

LEVERAGING ALLIANCE NETWORKS THROUGH INFORMATION TECHNOLOGY: EVIDENCE FROM PANEL REGRESSIONS

Completed Research Paper

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Abstract

Despite the expectation that Information Technology (IT) is valuable in managing and leveraging multiple alliance relationships and the resultant alliance networks, a paucity in theoretical and empirical examination persists in the literature. Employing social network analysis (SNA), we examined whether IT investment moderates the effect exerted by a firm's structural properties in alliance networks (direct partners, indirect partners, and structural holes) on its performance. Drawing upon previous research on dynamic capabilities and the knowledge-based view of the firm, we propose a conceptual model and discuss a potential underlying mechanism. Our empirical analysis of 306 U.S. public firms, which provide 971 observations during an 8-year span from 1998 to 2005, suggests that IT investment helps firms to (1) manage the burden of increasing complexity in coordinating multiple alliances, and (2) overcome the relative informational disadvantage resulted from their limited access to indirect partners and structural holes.

Keywords: Alliance networks, IT capabilities, Dynamic capabilities, Knowledge-based view, Panel regression analysis

Introduction

“We have found very few sectors where a single class of partners or even a single partner within a group enables us to address our key concerns. Our approach has been to generally follow a multipronged approach, with different time horizons and priorities across our partner portfolio. - Steve Steinhilber, Vice president of Strategic Alliances at Cisco” (Steinhilber 2008)

Multiple alliance partnerships have become indispensable in today’s business environment, even as industrial knowledge bases have become increasingly large and complex (Powell et al. 1996). An alliance allows two or more independent firms to exchange, share, or co-develop resources or capabilities to achieve mutually relevant benefits through a contractual arrangement (Gulati 1998; Kale and Singh 2009). However, an emerging consensus in the corporate world asserts that firms can no longer rely on single high-profile alliances and must instead leverage a *portfolio* of alliances that provides access to the external resources that they need to survive (Gomes-Casseres 1998; Hoffmann 2007). As a result, most firms try to achieve their strategic goals by leveraging several coordinated alliances with multiple partners. A corporate “snapshot” provided by Dyer et al. (2001), for example, revealed that the top 500 global business organizations had an average of 60 major alliances apiece. These complex webs of interfirm alliances, often referred to as alliance networks, have been shown to accelerate the creation and distribution of knowledge through interfirm collaboration. Moreover, the structural properties of a firm operating within such interconnected systems are considered to be important determinants of the quantity and quality of information that a firm acquires from its network (Ahuja 2000; Gulati 1998; Schilling and Phelps 2007). However, the extent to which a firm benefits from its alliance network can be contingent on other factors, including the firm’s internal capabilities. Relationship management within a complex alliance network requires a new set of firm capabilities. Increased scope, scale and interdependency among alliances raise new and important administrative issues that are distinct from those of individual alliances, such as resolving potential conflicts between alliances and coordinating the internal and external resources accessible through such partnerships (Duysters et al. 1999; Gulati 1998; Hoffmann 2007; Parise and Casher 2003; Wassmer 2010).

This study is motivated by many real-world examples of how information technology (IT) can influence the effect of an alliance network on firm performance by enhancing the firm’s internal capabilities. IT may support firms in mitigating the managerial challenges that arise from multiple partnerships and may serve as vehicles for acquiring and exploiting external knowledge. For example, many firms active in alliances such as Fedex, Cisco Systems, and Ernst & Young are equipped with IT applications and databases that provide real-time information on all existing partnerships, and allow alliance managers to easily access this database on a tiered basis to obtain information about on-going alliances. These IT tools, which are specifically designed for the management of alliances, may enable firms to prevent potential conflicts of interests between alliances and to leverage current partnerships for future business opportunities (Corporate Strategy Board 2000; Gomes-Casseres 1998). In addition, corporate-level IT, such as ERP systems, instant messaging and knowledge portals, may be used to facilitate coordination, communication, and knowledge sharing among employees who are working for different alliances. In addition, information acquisition and processing capability enhanced by Business Intelligence (BI) systems have greatly increased the amount of information and knowledge made available to firms from external sources, including but not limited to alliance networks (Chi et al. 2010). This type of IT-enhanced capability could conceivably increase or decrease the needs and benefits of knowledge acquired from alliance partners. However, prior information systems (IS) studies on inter-organizational relationships, which have traditionally focused on relation-specific or partnering issues and transactional aspects, are relatively silent with respect to issues concerning the leveraging of multiple alliance relationships. As Chi et al. (2010) have noted, “issues such as designing a firm’s technology infrastructure to better exploit the benefits afforded by alliance networks are important aspects that deserve research attention yet remain underexplored”.

This study explores what influence IT investment will have on the relationship between alliance networks and firm performance. It adopts a perspective that focuses on a focal firm’s egocentric alliance network (Wassmer 2010), an approach which allows considering not only direct alliance partners, but also relationships *among* a firm’s partners (i.e. a local network configurations that is often characterized as the

access to structural holes) as well as the partners of its partners (indirect partners). By employing social network analysis (SNA), this study empirically investigates whether a firm's IT investment increase or decrease the performance impact of having more number of direct and indirect partners and of spanning structural holes, using the data of 306 U.S. public firms, which provide 971 observations during an 8-year span from 1998 to 2005. The analyses show that IT investment provides greater benefits for firms (1) with a greater number of direct partners, (2) in a network lacking structural holes, and (3) with a fewer number of indirect partners. Our results provide evidence that IT investment help firms (1) reduce the burden of increasing complexity in coordinating multiple alliances and (2) overcome the relative informational disadvantage resulted from their limited access to indirect partners and structural holes.

Background Literature

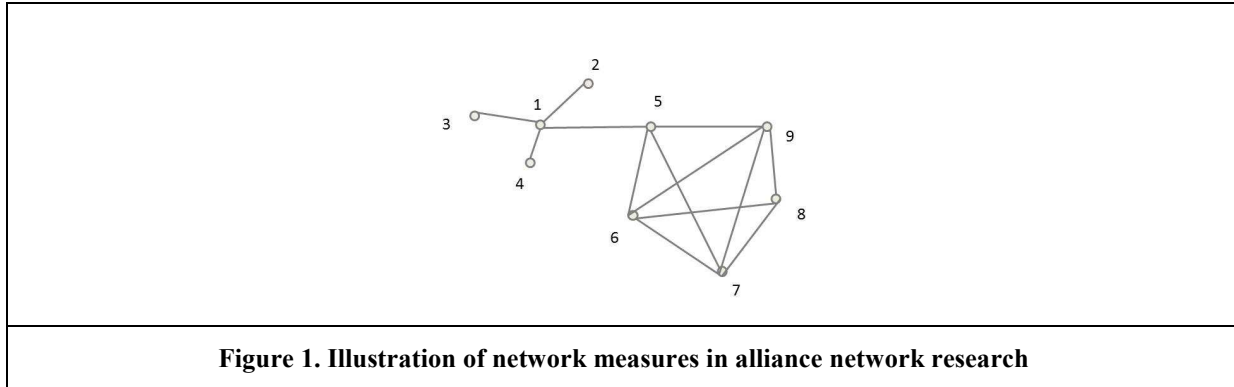
IT Business Value and Interorganizational Relationships

IT business value research has identified a diverse set of internal firm characteristics, such as work composition (Francalanci and Galal 1998), diversification (Chari et al. 2008), and manufacturing capabilities (Banker and Bardham 2006), of which impact on performance influences or is influenced by a firm's IT investment. However, with a few recent exceptions (Chi et al. 2010; Chiasson and Davidson 2005), external firm factors, especially interfirm networks, have rarely been investigated in depth.

IS researchers studying interorganizational relationship management have examined various issues that pertain to the impact of IT on organizational performance in interorganizational relationships. For example, researchers examine the effect of efficiency gains via IT on firm size (Brynjolfsson et al. 1994; Clemons and Row 1992; Gurbaxani and Whang 1991) and the number of suppliers of a firm (Banker et al. 2006; Malone et al. 1987), the effect of a specific type of IT, such as interorganizational systems (IOS), and a firm's ability to use IT for its partnering issues, such as IT integration and IT flexibility (Gosain et al. 2004; Klein and Rai 2009; Malhotra et al. 2005, 2007; Rai and Tang 2010; Saraf et al. 2007; Tafti et al. *forthcoming*). Some researchers consider IT to be a key determinant of a firm's information processing capability and examine the impact of the alignment between the needs and the capability for information processing in each relationship on firm performance (Bensaou and Venkatraman 1995; Malone and Rockart 1991; Mani et al. 2010; Premkumar et al. 2005). Our review concurs with the assertion of Malhotra et al. (2005) that IS studies on interorganizational relationship issues have tended to focus either on the supporting IT interface or the relational aspect of IT-supported interorganizational interactions. Though studies in this vein provide insights for improving the effectiveness of interorganizational processes, the prospective application of these frameworks to the issues arising from leveraging *multiple* relationships from a focal firm's perspective is somewhat limited.

Alliance Networks and Firm Performance

Earlier alliance network studies proceeded from a social network perspective, which argues "that economic actions are influenced by the social context in which they are embedded and that actions can be influenced by the position of actors in social networks" (Gulati 1998 p. 295). These studies focused on identifying the structural properties of a firm in an alliance network that influence its performance. Key structural factors examined in prior studies include the number of direct and indirect partners (Ahuja 2000; Powell et al. 1996) and the local relationship configuration among direct partners, which are often characterized as structural holes (disconnections between a firm's partners) (Burt 1992; Chi et al. 2010; Coleman 1988). We illustrate these network measures in Figure 1, where each node represents a firm, and a link between two firms indicates an alliance relationship between them. The direct partners refer to the firms with which a focal firm has a direct alliance partnership. For example, Firm 2, 3, 4, and 5 are the direct partners of Firm 1. On the other hand, indirect partners refer to the firms that share common alliance partners but do not have direct interactions with a focal firm. For Firm 1, Firm 6, 7 and 9 are indirect partners via Firm 5. Firm 8 is also considered as an indirect partner of Firm 1 with three steps via Firm 5 and Firm 9. Structural holes describe the degree of disconnectivity between a firm's direct partners in a network. A firm in a network rich in structural holes is the one that keeps a unique brokerage position connecting others that do not have direct links with each other. For example, in Figure 1, Firm 1 is



considered to span greater structural holes than Firm 8. Alliance network research has shown that that the quantity, quality, and diversity of resources the firm can leverage from its network are determined by these structural properties.

Recent research has begun to emphasize that the value that a firm derives from its alliance networks depends not only on the structural properties of a firm within alliance networks, but also the internal firm capability to leverage the new resources originating from alliances (Hoffmann 2007; Wassmer 2010). This research focuses on the managerial issues generated by interdependencies between alliances and internal processes and between alliances themselves. Because alliances are often initiated and executed at a business unit level in many organizations, and alliance managers tend to cultivate a narrow focus that is specific to the scope of their discrete markets, they “may be completely unaware of any impact their decisions might have on the broader cross-company relationships” (Steinhilber 2008). On the one hand, a given alliance may jostle with another in the portfolio for the firm’s physical or managerial resources, potentially degrading or offsetting any advantage the partnership would otherwise create. On the other hand, the value of an alliance can be enhanced by the presence of another alliance in the portfolio, such as providing complementary offering and promoting similar standards or infrastructure. (Parise and Casher 2003). Such positive or negative dependencies prevail among alliance interdependencies. Accordingly, recent alliance research advises firms to consider their entire set of individual alliances as a portfolio and to take a portfolio approach in managing alliances (Hoffmann 2007; Kale and Singh 2009; Wassmer 2010). Firms require a capability that “comprises multiple dimensions, including the skills to configure an alliance portfolio (to create a set of complete, noncompetitive, and complementary alliances), to foster and maintain trust across different alliance partners in the portfolio, to resolve conflicts between alliances in the portfolio, to coordinate strategies and operations across alliances in the portfolio, to create routines to share operational know-how across alliances in the portfolio, to monitor the extra-additive benefits (and costs) that arise due to interaction between different individual alliances in the portfolio, and so on” (Kale and Singh 2009 p. 57). In addition, with the consideration of the significant variance in resource bases across firms, Chi et al. (2010) suggest that access to external knowledge through alliance networks may on occasion be of no *additional* use for some firms if those companies already possess an alternative mechanism for accessing equivalent resources. If a firm already possesses a significant proportion of the knowledge flow of the network, the additional access to information provided by alliance networks may represent only a marginal expansion in its knowledge base and provide little value. The findings of this stream of research heighten the need to carefully assess the capabilities of a firm, in addition to the structural properties that the firm holds in the network.

Theory and Hypothesis Development

The theoretical model of this study is based on the dynamic capabilities perspective and the knowledge-based view of the firm. The former theory perspective asserts that dynamic capabilities, or “the firm’s ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments” (Teece et al. 1997 p. 516) enable firms to unleash value derived from firm resources through innovative dynamic resource reconfiguration. A firm’s ability to initiate and leverage alliances constitute a key dynamic capability (Eisenhardt and Martin 2000) because alliances transfer new resources into the firm from external sources, allowing access to resources that would be difficult to

obtain otherwise. Under the new resource configuration, firms are required to integrate external resources from alliance partners with their own resource pools and reconfigure the optimal allocation of these assets to generate competitive advantages (Eisenhardt and Martin 2000; Teece et al. 1997). In contrast, the knowledge-based view, another theoretical underpinning, views a firm's knowledge base, which consists of knowledge developed internally and/or acquired externally (e.g. from alliance partners), as a key firm resource, asserting that the growth of a firm primarily depends on its ability to generate new applications of knowledge in its knowledge base (Grant 1996; Kogut and Zander 1992). This theory emphasizes knowledge integration, which involves capturing, storing, interpreting, synthesizing and applying current and acquired knowledge resources" (Kogut and Zander 1992). Both theories amplify the significance of a firm's active interventions and deliberate efforts to utilize newly accessible resources from alliance partners by integrating or co-utilizing them with its internal resources. Prior IS researchers have theorized that the effectiveness of these activities can be greatly enhanced by the use of IT (Sambamurthy et al. 2003). We elaborate below how IT enhance capabilities for dynamic resource reconfiguration and knowledge acquisition and exploitation from an alliance network perspective and influence the effect of structural network properties on organizational performance.

IT investment and Firm Capabilities for Leveraging Alliance Networks

Portfolio Management

IT may enhance a firm's capabilities to manage a portfolio of multiple alliances in at least three ways. First, understanding dynamics related to all existing and perspective alliances and associated partners is vital to assist firms in designing effective alliance networks (Hoffmann 2007; Wassmer 2010). Firms may use IT to support these intensive information gathering and processing activities concerning the initiating and selecting of alliance partnerships. For example, Cisco System uses Partner Candidate Assessment database that contains a list of potential candidates for alliances with brief evaluations that include both quantitative and qualitative information, such as a candidate's current market position, future outlook, and its strategic and organizational fit with Cisco (Corporate Strategy Board 2000). Second, IT may enable superior coordination across business units which may have overlapping alliance initiatives and facilitate a harmonious alignment between alliances and the rest of the organization (Sambamurthy et al. 2003). Numerous studies have documented the importance of IT in a firm's coordination efforts, which comprise complex and information-intensive activities (Chari et al. 2008; Dewan et al. 1998). Augmenting reach and connectivity through electronic internal linkages can supply new insights for operational and strategic applications of existing resources under a new resource configuration. Boosting interconnections in this fashion facilitates swift, assertive decision-making aimed at coordinating alliances and maximizing efficiency in resource allocation by providing the appropriate information in a quick, reliable, and consistent format. Last, IT-enhanced performance management capabilities can help firms maintain the good health of their alliance relationships (Parise and Casher 2003). The performance management of alliances is a particularly intricate process due to the difficulties of identifying, measuring, and rewarding the contribution of an individual alliance (Ernst and Bamford 2005; Gulati 1998). Therefore, corporate managers must develop appropriate metrics, and gather and process relevant information. IT can support firms in designing sophisticated performance metrics and analytics by heightening the performance visibility of various processes and enabling firms to monitor progress on intermediate goals for timely managerial intervention (Davenport and Beers 1995; Gurbaxani and Whang 1991; Mithas et al. 2011).

Knowledge Exploitation

The inflow of external knowledge from alliance partners is likely to expand a firm's organizational knowledge base. However, the extent to which this infusion of new knowledge is converted into an increase in performance depends on the firm's capability to assimilate the knowledge into its organizational context and discover new applications of the data through knowledge integration (Grant 1996; Kogut and Zander 1992). Three main areas exist in which IT may influence the process of exploiting knowledge bases that have been expanded with external knowledge taken from alliance partners (Malhotra et al. 2005; Zahra and George 2002). First, IT-enabled organizational memory, such as

databases and knowledge repositories, can significantly upgrade a firm's capability to store external knowledge acquired from alliance partners within its internal knowledge repository. IT memory may assist firms in overcoming information overload resulted from massive amount of externally derived information by expanding an enterprise's cognitive capacity (Malhotra et al. 2005). Second, business intelligence (BI) applications and data analysis and mining software, can assist firms in interpreting and assimilating knowledge from alliance partners into the firm's organizational context. Knowledge, especially externally acquired information, becomes valuable only if it is incorporated into the firm-specific organizational context (Malhotra et al. 2005; Roberts et al. 2011). Various IT-enabled analytics and interpretive systems facilitate organizing, rearranging, and processing externally obtained information. These systems help firms to process massive quantities of raw data and identify the underlying patterns (Malhotra et al. 2005; Trkman et al. 2010). Additionally, IT-enabled communication channels, such as online messengers and communities, foster mutual understanding among employees and enable them to share contextual knowledge, further accelerating knowledge assimilation. Third, IT support firms in the integration of knowledge that involves merging, categorizing, classifying, and synthesizing existing know-how and newly acquired external knowledge (Alavi and Leidner 2001; Kogut and Zander 1992). Digitized knowledge in the form of knowledge repositories and directories streamlines knowledge integration and combination processes by providing a platform to acquire, locate and retrieve the necessary complementary know-how (Alavi and Tiwana 2002; Sambamurthy et al. 2003). Meanwhile, internal knowledge portals provide immediate access to new knowledge from alliance partners across business units, allowing firms to readily identify the ways in which new external knowledge complement their existing knowledge bases (Roberts et al. 2011).

Knowledge Acquisition

An increasing number of IS studies highlights an IT-enhanced capability of knowledge acquisition from both internal and external sources (Overby et al. 2006; Sambamurthy et al. 2003; Weill et al. 2002). Internally, augmented communication of knowledge through digitized knowledge platforms, such as internal online communities, Web 2.0 technology, knowledge repositories, and data mining tools, can sharpen a firm's ability to discover valuable internal knowledge that could have been difficult to identify and recognize due to organizational silos across business and/or geographical units. Externally, the use of knowledge-oriented technologies increase firms' access to highly diffuse information scattered across markets and accelerate the actions of acquiring, processing, and interpreting this information at a low cost by expanding visibility, transparency, and codifiability of knowledge (Galunic and Rodan 1998; Pavlou and El Sawy 2006; Sambamurthy et al. 2003). For example, BI applications enable firms to capture market opportunities from deep industry information, allowing firms to stay abreast of the latest market intelligence (Galunic and Rodan 1998; Sambamurthy et al. 2003).

Hypotheses Development

Based on the theoretical arguments in the previous section, we propose that the interaction effects between a firm's network properties within an alliance network and the firm's IT resources can be positive or negative, depending on whether the capabilities enhanced by IT investment complement or replace the benefits assumed by each structural property for firm performance (Figure 2). If the benefits pertaining to each property overlap with the benefits that can be resulted from the use of IT, IT investment would not necessarily provide additional advantages; indeed, it might even reduce the magnitude of the positive impact that structural properties have on performance.

Direct partners

Alliances provide substantive benefits, such as knowledge sharing, resource complementarity, and the scale effect (Ahuja 2000; Gulati 1998). Alliance researchers argue that firms with a greater number of direct partners are likely to have greater access to valuable, reliable, key information as compared to those with fewer partners in the network, based on the assumption that each partner adds information to the network (Ahuja 2000; Koka and Prescott 2002). Thus, we hypothesize that,

Hypothesis 1A. *The number of direct partners is positively associated with firm's performance.*

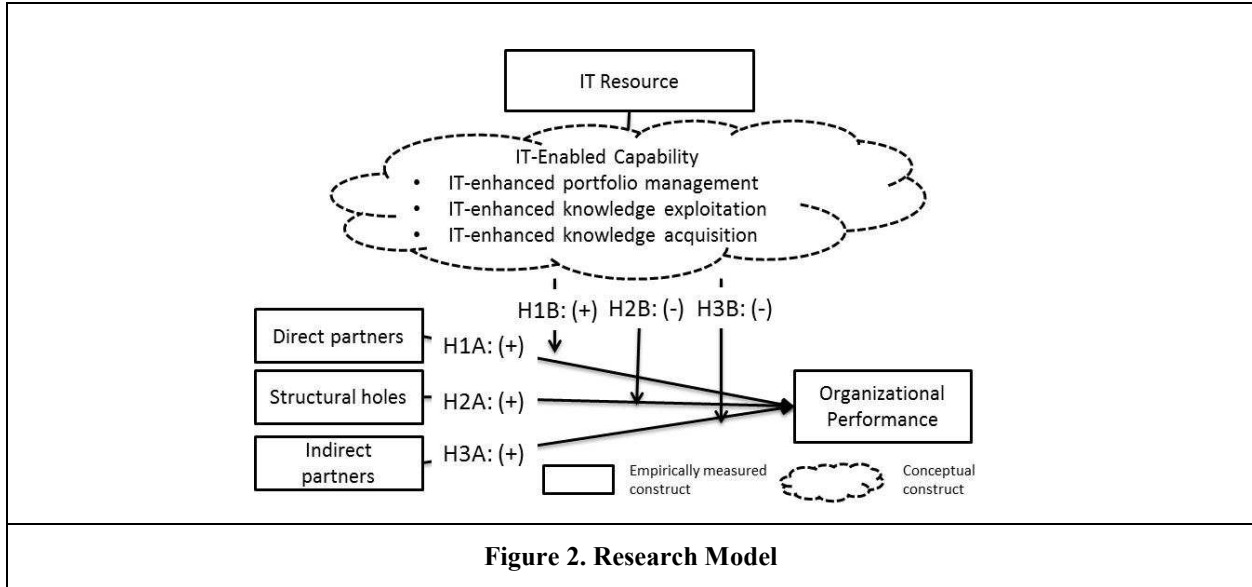


Figure 2. Research Model

The theoretical framework strongly suggests a positive moderating effect of IT investment on the relationship between the number of direct partners and firm performance for mainly three reasons. Firstly, the benefits from the external knowledge that direct partners can provide to the focal firm are not likely to be replaced by the ones provided by the IT-enhanced knowledge acquiring capability. Firms enter into alliances when they have specific strategic needs and select their alliance partners after careful consideration. Therefore, it would be reasonable to assume that firms join a particular alliance because the resources provided by direct alliance partners are unavailable within the firm by other means, including the use of IT. Newly obtained external knowledge will thus probably not overlap with existing stores of knowledge, but in fact, will likely expand the knowledge base. Secondly, as the size of the knowledge base increases, the IT-enhanced capability to exploit that knowledge would increase the benefits of direct partners. Finally, the effect of IT-enhanced capability on alliance portfolio management may mitigate any potential challenges in dealing with the number of direct partners and alliance relationships. Therefore, the benefits of enhanced capabilities resulting from IT investment are likely to be magnified in firms with a greater number of alliance partners. Thus, we hypothesize that the effect of the number of direct partners is positively moderated by IT investment:

Hypothesis 1B. *The relationship between the number of direct partners and firm’s performance is positively moderated by the IT investment of the firm.*

Structural holes

Social network researchers propose that access to structural holes influences firm performance but continue to debate whether a cohesive or disconnected network is more conducive to successful firm performance (Ahuja 2000). Prior studies have shown that each network configuration provides distinctive advantages and disadvantages in terms of the quality and diversity of knowledge accessible through alliances (Ahuja 2000; Burt 1992; Coleman 1988). Some researchers view links that lead to the same actors as redundant and advocate the value of structural holes, arguing that unconnected partners can provide diverse perspectives, new ideas, and information from partners that are more additive than overlapping (Burt 1992; Koka and Prescott 2002). They assert that the connectivity among partners can impede the diversity of available resources and knowledge, thereby delimiting the awareness of new opportunities (Ahuja 2000). However, as Duysters et al. (1999) have also noted, this network configuration may require special managerial attention and relationship management due to the potential lack of trust, which refers “the mutual confidence that no party to an exchange will exploit another’s vulnerabilities” (Barney and Hansen 1994 p. 176). Researchers advocating densely connected networks argue that the connectivity among partners is likely to reduce opportunism and prompts trust generation among partners, because the threat of a deteriorating reputation with respect to multiple partners will

discourage the focal firm from behaving opportunistically with any single partner (Coleman 1988). Trust among alliance partners may foster communication and cooperation, enhance the speed and likelihood of information access, and encourage the willingness to share secret information. This network configuration may be particularly useful when firms in the network are faced with a common external threat or when the network is constituted of potential competitors. In summary, the effect of structural holes on performance largely depends on the context. With the consideration of our multi-industry alliance network context, we hypothesize the positive effect of structural holes on firm performance.

Hypothesis 2A. *The access to structural holes is positively associated with firm's performance.*

Sophisticated information gathering and processing capability enhanced by IT may alter the organizational context to generate a favorable network configuration. The IT-enhanced knowledge exploitation capability may be beneficial for firms in either network configuration; for firms in a densely connected network, IT may enable firms to better exploit the benefits of high-quality knowledge transferred from trusted partners, while it enable firms in a structural-hole-rich network to better exploit the benefits of diversity in the knowledge gathered from its diverse partners. However, the IT-enhance knowledge acquisition capability may provide greater benefits for firms in a densely connected network which lacks the inflow of diverse and fresh insights. Awareness of new opportunities, key benefits of access to brokerage opportunities, may be alternatively enhanced by bolstering knowledge acquisition capability supported by IT (Chi et al. 2010; Sambamurthy et al. 2003). Therefore, the disadvantages in densely connected networks, the lack of diversity, might be compensated by increased information flow reinforced by the use of IT at least to some extent (Overby et al. 2006; Sambamurthy et al. 2003; Weill et al. 2002). On the other hand, mutual trust among firms in the same network, unique benefits of densely connected networks, would be relatively harder pressed to engender with the investment in IT, because trust among alliance partners, one of the major benefits of networks with high connectivity, is “fundamentally a social process, since these psychological mechanisms and expectations are emergent features of a social structure that creates and reproduces them through time” (Uzzi 1997 p. 45). Thus, we expect that IT investment would reduce the relative advantages of a structural-hole-rich network. This leads to the following hypothesis:

Hypothesis 2B. *The relationship between a firm's access to structural holes and its performance is negatively moderated by the firm's IT investment; In other words, the impact of IT investment on firm performance will be greater for firms in a densely connected network.*

Indirect partners

Alliance researchers argue that, despite lacking a formal alliance arrangement with the focal firm, indirect partners also provide informational benefits, because linkages in the alliance network serve as conduits through which companies receive access to external knowledge. The researchers argue that a higher number of indirect partners increase the opportunity to quickly access valuable market information, which potentially heightens firms' awareness of key market data (Ahuja 2000). This market information can contribute positively and significantly to the firm's performance, an effect known as knowledge-spillover (Ahuja 2000; Powell et al. 1996; Schilling and Phelps 2007). Unlike direct partners that require significant investment of managerial resources, indirect partners can serve as “an effect way for actors to enjoy the benefits of network size without paying the costs of network maintenance associated with direct ties” (Ahuja 2000 p. 448). Thus, we hypothesize that the benefits of knowledge spillovers from indirect partners with relatively low or no maintenance costs for the firm would contribute positively and significantly to its performance.

Hypothesis 3A. *The number of indirect partners is positively associated with firm's performance.*

We propose that the extent of benefits that a firm can glean from indirect partners is contingent on the focal firm's IT, particularly because benefits from indirect partners are primarily not physical resources, but rather knowledge and information, whose utilization critically depends on IT support. One may argue that an IT-enhanced capability to exploit knowledge bases may help firms to optimally harness the information shared by indirect partners and create positive synergy (Malhotra et al. 2005). We expect, however, that IT investment may reduce the relative advantages of having a greater number of indirect partners, because IT-enhanced information acquiring capability may provide alternative access to similar

information. Knowledge obtained from indirect partners can be valuable to a firm if it could not have been obtained otherwise and thus expands the firm's knowledge base (Grant 1996). However, unlike knowledge shared with direct alliance partners, which is often highly tacit in nature (e.g. accumulated skills and expertise), knowledge from indirect partners involves predominantly non-tacit information, such as industry news and gossips about the dynamics of a competitive environment and external challenges and/or opportunities, which can be transferred through relatively fewer interactions (Ahuja 2000). IS research has shown that the use of IT can also greatly enhance a firm's ability to discover non-tacit information that can be easily codified, shared, and transferred by IT (Alavi and Leidner 2001; Overby et al. 2006; Sambamurthy et al. 2003; Weill et al. 2002) If a firm already has a sufficient amount of necessary external information with the support of sophisticated IT tools, a greater number of indirect partners would not necessarily benefit the firm. On the other hand, a firm with a smaller number of indirect partners would enjoy greater benefits by investing in IT. Therefore, we expect a negative moderating effect between IT investment and indirect partners on firm performance:

Hypothesis 3B. *The impact of indirect partners on the firm's performance will be moderated negatively by the IT investment of the firm: the impact of IT investment on firm performance will be greater for firms with a less number of indirect partners.*

Research Design and Methodology

Data and Measures

To test our hypotheses, we examined the interaction effect of IT investment and alliance network properties (direct partners, indirect partners and structural holes) on firm performance. This study uses data from multiple sources: an InformationWeek (IWeek) survey that provides firm IT investment data for an 8-year span from 1998 to 2005, the Securities Data Company (SDC) Platinum database on Joint Ventures and Alliances that provides alliance data gathered from various sources¹, Compustat North America and the Compustat Segment for financial and industry data.

For the measure of firm performance, we used operating profit per employee after log-transformation as the dependent variable. The key explanatory variable, ITINV, is measured as the ratio of annual IT expenditure to the total sales of a firm. IT expenditure includes hardware, software, network infrastructure, salaries and recruitment of IT professionals, internet-related costs, and IT-related services and training. Given the comprehensiveness of this measure in capturing all of a firm's IT-related expenses, this construct has been frequently used as a proxy for the overall IT available within the firm (Bharadwaj et al. 1999; Chari et al. 2008; Tafti et al. *forthcoming*). Total IT expenditure includes other expenditures besides those spent on supporting alliance management. However it is difficult to distinguish alliance-specific IT expenditure from total expenditure, due not only to the broad spectrum of IT-supported alliance activities described in the hypothesis development, but also to the fact that many aspects of IT support are integrated into firms' general purpose IT applications, such as corporate intranets or corporate knowledge management systems. Therefore, total IT expenditure may serve as a useful proxy for the level of support from IT for alliances.

To construct variables for alliance networks, we created a network for each year with three-year windows, using the data from the SDC database concerning *all* alliances that were formed during the 1996 to 2005 period (Chi et al. 2010). For example, a network for 1998 includes all alliances formed between 1996 and 1998; a network for 2004 includes all alliances formed between 2002 and 2004, and so forth. Three-year windows were used to incorporate the changes in networks, under the generally employed assumption that alliances typically last for 3 years (Chi et al. 2010; Schilling and Phelps 2007). The following network measures were obtained for each firm from the networks: 1) direct partners (*DIRECT*), 2) structural holes (*HOLES*), and 3) indirect partners (*INDIRECT*). Direct partners (*DIRECT*) is measured as the number of

¹ The data originate from publicly available sources such as trade publications, SEC filings, and news and wire sources. The use of publicly announced alliances is a well-established approach in alliance network research in the management discipline (Schilling 2009), based on the assumption that public firms would, due to government regulations, announce most inter-firm alliances that may have financial and strategic impact on their market value.

alliance partners with which a focal firm has at least one alliance partnership in any given 3-year period. To account for the potential non-linearity of relationship between this count measure and performance, this measure is log-transformed. To measure a firm's access to structural holes, we used Burt's network constraint index (Burt 1992) and subtracted this index from one so that the higher values indicate a firm's access to more structural holes in its network (*HOLES*), a method that is commonly used in alliance research (Ahuja 2000; Baum et al. 2000; Chi et al. 2010). Mathematically, this measure is computed as $1 - \sum_j (p_{ij} + \sum_q p_{iq}p_{qj})^2$ for $q \neq i, j$, where p_{ij} is the proportion of i 's direct relations invested in partner j . $\sum_q p_{iq}p_{qj}$ indicates the extent to which another partner q , in which i has invested time and resources, is also connected to contact j . Thus, for a firm i , the partner j is redundant to the extent that another i 's partner, q , has also an alliance relationship with j . For a count of indirect partners (*INDIRECT*), we used a distance-weighted measure similar to the approach used in Ahuja (2000) and Burt (1997). This approach measures indirect partners as the weighted count of firms that can be reached by the focal firm in two or three steps³ in its alliance network with weights, which allows us to account for the decrease in the strength of a relationship in line with the increasing length of its corresponding path distance and the increasing total number of indirect partners. Specifically, this measure attaches weights of the form $1/[f_i/(N+1)]$ to each link, where f_i is the total number of nodes that can be reached, up to and including the path distance i ; N , meanwhile, is the total number of firms that can be reached by the focal firm in three steps.

We controlled for various firm-level and industry level factors which affect firm profitability. First, we controlled for the effect of economies of scale and scope by including a measure for firm size (*SIZE*), market share (*MS*), and the level of diversification (*DIV*). These constructs are measured as $SIZE = \log(\text{the number of employees})$ and $MS = \sum MS_i P_i$ where MS_i is a firm's market share in each of its industries i and P_i is the proportion of the firm's sales in the industry. *DIV* is measured as $\sum P_t \ln(1/P_t) - \sum P_u \ln(1/P_u)$ where P_t is the percentage of sales in each 4-digit SIC industry and P_u is the percentage of sales in each 2-digit SIC industry. Second, because this is a cross-industry study and performance varies from industry to industry, we included three industry-level factors: industry average operating profit per employee (*IND_PROFIT*), industry capital intensity (*IND_CAP*), and industry concentration (*IND_CONC*). Each construct is measured as $IND_PROFIT = \sum OP_i P_i$, $IND_CAP = \sum C_i P_i$, and $IND_CONC = \sum CR_{4i} P_i$, respectively, where P_i is the proportion of a firm's sales in the industry, OP_i is the average operating profit per employee, C_i is the capital intensity (Assets/Sales), and CR_{4i} is the sum of the top four firms' market share in the industry i .

From the IWeek sample, we retained only publicly listed and identifiable firms for our analyses and obtained relevant financial information as controls from the Compustat databases. We retrieved alliance network information for these firms from the networks constructed from the procedure discussed above. The final sample consists of 949 firm-level observations of 331 public firms in the United States from 1998 to 2005, creating unbalanced panel information.

Statistical Method: Fixed Effect FGLS Panel Regression

The unit of analysis is a firm. Though we controlled for several important confounding factors, the ordinary least square (OLS) estimation remains inefficient because cross-section time-series data often violate the assumption of exogeneity and homoscedasticity of error terms due to firm-specific unobserved heterogeneity. The model is estimated using the fixed effect feasible generalized least square (FGLS) panel analysis method (Wooldridge 2002 p. 276). Mathematically, the panel model can be expressed as $y_{it} = \mathbf{x}_{it}\beta + c_i + u_{it}$, where \mathbf{x}_{it} is a $1 \times K$ matrix of observable explanatory variables (the variables

² If i is connected with j and q , $p_{ij} = p_{iq} = 1/2$, under the assumption that i invests equal amounts of time and resources to each relationship.

³ In Ahuja (2000), the measure of indirect partners is calculated as the total number of firms that can be reached by the focal firm in any number of steps. This approach was feasible and plausible, because his study focuses on a single industry (chemical) and considers only alliance partnerships with firms in the same industry. Instead of restricting the industries from which the sample firms are drawn, we imposed the assumption that indirect partners over three-step distances do not have a meaningful effect on the focal firm due to depreciation of information flow in the course of traversing alliance linkages. This assumption was necessary to delimit networks due to their huge size.

discussed in the previous section) and u_{it} are idiosyncratic errors which change across t as well as across i . In this panel model, c_i is the unobserved, time-constant variable that is often referred to as the unobserved effect. The choice between fixed-effect and random-effect models depends on the assumption concerning the correlation between explanatory variables and unobserved effects, which is $Cov(\mathbf{x}_{it}, c_i)$. While a random-effect model imposes the assumption of zero correlation between observable and unobservable variables ($Cov(\mathbf{x}_{it}, c_i) = 0$) and estimates β by placing c_i into the error term, a fixed effect relaxes this assumption and allows arbitrary correlation between these variables. Therefore, a fixed effect is more robust than random effects analysis. One drawback of using the fixed effect model is that time-constant observable factors cannot be estimated; however, this is not a critical issue because time-constant factors are not of direct interest to this study. In addition, to account for potential heteroskedasticity across firms, we estimated the fixed-effect model by using the FGLS method⁴, which allows the variances of error terms to vary across firms. This procedure allows for potential correlation between error terms across the observations within observations by a given firm. For easy interpretation of interaction terms, we centered IT and alliance network variables to their respective means.

Results

The results from the FGLS panel analysis are shown in Table 1. We treated the model with IT, network, and control variables as a base case (Model I) and expanded the model by including the interactions (Model II). All our hypotheses are supported except Hypothesis 1A.

First, the coefficient of direct partners is negative and significant ($p < 0.01$), failing to support Hypothesis 1A, while the coefficients of IT investment and its interactions with direct partners are positive and significant ($p < 0.01$), supporting Hypothesis 1B. Our finding contradicts to Hypothesis 1, but we interpret the result as follows. For the firms in our sample, the marginal increase in the number of direct partners works adversely for firms with the average level of IT investment, if they (already) have the average number of alliance partnerships. This result indicates that merely increasing alliance activities without considering the firm's capability to manage them might have a detrimental effect on firm performance. The positive interaction effect of direct partners with IT investment indicates that firms need to consider additional investment in IT, if they wish to manage a larger alliance network (i.e. more number of direct partners) than the average firms, because IT investment may enable firms to overcome managerial challenges and complexities due to increased alliance activities, while helping to leverage the newly accessible resources to bolster firm performance.

Second, the positive and significant effect of structural holes ($p < 0.01$) suggests that the firms in our sample generally find themselves in networks rich in structural holes wherein it is more desirable for firms to access diverse information, supporting Hypothesis 2A. The interaction effect of IT investment and structural holes is negative and significant ($p < 0.01$), supporting Hypothesis 2B. This result suggests that an increase in IT investment reduces relative benefits provided by structural holes. The negative interaction effect of IT investment and structural holes indicates that an increase in IT investment attenuates the relative advantage that a firm can enjoy by keeping a breakage position and getting diverse information.

Third, the positive and significant effect of indirect partners ($p < 0.01$) substantiates the findings of prior studies that highlighted the benefits of having a large number of indirect partners, supporting Hypothesis 3A. The interaction of IT investment with indirect partners is negative and significant ($p < 0.01$), supporting Hypothesis 3B. The negative interaction of indirect partners with IT investment suggests that, regardless of the benefits that IT investment and indirect partners can bestow on a company, merely having a large pool of indirect partners *and* IT investment may not be necessarily more advantageous for a firm.

⁴ Mathematically, FGLS assumes $E(u_i u_i' | \mathbf{x}_i, c_i) \neq \sigma_u^2 \mathbf{I}_T$ but $E(u_i u_i' | \mathbf{x}_i, c_i) = \sigma_u^2 \mathbf{\Lambda}$, where $\mathbf{\Lambda}$ is a $T \times T$ positive definite matrix

Table 1. IT Interactions with Alliance Networks – FGLS Fixed Effect Models

Dependent variables: log (operating income per employee)					
	Model I (Main Effect)	Model II (Moderating Effect)	Model III (Additional Controls ²)	Model IV (5-yr alliance tenure)	Model V (Selection Bias)
IND_PROFIT	0.109*** (0.0147)	0.107*** (0.0131)	0.120*** (0.0138)	0.122*** (0.0124)	0.0650*** (0.0185)
SIZE	-0.186*** (0.0212)	-0.223*** (0.0262)	-0.158*** (0.0216)	-0.219*** (0.0170)	-0.262*** (0.0348)
MS	0.327*** (0.0677)	0.331*** (0.0445)	0.364*** (0.0423)	0.466*** (0.0540)	0.602*** (0.0702)
DIV	-0.0397 (0.0517)	-0.0643 (0.0522)	-0.0280 (0.0373)	-0.0876** (0.0347)	-0.0339 (0.0818)
IND_CAP	-0.00524 (0.00577)	-0.0106 (0.00757)	-0.000559 (0.00849)	-0.0165** (0.00810)	-0.0973*** (0.0199)
IND_CONC	-0.293*** (0.0383)	-0.274*** (0.0543)	-0.341*** (0.0516)	-0.267*** (0.0397)	-0.280** (0.119)
ITINV	0.0121*** (0.00239)	0.0114*** (0.00295)	0.0108*** (0.00317)	0.0110*** (0.00287)	-0.0151* (0.00797)
DIRECT	-0.0439*** (0.0168)	-0.0599*** (0.0165)	-0.105*** (0.0150)	-0.110*** (0.0157)	-0.00110 (0.0226)
HOLES	0.0954*** (0.0347)	0.141*** (0.0360)	0.217*** (0.0349)	0.130*** (0.0353)	-0.00509 (0.0484)
INDIRECT	0.000494*** (0.0000723)	0.000537*** (0.0000852)	0.000632*** (0.0000824)	0.000263*** (0.0000358)	0.000322*** (0.000123)
ITINV × DIRECT		0.0419*** (0.00728)	0.0457*** (0.00700)	0.0314*** (0.00546)	0.0624*** (0.0100)
ITINV × HOLES		-0.0725*** (0.0152)	-0.0945*** (0.0160)	-0.0769*** (0.0151)	-0.134*** (0.0211)
ITINV × INDIRECT		-0.000145*** (0.0000527)	-0.000179*** (0.0000488)	-0.0000441*** (0.0000132)	-0.000167** (0.0000703)
Selection indicator					0.0151 (0.0179)
Firm dummies	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
Constant	4.663*** (0.163)	4.786*** (0.172)	3.305*** (0.173)	2.941*** (0.0673)	5.373*** (0.219)
Observations	949	949	948	1159	622
Number of groups	331	331	331	359	252
Chi-square	474132.9***	619511.7***	403088.0***	579361.8***	259959.5***
Df	266	269	273	308	170

1. Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

2. Additional controls: capital intensity (total asset/sales), capital structure (total liability/sales), industry growth and industry uncertainty (the growth and the instability in sales in an industry respectively, the measures suggested by Ray et al. 2009).

We conducted several robustness checks. First, we estimated the model with additional controls: capital intensity, capital structure, industry growth, and industry uncertainty. The resulting FGLS estimates were consistent in showing support for the hypotheses (Model III). Second, we checked whether the results are robust to the choice of the span of alliances⁵. To demonstrate the sensitivity of our results, we expanded

⁵ We thank an anonymous reviewer for this constructive suggestion.

the window from three years to five years. The results using the five-year alliance tenure assumption appear in Model IV. Comparing the results in Model II and Model IV, we observe that the relative effect sizes are stable and that the directionality of effects is preserved. Last, we considered potential sample selection bias due to the nature of our sample – unbalanced panel data; some time periods are missing for some firms. We needed to ensure whether the firms were dropped out randomly and did not violate the assumption of exogeneity of independent variables. In order to test this possibility, we followed the approach originally developed by Nijman and Verbeek (1992) and refined by Wooldridge (2002) for a fixed-effect panel model. Following this approach, we included the lagged selection indicator, which represents whether a firm's observation for the prior time period is also included in the sample. The significance of this indicator shows whether selection in the previous time period is significant in the equation at current time. Our result provides no evidence of selection biases (Model V).

Discussion

Before discussing this study's potential contribution to IS literature, it is necessary to first acknowledge its limitations. First, the theoretical framework identified three distinct capabilities that can be significantly influenced by IT investment, but these capabilities were not directly measured in an empirical setting. Rather, based on the assumption that IT investment may improve the overall level of these firm capabilities, the empirical analysis was limited to examining the interactions between IT investment and structural properties. Therefore, one potential path for future research would be to directly examine whether IT investment actually improves these capabilities and to identify their effect on the relationship between structural properties and a company's performance. Second, this study focused exclusively on publicly reported contractual alliance arrangements, and hence, the data presented do not include the countless informal collaborations that could potentially promote knowledge transferal. Moreover, this study does not address the specific characteristics of the knowledge that is transmitted within the network.

Despite these limitations, this study potentially offers several important theoretical contributions and managerial implications. First, this study contributes to literature on the business value of IT by providing theoretical arguments and empirical evidence that a firm's IT investment is a major determinant of the relationship between the firm's performance and its alliance network. An alliance network is an external environment which has recently come to the forefront in management research by virtue of its significant influence on a firm's actions and resultant performance (Gulati 1998) but remains understudied in IS research. Given the rapid proliferation of alliances today, the failure to conscientiously study the networks in which firms are embedded risks engendering an incomplete understanding of IT business value. Second, our study represents a nascent study that applies several SNA theories and techniques relatively new to IT business value research. Our study of macro phenomena (at the organizational level) provides a few useful insights that can be broadly applied to social network research of micro phenomena (at the individual level) in IS as well, in that our results underscore the need for network researchers to carefully assess the attributes/ capabilities of the actor, in addition to the structural properties that the individual holds in the network. Third, despite the critical role played by interfirm alliances as an external source of valuable knowledge and the increasing interest in the payoff of IT investment for the management of various types of business collaboration, there is a general dearth of empirical examinations of the performance impact of IT investment in alliances, minus the occasional exception (Chi et al. 2010; Tafti et al. *forthcoming*). Accordingly, this study seeks to improve understanding of the performance impact of IT investment in an economically significant context (interfirm alliance networks) that has been overlooked by scholars in extant IS research. Finally, on the level of practical applicability, this study recommends that companies carefully assess whether their IT infrastructure is adequately designed to support the burden of increasing managerial complexity and to fully leverage new business environments. Our study suggests that investing in IT may offer a viable solution by which firms may overcome the limitations spawned by their limited access to the industry and market knowledge conferred by alliance networks.

Conclusion

A firm's portfolio of alliances and the resultant properties in its alliance networks are key to determining the relative success or failure of a firm's performance. Despite high expectation on the value of IT investment in managing and leveraging expanded resource pools through multiple alliance relationships,

a paucity in theoretical and empirical examination persists in the relevant literature. This work thus represents an initial effort to thoroughly parse the interactions between IT investment and alliance networks. By employing social network analysis (SNA) techniques and consulting relevant data on U.S. firms, we empirically examined the moderating effect of IT investment as it relates to the link that exists between alliance network properties and firm performance. Our findings will expand general understanding of the influence of IT resources within the alliance context.

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