The configuration and performance of international innovation networks: some evidence from the Chinese software industry

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Abstract: Research in social networks has demonstrated that firms in changing environments will benefit from innovation networks. However, the lack of consensus on what factors and how these factors impact performance impedes further research in this area. In this paper, the concept of an International Innovation Network (IIN) and its performance is clarified. Then, based on reviews of the social network and knowledge management literatures, along with the results of previous empirical studies, we clarify the relationships between the performance of a focal firm entering an IIN and each configuration, such as the network structure (range and density), network relationship (tie strength, duration and norm distance) and network position (centrality). We conduct a case study from the Chinese software industry to test our conclusions and then propose an integrative model. We also come up with some efforts that the firm can make in order to improve its performance. Finally, future research is discussed

Keywords: international innovation network; IIN; network configuration; knowledge learn; innovation performance.

Reference to this paper should be made as follows: Fang, G. and Pigneur, Y. (2010) 'The configuration and performance of international innovation networks: some evidence from the Chinese software industry', *Int. J. Learning and Intellectual Capital*, Vol. 7, No. 2, pp.167–187.

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1 Introduction

Many researchers have suggested that knowledge is the principal source of competitive advantage. Globalisation and other rapid changes in markets and technologies increasingly require firms to acquire and generate new knowledge in order to remain competitive.

However, knowledge transfer is not easy across firm boundaries (Singh, 2005). Consensus has grown in the literature that innovation networks form an efficient mechanism to effectuate the potential for learning and innovation across firms (Uzzi, 1997; Gilsing and Nooteboom, 2005). Recently, the growing demand for knowledge has further initiated the creation of a new global innovation ecosystem called the international innovation network (Zander, 2002). International Innovation Networks (IINs) help firms identify and capture global collaborative opportunities; search and utilise external knowledge, information and ideas worldwide; and improve innovation success through cooperation with partners.

According to the previous studies on social network theory, the configurations of an innovation network, such as the network structure (Reagans *et al*., 2004; Walker *et al*., 1997), network relationship (Gilsing and Nooteboom, 2005; Reagans and McEvily, 2003) and network position that the focal firm occupies (Tsai, 2001; Bell, 2005; Salman and Saives, 2005) are all crucial factors that will impact the performance of the focal firm when it enters the innovation network. The firms need special capabilities to build an advantageous innovation network or improve the configuration of an existing one so as to enjoy high innovation success through it. The antecedent of these efforts is to understand clearly what the network structure, relationship and position are and how they influence the performance of the focal firm entering an IIN. However, although prior studies have provided some foundation to understand these issues, our knowledge remains underdeveloped and unsystematic.

The purpose of this paper is to build an integrative model of the IIN. Firstly, the concept of an IIN and its performance is clarified. Then we identify the crucial factors which affect the performance of the focal firm involved in an IIN. We conduct a case study from the Chinese software industry to test our conclusions. Finally, an integrative model of the IIN and its performance is developed. The contribution of this paper is that it enables the integration of different researches within the social network area and expands them into the international context. The paper is also unique in coming up with a network pattern from which the focal firm can obtain benefits, mostly when it participates in an IIN.

2 Concept of the international innovation network

In the era of globalisation, international competition is increasingly viewed as taking place at the level of organisational networks rather than at the level of the individual organisation. Learning knowledge and capabilities from network partners is the main purpose of firms' involvement in IINs (Kale *et al*., 2000).

Social network theory was originally proposed to describe the relationships among individuals. Some researchers used this theory to analyse and study the mechanism of knowledge transfer or knowledge diffusion among people (*e.g.*, Obstfeld, 2002; Reagans and McEvily, 2003; Singh, 2005). Recently, there have also emerged some studies which focused on the cooperational innovation between organiations using this theory (Uzzi, 1997; Bell, 2005; Gilsing and Nooteboom, 2005; Salman and Saives, 2005). Due to the increased amount and complexity of knowledge, no single firm can afford to innovate continually and to develop world-class competencies in all the different fields. Also, firms which want to do business in international markets will suffer from lack of knowledge of the local market when they enter a new country. Firms therefore try to find cooperative partners globally to form IINs, the benefits of which include:

- more opportunities to access the latest technical breakthroughs and new insights to problems (Ahuja, 2000)
- learning and internalising new technologies, know-how and physical assets beyond firm and country boundaries
- sharing risk or uncertainty with their partners (Bleeke and Ernst, 1991).

Unfortunately, there is little consensus in the literature on the definition of IIN. As a network originally meant a complex, interconnected group or system, DeBresson and Amesse (1991) regarded innovation networks simply as innovating companies working together. Van Aken and Weggeman (2000) argued that the innovation network is a system of autonomous and legally equal organisations connected by select and persistent business relations to deal with product or process innovation or both. Drawing on this argument, the IIN is defined in this study as a system of autonomous and legally equal organisations connected globally by select, formal and persistent relations to share information, transfer knowledge, or innovate cooperatively. According to this definition, IIN is an institutional arrangement of partners from different countries to cope with systemic innovation (Freeman, 1991). The forms of IIN include joint ventures, licensing arrangements, management contracts, subcontracting, research associations and other formal forms of international cooperation on innovation.

Another important issue in IINs is the performance of the entering firm and how to measure it. The most important performance criterion of the firm entering an IIN is the amount of knowledge learned from its partners, so some researchers in the social network area have used the learning achieved (Kale *et al*., 2000), knowledge shared with each other (Tsai, 2002), or the receipt of useful knowledge (Levin and Cross, 2004) to measure the performance. Meanwhile, more researchers have measured the performance of a firm entering an innovation network by innovation output or innovation success. For example, Owen-Smith and Powell (2004) and Salman and Saives (2005) used the number of patents or licences owned by the focal firm, Ahuja (2000) used the number of successful patent applications and Tsai (2001) used the number of new products introduced to empirically test the relationship between some configurations of innovation network and

its performance. The performance of focal firm within IIN in this study comprises both measures: the amount of knowledge gained from partners and the firms' innovation output. In our opinion, this definition of performance would reflect the goal of IINs more appropriately.

3 The configuration of an IIN

Most researchers in the area of social networks paid attention mainly to some configurations of the innovation network to explain the effective knowledge transfer within networked partners or the performance of the focal firm. In addition, the knowledge management literature also contributes ideas about the properties of knowledge and the mechanism of knowledge transfer between senders and recipients. Relevant empirical studies from these areas are briefly highlighted in Table 1, which summarises and classifies the constructs used in each research study by network configuration, level of analysis and the main findings.

The table, which includes the main recent empirical researches in the area of social networks in innovation networks, indicates that though the points of view of scholars have not entirely reached a consensus, researchers have tried to find out how the configurations of a network impact the performance of the entering firm. Among these configurations, we can identify and integrate three, to which researchers have paid the most attention, *i.e.*, the network structure, network relationship and network position. They substantially impact the extent to which the firms get knowledge from their partners within the IIN, or the success of their innovations.

3.1 Network structure

In prior studies, many researchers confirmed that the network structure influences the knowledge transfer and the performance of innovation within the network. Researchers used different properties of networks to act as proxies of the network structure, such as structural holes or density of ties (Ahuja, 2000; Dyer and Nobeoka, 2000; Gilsing and Nooteboom, 2005; Obstfeld, 2002; Singh, 2005; Walker *et al*., 1997), size of the network (Baum *et al*., 2000), diversity of partners (Baum *et al*., 2000; Cummings, 2004), and scope or range of the network (Gilsing and Nooteboom, 2005; Reagans and McEvily, 2003; Reagans *et al*., 2004). The levels of these studies varied from individual to intraorganisational and interorganisational. For example, Gilsing and Nooteboom (2005) argued that exploration networks require a density of ties to improve the competence for innovation and the governance of relational risk. As they pointed out, the classical features of the network structure are network size, stability and density (number of direct ties in relation to total possible number of direct ties). In their research evaluating the potential of a work group, Reagans *et al*. (2004) found that internal density and external range of the social network will positively impact a team's performance. It is also true at the individual level that the network structure would be positively associated with the ease of knowledge transfer within the innovation network (Reagans and McEvily, 2003).

We integrate these studies about the effects of network structure on performance by focusing on the importance of two main dimensions of network structure – network range and density of ties – and focus our attention on the interfirm level.

Table 1 Summary of constructs used in recent empirical researches on innovation networks in the social network area

Authors	*The constructs influencing performance*			*Level of analysis*	*Main findings*
	Network structure	*Network relationship*	*Network position*		
Ahuja (2000)	Structural holes, indirect ties, direct ties			Interfirm	Direct and indirect ties both have a positive impact on innovation but the impact of indirect ties is moderated by that of direct ties.
Baum *et al*. (2000)	Size of the network, diversity of partners			Interfirm	The performance of a startup increases with the size and diversity (for example, includes rivals) of the alliance network.
Bell (2005)			Centrality	Interfirm	Locating the centrality in the managerial tie network enhances firm innovation, while centrality in the institutional tie network does not.
Cummings (2004)	Structural diversity			Interfirm	The value of external knowledge sharing increases when work groups are more structurally diverse.
Cummings and Teng (2003)		Norm distance		Interfirm	Transfer success decreases as the norm distance between source and recipient increases.
Dyer and Nobeoka (2000)	Structural holes	Tie strength		Interfirm	A highly interconnected strong-tie network is better suited for the diffusion (exploitation) of existing knowledge than the exploration of new knowledge. A network evolves from a collection of dyadic weak ties to a weblike structure with strong multilateral ties.
Gilsing and Nooteboom (2005)	Density of ties, scope	Stability, duration, frequency of interaction, control, trust/openness	Centralisation	Interfirm	The effect of the density and strength of ties on knowledge transfer is moderated by the type of knowledge.
Hansen (1999)		Tie weakness		Interunit	Weak ties help in the search for useful knowledge but impede the transfer of complex knowledge, which tends to require a strong tie.

Table 1 Summary of constructs used in recent empirical researches on innovation networks in the social network area (continued)

	The constructs influencing performance				
Authors	*Network structure*	*Network relationship*	*Network position*	*Level of analysis*	*Main findings*
Kraatz (1998)		Tie strength		Interorganisation	Networks can promote the social learning of adaptive responses; strong ties to other organisations mitigate uncertainty and promote adaptation by increasing communication and information sharing.
Levin and Cross (2004)		Tie strength		Interindividual	The link between strong ties and receipt of useful knowledge was mediated by trust. Once trust is controlled, the structural benefit of weak ties emerges.
Madhavan *et al*. (1998)			Centrality	Interfirm	The centrality of the firm before a structure-reinforcing event will be positively correlated with its centrality after the event.
Manev and Stevenson (2001)		Cultural distance		Interindividual	Managers establish and maintain strong expressive ties with peers who come from similar cultures.
Obstfeld (2002)	Structural holes			Interindividual	The small the number of structural holes, the greater the innovation involvement.
Owen-Smith and Powell (2004)			Centrality	Interfirm	Centrality will positively effect innovation.
Powell *et al*. (1996)		Diversity of ties	Centrality	Interfirm	The greater the diversity of ties, the more centrally connected the firm becomes. The greater the centrality, the more rapid the firm's growth.
Reagans and McEvily (2003)	Network range	Tie strength, social cohesion		Interindividual	It is easier to transfer all kinds of knowledge in a strong tie and more difficult to transfer all kinds of knowledge in a weak tie.
Reagans *et al*. (2004)	External range, internal density			Interunit	Both internal density and external range have a positive effect on a team's performance.

Table 1 Summary of constructs used in recent empirical researches on innovation networks in the social network area (continued)

Authors	*The constructs influencing performance*			*Level of analysis*	*Main findings*
	Network structure	*Network relationship*	*Network position*		
Salman and Saives (2005)			Centrality	Interfirm	By occupying a central position in a network, a firm is more likely to access useful knowledge.
Simonin (1999)		Cultural distance		Interfirm	Cultural distance is positively related to ambiguity, which is negatively related to knowledge transfer.
Singh (2005)	Indirect ties, direct ties			Interindividual	The existence of a tie is found to be associated with a greater probability of knowledge flow.
Tsai (2001)				Interunit	Units can produce more innovations and enjoy better performance if they occupy central network positions.
Tsai and Ghoshal (1998)			Centrality	Interunit	The centrality of a business unit will be positively associated with the level of trustworthiness, vision shared and resource exchange, which in turn will be positively associated with the level of product innovation.
Uzzi (1996)		Embedded ties, arm's-length ties	Centrality	Interfirm	Organisations tied to network partners by embedded, as opposed to arm's-length, ties increase their probability of survival.
Uzzi and Lancaster (2003)		Embedded ties, arm's-length ties		Interindividual	Arm's-length ties promote the transfer of public information, while embedded ties are suited for the transfer of private information.
Walker *et al*. (1997)	Structural holes			Interunit	The more relationships a firm forms, the more likely its social capital will increase.

3.1.1 Range

Network range refers to the extent to which network connections span institutional, organisational, or social boundaries (Reagans and McEvily, 2003). Thus, there are two main features of network range: size and diversity of members. Concerning the size of a network, very few studies have tested its effects on the performance of firms within a network. As Bianchi and Bellini (1991) argued, when the number of entrants rapidly increases, the transaction-cost advantages based on a common language and reciprocal reliability go down. However, an adequate number of members in the network is the basis of communication and knowledge transfer. With abundant partners, the focal firm can assess the value of relevant knowledge residing at different points in the network, can learn more from various organisations and exploit more resources that are made available through the network relationships, and, eventually, can successfully promote the level of innovation and performance.

Network diversity is a core consideration for reasons of communication and innovation. The value of external knowledge sharing increases when network members are more structurally diverse. As Cummings (2004) argued, because of the different organisational affiliations, roles, or positions of the partners in the structurally diverse network, the focal firm can learn diverse knowledge from unique sources. In the context of global cooperation, network diversity also means partners abroad. According to the innovation theory, end users, manufacturers, research organisations, even competitors at home and abroad should be sources of innovation, especially in a situation of a turbulent market, rapid change technologies and increasing globalisation. In fact, in the context of globalisation, partners which have different experiences and heterogeneous characteristics will bring new and fresh ideas and knowledge of the market they reside in. This will be particularly useful to firms that want to enter a new market abroad. In sum, the range of the innovation network has a positive impact on the focal firm's capacity for learning (Reagans and McEvily, 2003; Reagans *et al*., 2004). Therefore, we can conclude that the network range is positively related to the performance of the focal firm within the IIN.

3.1.2 Density

Network density refers to the number of direct ties established by the focal firm in relation to the total possible number of direct ties (Gilsing and Nooteboom, 2005). With direct ties to affluent partners, the focal firm can establish stable relationships and cultivate mutual trust with partners. A stable relationship and mutual trust are very useful, according to the knowledge management theory, for sharing standards or routines, and exchanging know-how or tacit knowledge.

This argument is consistent with the latest researches on structural holes theory (Ahuja, 2000). Structural holes are gaps in information flows between partners within a network, or disconnections between a firm's partners. In the early stage of research on structural holes, Burt (1992), who first put forward this concept, considered a structural hole as opportunities for people on either side of the hole to access different flows of information, and as a unique source of knowledge. So, maximising the structural holes spanned or minimising redundancy between partners is an important aspect of constructing an efficient, information-rich network. However, some recent researches have indicated that dense networks of shared understanding are the basis of successful

knowledge transfer that leads to innovation (Obstfeld, 2002). Drawing on a longitudinal study of firms in the international chemicals industry, Ahuja (2000) found that in the interfirm collaboration network, increasing the structural holes has a negative effect on innovation, and the direct ties between partners has a moderating effect on the relationship of indirect ties and knowledge transfer. That means, compared with indirect ties, direct ties has the main impact on knowledge sharing between partners, because direct ties between the partners provide more resource-sharing and information-spillover benefits than indirect ties do. In addition, dense ties between partners can foster the development of knowledge-sharing routines (Uzzi, 1991; Walker *et al*., 1997), and can also provide more possibilities to find new opportunities. Therefore, we can conclude that network density is positively related to the performance of a focal firm entering the IIN.

3.2 Network relationship

According to Table 1, the researchers used tie strength or frequency of interaction (Dyer and Nobeoka, 2000; Hansen, 1999; Gilsing and Nooteboom, 2005; Kraatz, 1998; Levin and Cross, 2004; Reagans and McEvily, 2003; Uzzi, 1996; Uzzi and Lancaster, 2003),[1] duration of ties (Gilsing and Nooteboom, 2005), and norm distance or cultural distance (Cummings and Teng, 2003; Manev and Stevenson, 2001; Simonin, 1999) to describe the relationship between networked partners. In this study, three dimensions of the network relationship are clarified according to the previous studies to specify their effects on knowledge transfer: tie strength, duration and norm distance. Tie strength means the frequency of interaction (Gilsing and Nooteboom, 2005) and the extent of confidence and reciprocity between partners (Granovetter, 1983); duration measures the stability of network relationships (Dhanaraj and Parkhe, 2006); whereas norm distance indicates the comparability between partners on work routines or value systems.

3.2.1 Tie strength

There is a long-term debate in the social network research about the different roles of weak ties (or arm's-length ties) and strong ties (or embedded ties) in knowledge transfer. Compared with strong-tie networks, the weak-tie networks have members between whom there are few interactions over time, a lower emotional intensity, a lower level of confidence and little reciprocity (Granovetter, 1983). One stream of research argued that weak ties are more efficient in knowledge transfer because the cost of setting up and maintaining ties increases with the strength of the ties (Burt, 1992). In addition, strong ties can lead to reduced variety and tend to be poor sources of new ideas and ways of learning. The other stream, contrarily, contended that strong ties can mitigate uncertainty (Kraatz, 1998) and are more accessible and able to be helpful (Krackhardt, 1992), and so strong ties lead to greater knowledge exchange (Levin and Cross, 2004).

Following this ambiguous condition, the subsequent researches adopted a contingent approach (Ahuja, 2000; Rowley *et al*., 2000; Gilsing and Nooteboom, 2005). That means, in different environments, weak ties and strong ties would act respectively as main channels for learning and knowledge transfer. For example, Uzzi and Lancaster (2003), Hansen (1999) and Gilsing and Nooteboom (2005) argued that weak ties promote the transfer of public information or simple knowledge from a wide range of actors, while strong ties are suited for the transfer of private information or complex knowledge. The reason is that weak ties require little investment in time or mutual obligation. As Uzzi and

Lancaster (2003, p.385) pointed out, weak ties "enable actors to economically maintain many ties to other actors". So, when time and other resources are limited, the importance of weak ties would emerge. Furthermore, Uzzi (1997, p.59) found empirically that networks which integrate both weak and strong ties "optimize an organization's performance potential", while network structures comprising only weak ties or strong ties "decrease organizational performance potential".

This view is furthered by Reagans and McEvily (2003). According to their empirical research, they concluded that it is easier to transfer all kinds of knowledge in a strong tie and more difficult to transfer all kinds of knowledge in a weak tie. However, tacit knowledge (complex and noncodified) was more difficult to transfer than explicit knowledge (simple and codified), so strong ties are more efficient in transferring tacit knowledge, and weak ties in transferring explicit knowledge.

Although the empirical evidence about tie strength is varying, the consensus is establishing and maintaining strong ties with partners need more effort and higher cost than for weak ties. If taking this cost into account, the conclusions of previous studies would be consistent: the strong tie does play a more important role in knowledge transfer between partners, but it is not efficient for transferring codified knowledge when we consider the high cost of maintaining it. However, on one hand, according to our definition, the IIN is composed of formal and persistent relations, so the number of members within the IIN is not very large. On the other hand, trust is crucial for innovation and successful relationships (Levin and Cross, 2004), and strong ties are necessary for this to be achieved. The focal firm should benefit from formal partners within the IIN through strong ties to get much codified and nocodified knowledge, while it should benefit from informal partners outside the IIN through weak ties, as Uzzi (1997) suggested, enlarging the scope of the search for information. Therefore, in this study, the conclusion is that tie strength is positively related to the performance of the focal firm entering an IIN.

3.2.2 Duration

Duration refers to the stability of the network relationship. Long-term interaction between partners is conducive to foster trust and common norms or routines within the IIN, which, in turn, can enhance the transfer of knowledge, especially tacit knowledge. Hence, the critical task for the focal firm within the IIN is to promote network stability (Kenis and Knoke, 2002). Conversely, instability would significantly impair the innovation output of the IIN (Lorenzoni and Lipparini, 1999). A recent research indicates that a stable network reinforces the relationships among network members. Thereby, a higher level of network stability is helpful to the focal firm's acquisition of knowledge and produces greater network innovation output (Dhanaraj and Parkhe, 2006). Consistent with these findings, therefore, we can draw the conclusion that duration is positively related with the performance of the focal firm within the IIN.

3.2.3 Norm distance

Norm distance refers to the extent to which partners within the IIN share the same organisational culture, value systems (Cummings and Teng, 2003), or language.

It is widely accepted that the distance and difference in organisational culture and norm between partners is an important barrier to effective interfirm knowledge transfer (Mowery *et al*., 1996), especially when knowledge is transferred internationally. The reason is that, facing the different societal value systems of foreign partners, the focal firm has to pay more attention or allocate more resources to communication, design common standards or work routines, and develop common managerial approaches. Lyles and Salk (1996) provided some empirical evidence in their study that cultural conflicts and misunderstandings can impede knowledge transfer between international partners or "minimize flows of information and learning" (Lyles and Salk, 1996, p.883). Simonin (1999) put forward the mechanism between cultural distance and knowledge transfer, *i.e.*, cultural distance would enhance the ambiguity of the knowledge transferred, which would in turn weaken the knowledge transfer between partners.

On the other hand, common norms would improve the transfer of knowledge between partners. Manev and Stevenson (2001) found in their empirical study that, when the cultural distance is small, strong ties between partners will be developed. As aforementioned, this would eventually increase the success of knowledge transfer. Thus, the focal firm desiring to learn from partners should overcome cultural differences and establish common norms with its partners. Common norms "not only provide predictability and understanding between the parties, but also ensure that a common approach will be adopted in the transfer process" (Cummings and Teng, 2003, p.47). Summarising these findings, therefore, a conclusion we can draw is that norm distance is negatively related to the performance of the focal firm within the IIN.

3.3 Network position

Firms which possess different network positions would have different opportunities to access new information and learn knowledge for innovations (Tsai, 2001). Network position refers to the pattern of relationships which describes one's location relative to other members in the IIN. In social network analysis, the firm's network position affects its ability to access external information and knowledge, to recognise and respond to new market opportunities, and to share the resource with partners. Thus, the network position of a firm could be considered one of its intangible strategic resources (Salman and Saives, 2005). Furthermore, the innovation benefits are only achieved by those organisations that are centrally positioned in a network (Owen-Smith and Powell, 2004).

3.3.1 Centrality

A widely accepted method that attempts to describe and measure the properties of firm location in a network is centrality (Bell, 2005; Gilsing and Nooteboom, 2005; Madhavan *et al*., 1998; Owen-Smith and Powell, 2004; Powell *et al*., 1996; Salman and Saives, 2005; Tsai, 2001; Tsai and Ghoshal, 1998). Centrality measures the involvement in the network (Bell, 2005) and describes the extent to which the focal firm "occupies a strategic position in the network by virtue of being involved in many significant ties" (Salman and Saives, 2005, p.205).

According to previous studies, the more central the firm is in the innovation network, the more innovations it produces (Powell *et al*., 1996; Tsai, 2001). First of all, the focal firm can obtain more timely information and understand the latest change in technology. For example, Powell *et al*. (1996) argued that centrality in a network helps the partners to improve common understandings and shared principles, and then enhance further exchanges. Meanwhile, Salman and Saives (2005) also contended that a firm's centrality within a network is positively related to the likelihood of it gaining access to complementary knowledge. Moreover, centrality would also be helpful to compare information across sources and assess its veracity (Bell, 2005). Finally, a firm occupying a central position in the IIN is less likely to miss vital information, as multiple information sources provide multiple channels to discover new information.

In addition, centrality shapes a firm's reputation (Powell *et al*., 1996), which enhances the firm's ability to access the resources of various partners. This, in return, would improve the special opportunities for the focal firm to learn tacit knowledge. In sum, centrality would enhance the trust, vision shared and resources exchanged between partners, which in turn would improve product innovation (Tsai and Ghoshal, 1998). Following the analysis mentioned above, therefore, the conclusion is that centrality is positively related with the performance of the focal firm within the IIN.

4 Case study

4.1 Methodology

As a preliminary study and a validation of the model developed in the previous section, we adopted a multiple case study approach. The case study can be used to provide a description or a test theory, or to generate theory (Eisenhardt, 1989; Yin, 2003). In this study, we will test the relationships between the network configurations and the performance mentioned above in the context of the Chinese software industry. We followed the steps of the case study argued by Eisenhardt (1989): selecting cases, collecting data, analysing within-case study data and cross-case patterns, and shaping hypotheses.

We selected four software firms in China which all had foreign partners and are involved in an IIN. The selection was not random, but was according to the aims of the study (Eisenhardt, 1989). All the selected firms have been in an IIN for at least two years. Table 2 gives their profiles (using pseudonyms).

Data and information were collected by interviews, questionnaires and archives supported by firms and/or from the internet. We conducted semistructured interviews with each respondent which lasted from two to three hours. Furthermore, each respondent answered a questionnaire for some quantitative data. The interviews were conducted mainly in 2007. Other types of information were also used in the study, such as internal reports, corporate brochures, or other public information from the internet.

Table 2 An overview of the four selected Chinese software firms

Firm	*Date founded*	*Number of employees*	*Main product/service*	*Respondent*[a]
eBansTech	2000	56	CRM for manufacturing	CEO
				Director of Sales & Marketing
				Manager of Technical Department
Ground	2004	8	Middleware for call centre system used by other system integration providers	CEO
				Manager of Technical Department
HansCom	1995	1200	Video Surveillance Online System, ERP for manufacturing and security agencies, call centre and CRM system	Vice President, has charge of the technical innovation of the whole firm
				Director of New Product Development Department
iStar	2003	60	Information security system for government and private firms	CEO
			A member of China's standard alliance AVS	

Note: [a] Each position represents one individual.

4.2 Results

The nature of the innovation of the selected firms and the characteristics of the IIN they built/entered in are summarised in Table 3.

According to the data from the selected firms, we marked each dimension of three configurations with high or low. For example, HansCom had a great number of partners in its IIN and interacted frequently with all of them. Thus, the *range* and *density* of HansCom are marked as high. On the other hand, eBansTech seldom interacted with partners and the relationships did not last so long, so the *tie strength* and *duration* of this firm are low.

Next, we measured the performance of the selected firms. We obtained information about the amount of knowledge gained from partners and the innovation output via questionnaires. Multi-item scales were used to collect data on these two constructs (see the Appendix). We adopted a seven-point Likert-type scale to measure each item. We first averaged all responses for each item from multiple respondents in one firm (if the respondents in a firm were more than one), and then averaged these averages across items within each construct to act as the measure of this construct. This method eliminated some individual response biases. The results are listed in Table 4.

Table 3 Summary of the innovation activities of the selected firms

Firm	*The purposes of building/entering an IIN*	*The characteristics of the IIN involved*
eBansTech	To improve their CRM system and develop new modules based on feedback from customers and partners	• Partners: mainly customers, also other firms in this area • Network structure: few partners; but cooperated with all of them • Network relationship: seldom interacted with partners, and relationships did not last long. No common culture has been built between partners • Network position: peripheral
Ground	To learn new knowledge and assimilate recipes for new technology to develop different middleware	• Partners: many suppliers, technical institutes • Network structure: few partners • Network relationship: interacted with partners closely and frequently, but the relationship always ended when a certain product was completed • Network position: low centrality
HansCom	To learn all kinds of knowledge related to a new product: the Video Surveillance Online System based on SIP	• Partners: a great number of equipment suppliers, technical institutes, universities, and even competitors • Network structure: many partners and interacted frequently with all of them • Network relationship: relationships were close and frequent, and lasted for a long time. Shared routines were built with foreign partners • Network position: high centrality
iStar	To learn new technologies to develop new products and satisfy new standards for emerging technologies	• Partners: industry counterparts, technical institutes, universities • Network structure: many partners • Network relationship: close, frequent and stable • Network position: high centrality

Table 4 The network configurations and performance of the selected firms

Configurations/Performance	*Variables*	*eBansTech*	*Ground*	*HansCom*	*iStar*
Network structure	Range	L	L	H	H
	Density	H	L	H	H
Network relationship	Tie strength	L	H	H	H
	Duration	L	L	H	H
	Norm distance	H	H	L	L
Network position	Centrality	L	L	H	H
Knowledge gained		2.5 (L)	2.3 (L)	6 (H)	5.5 (H)
Innovation output		2.9 (L)	1.2 (L)	6 (H)	6.7 (H)

Notes: H represents high; L represents low.

Finally, we checked the relationships between each dimension of the configurations and performances. It is clear from Table 4 that *range*, *density*, *tie strength*, *duration* and *centrality* are positively associated with the selected firms' *knowledge gained* and *innovation output*, while *norm distance* is negatively associated with their performances. Although the density of eBansTech and the tie strength of Ground is not consistent with this judgement, generally, we can come up with some propositions, which we will empirically test in a future research, as follows:

Proposition 1 *The range of the IIN a firm has entered is positively associated with the knowledge the firm has gained from its partners and its innovation output.*

Proposition 2 *The density of the IIN a firm has entered is positively associated with the knowledge the firm has gained from its partners and its innovation output.*

Proposition 3 *The tie strength of a firm with its partners in the IIN is positively associated with the knowledge the firm has gained from its partners and its innovation output.*

Proposition 4 *The duration that a firm has kept its relationships with its partners in the IIN is positively associated with the knowledge the firm has gained from its partners and its innovation output.*

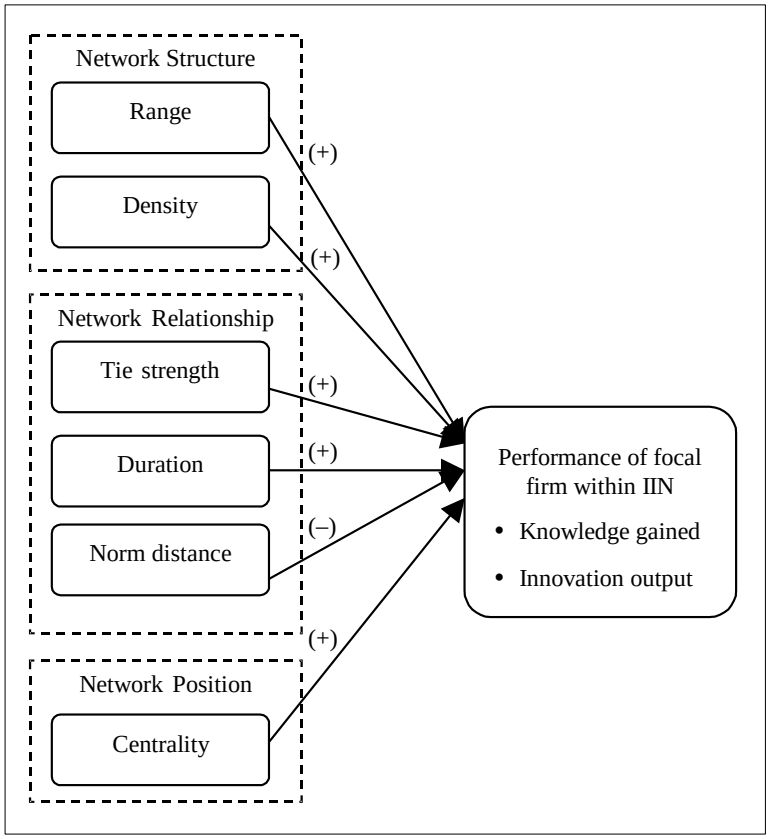
Proposition 5 *The norm distance between a firm and its partners within the IIN is negatively associated with the knowledge the firm has gained from its partners and its innovation output.*

Proposition 6 *The centrality of the firm in the IIN is positively associated with the knowledge the firm has gained from its partners and its innovation output.*

5 The integrative model

Based on the discussion above, the integrative model in this study, which describes the configurations of the IIN which impact the performance of the focal firm and the mechanism by which they do this, is shown in Figure 1. Network structure impacts the performance of the focal firm within the IIN through the factors range and density of the network; network relationship influences performance through the factors tie strength, duration and norm distance; and network position affects performance through the factor centrality.

Figure 1 Integrative model of the IIN

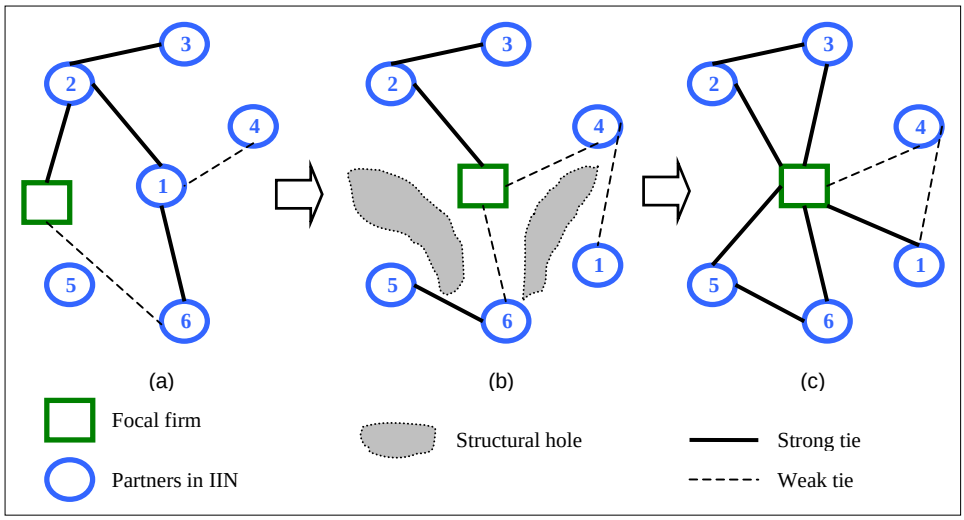


In the context of the IIN, therefore, in order to gain more useful knowledge from partners within the network and improve its innovation output, the efforts the focal firm can make include:

- enlarging the range of cooperation globally, include direct or indirect connections
- increasing the number of direct ties with partners
- enhancing the frequency of interaction and reciprocity between partners
- improving the stability of network relationships
- establishing common norms with its partners
- occupying a central position in the network.

According to these principles, the position of the focal firm in Network (a) in Figure 2 is peripheral. It looks as if the centre of the network is Firm 1, and most information would be exchanged through Firm 1. In Network (b), though the focal firm occupies a central position, there are some structural holes between it and its partners. The best network pattern is Network (c), because the focal firm has not only established affluent and close relationships with its partners, but located itself in the centre of network.

Figure 2 International Innovation Network (see online version for colours)



6 Conclusion and future research

In recent years, increased attention has been focused on the role and importance of innovation networks in a firm's innovation and competitive advantage. Although previous research has shown the firm performance benefits of innovation networks, further research is needed to understand how the configurations of a network shape the performance of a focal firm within the IIN. This study found that the structure of the network a focal firm is involved in, the relationship with its partners and the position the focal firm occupies would influence the amount of knowledge gained from partners and the level of innovation success. An integrative model is presented in this study. First, this model integrates the results of prior studies and identified six factors impacting performance, which is useful for scholars in this area for further research; second, this model provides some suggestions about the efforts firms can make, which is helpful for practitioners in global markets to improve benefits from the networks.

The conclusion of this study is based on a literature review and case study, so more empirical tests are needed in the future to improve the reliability. Besides, firms in the global market have no choice on whether to have relationships or not and whether to care about them; the only choice for firms is how to cope with them effectively and efficiently (Ritter *et al*., 2002). To face an environment that is changing rapidly, firms are trying to take some proactive approaches to establish collaborative relationships or innovation networks and, more important, to maintain and manage these relationships successfully. This needs some special capabilities. From the perspective of strategy management, the purpose of these capabilities is to build an appropriate network structure, mobilise and maintain effective relationships, and occupy a good network position, and eventually, to gain competitive advantage. One of our next researches is to understand what these capabilities are and the mechanism by which these capabilities impact the level of

knowledge transfer and innovation output within the IIN. Furthermore, we will also try to find out where these capabilities come from and how to foster them. These are our future tasks.

Acknowledgements

The authors thank Prof. Antoine Perruchoud and Lan Zhu at the University of Applied Sciences, Switzerland for their help in funding this research within the SoftCust project, the purpose of which is to localise Swiss original software applications in the Chinese market.

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Note

1 Actually, Uzzi (1997) and Uzzi and Lancaster (2003) used the terms 'arm's-length tie' and 'embedded tie' here. In our study, we consider that the meaning is same for arm's-length tie and weak tie, as well as for embedded tie and strong tie. For more information, see Uzzi and Lancaster (2003).

Appendix

Items used to measure performance

Items	*References*
(a) Knowledge gained from partners	
Our firm learnt or acquired a great deal of new or important information/knowledge from the partners.	Simonin (1999), Kale *et al*. (2000)
Our firm learnt or acquired a great deal of critical capabilities or skills from the partners.	
This network has helped our firm to enhance its existing capabilities/skills.	
(b) Innovation success	
Our firm often leads the industry at introducing new or improved products/services.	Deshpandé *et al*. (1993), Ahuja (2000), Ritter and Gemünden (2004), Bell (2005), Salman and Saives (2005)
Our firm often leads the industry at adopting new technologies or new software architecture.	
Compared with our main competitors, we have a greater number of successful patent applications, or granted patents (includes registered software copyrights).	

Note: Respondents were asked to use a seven-point Likert scale to provide responses on each item, such that 1 = strongly disagree and 7 = strongly agree.