner, 1960). One argument could be that information exchanged through reciprocal network may become less complementary in a same way as through multiplex ties. However, this was not evident in the context of GVTs. Instead, reciprocal interactions in sharing knowledge were strongly linked to complementary and diverse information. This could be due to actors' willingness to reach towards distant parts of their network in order to find different potential ways for fulfilling the norm of reciprocity (i.e. in returning important favours to their co-workers). Overall, the strength of reciprocity norms in GVTs was surprising considering different types of distances between actors (physical and cultural) as well as infrequent face-to-face interactions.

LIMITATIONS AND FUTURE RESEARCH

First, our cross-sectional data do not allow a causal direction to be established. We cannot discern whether multiplex ties affect the flow of information and resources, or whether the fact that a person is a good source of information could lead to greater interaction and further development of that relationship into the friendship domain. Future studies should include longitudinal research designs which capture the directionality between variables and examine the dynamic nature of international networks over time (i.e. co-evolution of network structures and affective states in flow of knowledge, information, and resources). This would also allow examination of how bonding between team members may over time dispel the effects of geographical and cultural distances in GVTs. Second, the types of ties that can arise between actors at different levels of analysis are numerous. We focus on communication, workflow, and friendship, but future studies could investigate various other relationships such as trust, conflict, and dislike. Reciprocity has been found to vary depending on the type of

exchanges (i.e. emotional versus instrumental) (Rook, 1987). This may have implications for knowledge flows in networks consisting of different types of ties. It is also important to explore potential moderating variables which may affect formation of different types of ties in GVTs. Use of various technologies (i.e. Skype, intranet, and videoconferencing) could moderate the nature and types of ties that form between team members.

Third, even though our variables were found to have a significant positive effect on both knowledge availability as well as complementarity of information, these benefits may be dependent on the type of knowledge and information concerned (i.e. tacit versus formal). For example, Ho and Levesque (2005) postulate that multiplexity may become less useful the more organization wide the information is: in other words, if the information is widely available through multiple channels then there is little need for deeper multiplex ties. Finally, while we model knowledge flows in terms of knowledge availability and complementarity of information, future studies may extend our findings into more explicit knowledge dimensions including innovations, product development, and patent citations for example. Unfortunately, exploration of issues regarding utilization and taking advantage of organizational knowledge stocks is beyond the scope of our study. As noted by Forsgren and Pedersen (2000), taking advantage of the knowledge benefits can be a challenge for MNEs to overcome. A question future studies may wish to ask is whether the knowledge availability and complementarity of information in MNEs *actually* leads to increased innovative capacity.

CONTRIBUTIONS

Our study fits well with two key issues in MNE literature: (i) how to organize international activities flexibly while maintaining reliable information, specialization of activities, and non-hierarchical structures (Buckley, 2010; Mudambi and Navarra, 2004), and (ii) discerning the extent to which networks and embeddedness plays a role in effective functioning of a

global firm (Coviello, 2006; McDermott, 2009; Ellis, 2010). We provide three contributions to the understanding of social networks and the GVTs. First, it extends research on knowledge-based GVTs by introducing social network concepts such as redundancy, and multiplexity into this stream of research. We ascertain that such network properties underpin sharing of information and resources within GVTs. This study likely represents the first systematic attempt to discern how the structure of a network and network relationships are linked to information sharing within these teams and from empirical standpoint. Thus, we elaborate the nature of networks within global teams and the conditions under which they can facilitate competitive advantage through the promotion of information, resources, and knowledge flows. This study also provides new insights into conceptual novelty of several key elements of variables affecting the knowledge flows as well as the nature of knowledge itself, thus forming a foundation upon which future research should be able to build when investigating knowledge sharing within MNEs from an organizational network perspective. Finally, our results have implications for managers. An important question is how factors positively affecting knowledge creation and sharing can be maximized. Our study examined several mechanisms which can facilitate these processes, and managers should strive to create an organizational environment and culture which makes it easy to structure interpersonal interaction accordingly. Overall, this study helps to unravel how MNEs can extend their resource base and build new organizational advantages by managing increasingly complex internal networks across national borders. By examining potential impediments for effective resource combination and utilization within organizational networks, this study contributes towards finding new ways by which multicultural teams may realize their full potential. Our study draws on ideas and methods from several disciplines in order to advance a fundamental understanding of the *social* context of the multinational company, resulting in contribution that could not have been obtained through a single-disciplinary lens.

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TABLES AND FIGURES

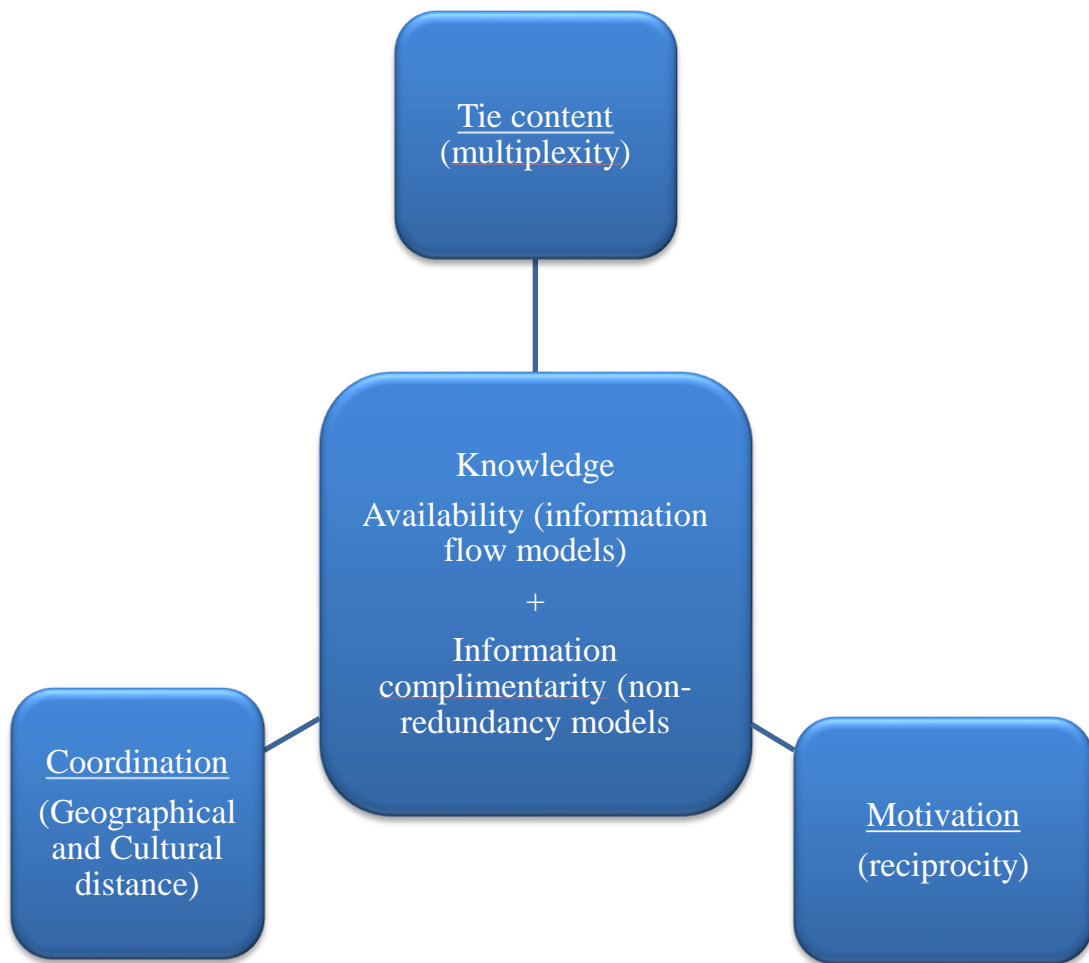


Figure 1 Conceptual model

Table 1 Variables

Variable	Operationalization of variable	Variable type	Model
Knowledge availability	Respondents evaluated on a scale of one to six how “good a source of information, ideas, and opportunities” their network contacts were perceived to be.	Dependent	1-10
Complementarity of information	Measure dichotomized from knowledge availability ties (where ties one to three were zero and ties four to six were one) by using inverse value of Burt’s (1992) dyadic redundancy measure.	Dependent	1-10
Gender	A matrix where actors <i>i</i> and <i>j</i> were connected if they had the same gender.	Control	1-10
Co-location	A matrix where actors <i>i</i> and <i>j</i> were connected if they had the same geographical location.	Control	1-10
Team membership	A matrix where actors <i>i</i> and <i>j</i> were connected if they belonged to the same team.	Control	1-10
Supervisory position	A matrix where actors <i>i</i> and <i>j</i> were connected if they were both supervisors.	Control	1-10
Geographical distance	Direct distance between dyads measured from Google Maps.	Independent	2 & 7
Cultural distance	Kogut-Singh (1988) index with GLOBE (House, 2004) values.	Independent	3 & 8
Multiplex ties	Combination of a friendship and an official workflow. Friendship ties was proxied from a question where respondents evaluated their network contacts on a scale of one to six (disagree-agree) whether they “meet with this person outside of work (e.g. for coffee, meals, or social events)”. The friendship matrix was dichotomized so that values from one to three were zero and values from four to six were one. These were combined with official work flow ties. In the final matrix, multiplex ties were one and other ties zero.	Independent	4 & 9
Reciprocity	$i \leftrightarrow j$, Knowledge-flow matrix (constructed from actors’ perceptions of another as a good source of “information, ideas, and opportunities”) was recoded so that values four to six were one and other values and non-reciprocal interactions were zero. Thus, the remaining ties responded to reciprocal knowledge exchanges.	Independent	5 & 10

Table 2 Regression coefficients and significance levels

	Mean	SD	1	2	3	4	5	6	7	8	9	10
1. Information flow	0.27	1.11	1									
2. Non-redundant ties	0.04	0.15	0.80***	1								
3. Physical proximity	0.04	0.20	0.30***	0.28***	1							
4. Gender	0.59	0.49	0.00	0.01	-0.02***	1						
5. Supervisor	0.51	0.50	-0.01	-0.01*	0.00	-0.01	1					
6. Team members	0.03	0.17	0.30***	0.25***	0.21	-0.01	0.00	1				
7. Geog.distance	59.66	439.00	0.45***	0.49***	-0.03	0.02	0.00	0.11***	1			
8. Cult.distance	0.03	0.18	0.51***	0.61***	-0.02	0.01	0.00	0.13***	0.63***	1		
9. Multiplex	0.07	0.37	0.41***	0.34***	0.25	-0.01	0.00	0.95***	0.16***	0.20***	1	
10. Reciprocity	0.02	0.15	0.65***	0.49***	0.22	0	-0.01	0.26***	0.29***	0.27***	0.35***	1

Notes. 10,000 permutations, $p^* < 0.05$, $**p < 0.01$, $***p < 0.001$

Table 3 Regression of factors affecting intra-firm knowledge flows

KNOWLEDGE AVAILABILITY MODELS					COMPLEMENTARITY OF INFORMATION MODELS					
1	2	3	4	5	6	7	8	9	10	
Physical proximity	0.25***	0.27***	0.28***	0.23***	0.16***	0.24***	0.27***	0.27***	0.24***	0.17***
Gender	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Supervisor	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.01
Team members	0.24***	0.19***	0.17***	-0.60***	-0.38***	0.22***	0.18***	0.16***	-0.07***	-0.01
Geog.distance		0.43***	0.2***	0.2***	0.16***		0.35***	0.14***	0.14***	0.09***
Cult.distance			0.36***	0.29***	0.25***			0.33***	0.28***	0.22***
Multiplex				0.83***	0.55***				0.28***	0.14***
Reciprocal dyads					0.32***					0.35***
R ² .	0.15	0.34	0.41	0.47	0.55	0.14	0.26	0.32	0.34	0.43
R ² .adj	0.15	0.33	0.41	0.47	0.55	0.14	0.26	0.32	0.34	0.43
R ² . Change	-	0.18	0.08	0.06	0.08	-	0.12	0.06	0.02	0.09
Sig.	p>0.001	p>0.001	p>0.001	p>0.001	p>0.001	p>0.001	p>0.001	p>0.001	p>0.001	p>0.001

Notes. 10,000 permutations, 25,400 observations, $p^* < 0.05$, $**p < 0.01$, $***p < 0.0$