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The relationship between network capabilities and innovation performance

Evidence from Chinese high-tech industry

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Abstract

Purpose – Innovation networks provide an efficient mechanism for organizations to realize their potential for knowledge learning and innovation improvement. Firms situated within innovation networks require specific abilities to acquire the knowledge and the complementary assets that facilitate their innovation performance. Motivated by recent research studies in the area of social network and RBV, the purpose of this paper is to improve the understanding of the precise manner in which network capability affects a firm's innovation performance.

Design/methodology/approach – Based on the data obtained from Chinese high-tech firms, the hypotheses are tested by using hierarchical multiple regressions.

Findings – This study identifies two types of network capabilities: network structural capability and network relational capability. The findings suggest that network structural capability has a greater positive impact on innovation performance than network relational capability does within an exploration-orientated network. However, network relational capability is more positively associated with innovation performance within an exploitation-orientated network.

Practical implications – A firm can enhance the value of its ego network by shaping and adjusting network configurations, rather than by passively reaping the benefits from existing relationships or ties with partners.

Originality/value – This paper contributes to strategic management theory and social network theory by illustrating how a networked firm can enable network value and appropriate this value according to its strategic purposes and by suggesting that a firm can improve its ego network's value through exerting its network capabilities to shape and adjust network configurations. This paper also advances the contingent approach within social network research by offering a new complementary perspective and new evidence from a Chinese context.

Keywords Innovation, Resource-based view, Innovation, Network capabilities

Paper type Research paper

1. Introduction

A firm situated within a network can acquire complimentary assets and resources from its network partners (Dyer and Singh, 1998; Kale *et al.*, 2000; Levin and Cross, 2004). In particular, the knowledge sharing and learning routines between network partners can contribute to the firm's ability to innovate (Tsai, 2001; Cooke, 2006). Previous research in strategic management theory has introduced the concept of network resources (Dyer and Singh, 1998; Gulati, 1999; Gulati *et al.*, 2000), which can be described as the source of a firm's

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competitive advantage (Barney, 1992; Madhok and Tallman, 1998). However, competitive advantages cannot be generated by resources alone. They are contingent on the ways through which resources are effectively exploited and deployed, and these require specific capabilities (Grant, 1991; Amit and Schoemaker, 1993). Consequently, it is believed that firms situated within innovation networks require specific capabilities to better exploit network resources for enhancing and improving their innovation performance.

Previous research in social network theory has suggested that because of firms' asymmetric access to resources and their differing capacities of information gathering, inter-firm networks can significantly influence a firm's performance (Granovetter, 1983). Similarly, Gulati (1998) argued that a firm's embeddedness within a network, which includes both structural embeddedness and relational embeddedness, can either facilitate or impede the benefits that the firm obtains from its partners. Firms that are "better connected" to their partners (Burt, 2000) can obtain more benefits from innovation networks through extensive knowledge sharing with each other than those that are not (e.g. Kale *et al.*, 2000; Levin and Cross, 2004; Tsai, 2002), thereby improving their innovation success (Bellamy *et al.*, 2014; Mahmood *et al.*, 2011; Owen-Smith and Powell, 2004).

However, there has been a long-running debate within the network literature on the kind of network configuration that enhances a firm's performance, i.e. what is the "better connection"? Weak ties (Granovetter, 1973) or strong ties (Krackhardt, 1992), and sparse structure (Burt, 1992) or dense structure (Coleman, 1988)? As a way to promote this debate further, several recent studies have proposed the use of a contingency approach. For instance, some studies have argued that weak or strong ties and sparse or dense structure can each be critical for a firm's innovation performance, depending on the particular context being studied (Ahuja, 2000; Wang *et al.*, 2017) and/or the firm's specific strategic purpose (Gilsing and Nooteboom, 2005). Such studies have shed light on our understanding of the specific conditions under which strong/weak and sparse/dense networks are positively related to firm performance (Rowley *et al.*, 2000).

Although previous studies have highlighted the need for different levels of network density or tie strength in particular contexts, substantially less attention has been focused on the differential impacts of network density compared to tie strength on the innovation performance of a firm with a specific strategic purpose. Especially, exploration and exploitation may require inconsistent network configurations and firm capabilities. Some recent research (e.g. Gilsing and Nooteboom, 2005) has already discussed the impact of exploration and exploitation on value extraction from innovation network. However, our knowledge still remains undeveloped and, at least, unsystematic.

Drawing on the resource-based view and social network theory, this study aims to deepen our understanding of the precise manner in which network capability affects a firm's innovation performance. Following the contingency approach, it further attempts to identify the specific capability, whether network structural or network relational, that a firm would need most to maximize value appropriation while keeping in line with the firm's strategic focus of exploration or exploration.

2. Theory and hypotheses

2.1 Network capabilities

Innovation network is a system of autonomous and equal firms connected by selective, formal and persistent relations to transfer knowledge, or to innovate cooperatively. It provides an efficient mechanism for embedded firms to acquire new knowledge from partners (Kale *et al.*, 2000), share risk or uncertainty with partners (Bleeke and Ernst, 1991) and cope with systemic innovation (Freeman, 1991). One major research stream in innovation network area is based on social network theory. The majority of recent studies indicate that network configurations affect a firm's success in innovation. Network configuration refers to "the make-up of networks and how these can be formed to benefit strategic goals" (Pittaway *et al.*, 2004, p. 143).

Among these configurations, two dimensions noted by previous researchers can be identified and integrated: network structures (e.g. Walker *et al.*, 1997) and network relationships (e.g. Gilsing and Nooteboom, 2005; Reagans and McEvily, 2003).

Another emerging research stream has attempted to delineate the source of value in inter-firm networks. Application of the resource-based view (Wernerfelt, 1984; Barney, 1991) has been expanded to incorporate the inter-firm context by identifying valuable resources and capabilities that reside within networks (e.g. Gulati, 1999). Firms can utilize external resources to complement their own resources, thereby facilitating their performance and, especially, the achievement of their organizational goals (Cunningham, 1995). The network resources perspective has advanced the theory of value creation within a network context. Dyer and Singh (1998) contended that relational rents can only be enjoyed by firms that combine, exchange and co-develop idiosyncratic resources with their partners. Networked firms do not merely respond passively to their existing network relationships (Dhanaraj and Parkhe, 2006); rather, they proactively and deliberately manage and design their own ego networks. They do so either to pursue specific network structures (e.g. widely dispersed) or to become "better connected" with their partners (e.g. stronger ties); they may also pursue both goals in accordance with their overall business strategies by utilizing specific network capabilities. Introducing the concept of network capabilities, which represent a firm's ability to develop, manage and utilize networks (Walter *et al.*, 2006), is thus vital for discussing the value creation and appropriation of network resources (Gulati, 1998).

Prior research has identified several network capabilities or competencies of firms, which relate to the firms' network management, including network competence (Ritter, 1999; Ritter and Gemünden, 2003, 2004), network management capability (Möller and Halinen, 1999), strategic network capability (Hagedoorn *et al.*, 2006; Zacca *et al.*, 2015), relational capability (Lorenzoni and Lipparini, 1999; Collins and Hitt, 2006) and networking capability (Mitrega *et al.*, 2012). For example, Ritter (1999) suggested that a networked firm requires network competence to manage its network. Hagedoorn *et al.* (2006) argued that strategic network capability, i.e., the specific intelligence of firms regarding their network settings and their choice of particular partners, has a significant effect on the engagement of firms in future partnering activities. Prior research suggested that network capability is the organizational capability toward managing external relationships, and it would be positively related to knowledge creation (Zacca *et al.*, 2015) and innovativeness (Parida *et al.*, 2017), and would finally influence organizational performance significantly (Mitrega *et al.*, 2012; Walter *et al.*, 2006).

These two streams of research emphasized that the configurations of a network shape the performance of a networked firm. Recent results from social network theory suggest efforts that firms could make to improve benefits from the networks. Meanwhile, research of strategic management suggested that a networked firm could certainly benefit from its abilities to manage its ego network. However, to bridge the gap between these two streams of research, a new framework must be developed to explain the relationship between configuration shaping and network management. Therefore, the purpose of network capability introduced in this paper is to improve each aspect of network configuration to optimize interactions with partners and obtain the resources located in network. Following Gulati (1998), this study focuses on two types of network capabilities. Gulati's framework demonstrated that there are two main types of network embeddedness: structural embeddedness that focuses on the structure of the entire network and the position occupied by the firms within the network; and relational embeddedness that emphasizes the direct ties and close interactions among partners. The capabilities pertaining to the structural design of a network and the management of relationships within it are considered to have an important role in a firm's innovation performance.

2.2 Network structural capability and innovation

Following Gulati's (1998) framework, network structural capability refers to a focal firm's ability to improve a network's structural configuration. Structural elements may include the network's size (e.g. Gilsing and Nooteboom, 2005), the diversity of membership within the network (e.g. Gkypali *et al.*, 2017), the network's density (e.g. Dhanaraj and Parkhe, 2006) and the relative competitive position of the focal firm within the network (e.g. Bell, 2005). Previous research has explored some of these network structural elements and the effects on innovation performance.

Through the identification, evaluation and selection of potential and capable collaborators, the network structural capability may enable the focal firm to establish an ego network that connects the partners who possess complementary knowledge and assets. Such a capability may also enable the focal firm to construct a high-density ego network, which would have high diversity and size, and thus can improve information velocity, inculcate shared norms and behaviors and increase the overall volume and speed of resource flows within the network (Gnyawali and Madhavan, 2001). According to Karamanos (2012), a dense network structure has a positive effect on innovation performance. Ahuja (2000) also found that direct and dense connections within a network provide more resource-sharing and information-spillover benefits than indirect ones, as they result in more innovation opportunities.

Generally, capabilities do not automatically lead to performance improvements. However, network capabilities could optimize the network configurations, which, in turn, could impact the performance. Such intermediate mechanism is consistent with the extant literature (see Niesten and Jolink, 2015). Meanwhile, the results of a relevant case study of six Chinese high-tech firms (not presented here) suggested that there might be a positive impact of network capabilities on performance. The process and result is consistent with the suggestion made by Ambrosini and Bowman (2009), who contended that a fine-grained case study would help to explore the relationship between capabilities and performance. Therefore, the above arguments lead to the following hypothesis:

H1. The higher the level of a firm's network structural capabilities, the greater the degree of innovation performance it will enjoy.

2.3 Network relational capability and innovation

Network relational capability refers to a focal firm's ability to effectively manage relationships with its network partners. This entails fostering strong ties, engaging in frequent interaction with each partner and maintaining long-term relationships (Dyer and Nobeoka, 2000; Uzzi and Lancaster, 2003; Gilsing and Nooteboom, 2005). These activities enable a firm to effectively manage and mobilize resource exchange and to coordinate activities with network partners.

Network relational capability enables the focal firm to handle and exploit relationships with individual partners to maximize the benefits and complementary assets that it gains from these relationships. This contrasts with network structural capability in terms of the respective strategic focus of these two kinds of capabilities. In other words, network relational capability places more emphasis on developing stronger ties and exploiting existing relationships, while network structural capability more focuses on the selection and exploration of new connections. The benefits of exploiting relationships with existing partners are numerous. For instance, by effectively deploying its network relational capability, a focal firm may foster high levels of intimacy, trust and compatibility with partners. And a trust-based and stable relationship can lead to a greater exchange of tacit knowledge (Reagans and McEvily, 2003), potentially generating higher innovation performance (Rese and Baier, 2011). Thus, the second hypothesis is proposed as follows:

H2. The higher the level of a firm's network relational capabilities, the greater the degree of innovation performance it will enjoy.

2.4 Exploration-oriented and exploitation-oriented networks

March (1991) developed a framework that differentiates between explorative and exploitative modes of organizational learning. Firms may alternate between explorative and exploitative learning modes, depending on their strategic purposes and environmental contexts. "Exploration" refers to the pursuit of new knowledge or technology (Levinthal and March, 1993), and involves basic research, invention, the development of new capabilities, risk taking and entry into new lines of businesses (Koza and Lewin, 1998). By contrast, "exploitation" means the development and use of things that are already known, and includes improvement and refinement of existing capabilities and technologies, as well as systematic cost reduction. Extending March's (1991) framework to innovation networks leads us to the postulation that firms joining an innovation network may be either exploration oriented, with a focus on seeking new opportunities, or exploitation oriented, with a focus on exploiting existing resources and capabilities (Rothaermel, 2001; Gilsing and Nooteboom, 2005).

For this reason, firms attempting to implement radical innovations, with a focus on explorative learning, tend to establish or join exploration-oriented innovation networks to acquire new knowledge and ideas (Ettlie *et al.*, 1984; Rothaermel, 2001). By contrast, firms attempting to implement incremental innovations, with a focus on exploitative learning, enter exploitation-oriented innovation networks to cooperate with partners and access complementary assets. Both types of innovation networks are beneficial for embedded firms, either because of changes in their fundamental architectures over the long run or because of improvements within their basic structures and cost reductions in the short run.

Attempting to elucidate whether there are any advantages derived from network configurations for these two types of organizational learning and innovation purposes, for example, structural holes (Burt, 1992) and dense connections (Coleman, 1988), or weak ties (Granovetter, 1973) and strong ties (Coleman, 1988; Krackhardt, 1992), has long been at the center of a prevailing controversy in network literature. There was mixed evidence, and the findings were inconsistent originally in this research field. Some studies have shown that dense networks improve knowledge transfer (Ahuja, 2000), and thus innovation success (Obstfeld, 2002), because dense ties tend to lead to the development of knowledge-sharing routines among partners (Walker *et al.*, 1997). However, other studies have argued that both strong and weak ties are positively associated with a firm's performance (Uzzi, 1997). Meanwhile, Reagans and McEvily (2003) suggested that it is easier to transfer various sorts of knowledge when there is a strong tie, as opposed to a weak tie. However, a weak tie is considered more efficient in transferring public or simple knowledge (Hansen, 1999), because maintenance is less costly (Uzzi and Lancaster, 2003). This debate has been resolved to some extent by certain studies' use of a contingency approach. Rowley *et al.* (2000) suggested that weak ties are beneficial for explorative purposes, while strong ties are positively related to the performances of firms engaged in exploitation. Likewise, Gilsing and Nooteboom (2005) argued that exploration requires higher network densities, since dense ties lead to some degree of redundancy in the types of knowledge sources, which is needed for ensuring the quality and reliability of information, and thus minimizing the uncertainty that is associated with exploration.

Although the contingency approach suggests that different types of networks are required for exploration and exploitation, previous studies have tended to focus on the differential benefits provided by weak or strong ties, or by sparse or dense connections. Consequently, there has been little or no attention paid to the different degrees of importance of tie strength and network density for the purposes of exploration and exploitation. This study attempts to shed some light on this issue by arguing that network structural capability and relational capability have interaction effects in relation to exploration/exploitation on a firm's innovation performance.

There are two main arguments that support the significance of interaction effects. First, there are differences in the knowledge or information requirements of exploration and exploitation. As Gilsing and Nooteboom (2005) pointed out, exploration-based learning is an expansive process that involves broad searches for new knowledge, whereas exploitation-based learning is a deepening process that aims to refine and strengthen existing technology. Explorative learning thus focuses on redundant and diverse connections with partners. Denser networks provide more alternatives in terms of general knowledge, and improve the chances of developing all kinds of ties, including both strong and weak ties, that are effective for transferring either complex or simple knowledge (Hansen, 1999). The purpose of exploitative learning is to gain specific information, implying that interactions with certain technology providers become increasingly important. Strong ties enable partners to establish trust relationships and frequent interactions, which lead to enhanced mutual understanding and the development of common norms or routines. Establishing a common standard or work routine facilitates the transfer of specific knowledge (Mowery *et al.*, 1996). Firms engaged in exploitation often focus their attention on a limited solution space (Rowley *et al.*, 2000), such as efficiency improvement or cost reduction. Stronger ties can serve better to solve these specific problems by providing tacit knowledge more efficiently (Hansen, 1999; Uzzi and Lancaster, 2003; Collins and Hitt, 2006).

Second, the different attributes of radical and incremental innovations lead to the diversity of foci in exploration or exploitation. Firms that invest heavily in radical innovation face high environmental uncertainty, rapid changes in technology and ambiguity of direction. To receive redundant information, they require dense networks rather than repeated partnerships (Goerzen, 2007). Diverse external collaborations can help them to obtain fresh ideas. In situations characterized by ambiguity in technological direction, dense networks enable firms to identify viable alternatives, discover the most likely future technological developments and verify the accuracy of their knowledge. This would, in turn, increase firm's exploratory innovation performance (Phelps, 2010). Compared with radical innovation, incremental innovation pays closer attention to efficiency and short-term costs. Firms that are oriented toward incremental innovation typically focus on specific problems and invest in one direction. They prefer to solve specific problems jointly rather than gather general knowledge, implying that they have low tolerance for information noise. Strong ties promote the sharing of specific information and joint problem solving (Uzzi, 1996; McEvily and Marcus, 2005). Consequently, firms within exploitation-oriented networks tend to depend more heavily on maintaining strong ties with specific information providers rather than on maintaining extensive relationships.

To recapitulate the above discussion, firms within explorative networks tend to be more heavily dependent on dense connections with diverse partners, compared with those within exploitative networks that typically prefer to maintain strong ties with specific information providers. Network structural capability improves a firm's ability to establish a dense network, while network relational capability enables a firm to create strong ties. Network structural/relational capability would, therefore, appear to yield positive interaction effects, which are associated with the type of innovation network, on a firm's innovation performance. Two further hypotheses are introduced as follows:

H3. The positive relationship between network structural capability and innovation performance is greater in exploration-oriented innovation networks than in exploitation-oriented innovation networks.

H4. The positive relationship between network relational capability and innovation performance is greater in exploitation-oriented innovation networks than in exploration-oriented innovation networks.

3. Research methodology

3.1 Data

The hypotheses were tested with the use of data from the survey that was administered to high-tech firms located in five provinces in eastern China. The Chinese high-tech industry was chosen for this study for two reasons. First, technological collaboration has been, and continues to be, a significant feature of this industry. Second, China's high-tech industry has developed rapidly since the 2000s, but its innovation level has remained relatively low than that found in other developed countries. The findings of this study may help practitioners and managers, especially in China, to improve their innovation activities through collaborations with network partners.

Potential participants were identified through an internet search and interviews held with key informants. This study targeted top executives, as they were considered to be knowledgeable about their firms and inter-firm cooperation activities. A total of 1,285 questionnaires were distributed via e-mail, or in paper format, and the final number of usable questionnaires was 211 (an effective response rate of 16.4 percent). Over 60 percent (66.8 percent) of the participating firms had less than 500 employees, and 58.3 percent of the firms were less than 10 years old.

3.2 Measurement scale

To ensure content validity of the measures used in this study, the measurement scale of the constructs was developed with the use of existing scales wherever possible, and a few items were slightly modified to fit the research setting. All items used the seven-point Likert scales.

The design of this scale followed the procedure introduced by Hinkin (1995). The format and items for each construct were initially developed based on a literature review and the combined inputs from relevant works. This effort was then complemented by field work undertaken within six Chinese high-tech firms to improve the selection of individual items. All items were then reviewed by a panel of experts within an inter-firm collaborative team composed of four professors and six managers from different firms. After conducting this review, some items that featured repeatedly, or were obscure, were eliminated or rephrased.

The resulting questionnaire was then pilot-tested. It was distributed to 325 individuals (approximately half were MBA students at a Chinese university; the remaining were employees of six Chinese high-tech firms). There were 113 responses in total, yielding a 34.8 percent response rate. Within this group, 84 were valid, resulting in a 25.8 percent effective response rate. After deleting two items with low loadings, an explorative factor analysis was performed. This demonstrated that each variable had a loading greater than 0.5 with the expected factor. In addition, each Cronbach's α value exceeded 0.70, which indicated acceptable levels of internal consistency.

4. Results

4.1 Scale assessment and preliminary analyses

Reliability and validity. To evaluate construct validity and internal consistency reliabilities (Gerbing and Anderson, 1988), this study used principal component factor analysis. The results provided support for the validity of the constructs. In addition, this study included interviews with academic experts, and some of the measures were consistent with those used in previous research, thereby increasing the content validity of the constructs. Additionally, a confirmative factor analysis based on partial least squares was conducted to examine discriminant validity. To obtain acceptable discriminant validity, the square root of the average variance extracted (AVE) of any variable in the model should be greater than the correlation coefficients between this value and any other variables (Chin, 1998; Fornell and Larcker, 1981; Hulland, 1999). As shown in Table I, the results indicated good discriminant validity. Cronbach's α value and composite reliability (CR) for each construct was well above the cut-off value of 0.7 (Nunally, 1978), demonstrating adequate internal consistency of the constructs.

Common method bias. Questionnaire, with random order of items, was separated into two parts and dispensed to different anonymous respondents, and data were collected through multiple sources. Then, a factor analysis (Harmon's one-factor test) of all variables was conducted to check for common method variance. The results showed four factors with eigenvalues greater than 1.0 that accounted for 78 percent of the total variance, with the first factor accounting for only 29 percent of the total variance. These results implied that common method bias was not a significant problem in the survey responses. Additionally, as argued by Siemsen *et al.* (2010), common method bias would not be a problem if the interaction hypotheses were found to be supported.

Multicollinearity. The variance inflation factor (VIF) was used to assess the degree of collinearity that existed within the regression models. All VIF values were found to be below 2.0, except for that of network structural capability (VIF = 2.096). These results indicated that substantial multicollinearity was not a serious issue in the study.

4.2 Regression analysis

This study treated the size and age of firms as control variables and analyzed the data with the use of hierarchical multiple regression. Table II presents the results of the regression analysis.

In Model I, firm size was positively related to innovation performance ($p < 0.001$). However, the effect of age was not significant. When the two network capabilities were included in Model II, the R^2 value increased significantly from 0.066 to 0.653. An *F*-test revealed that adding the two network capabilities contributed significantly to the explanation of the dependent variable ($p < 0.001$). The results of Model II showed that the coefficients for each

Variables	Cronbach's α (CR)	Mean	SD	1	2	3	4	5
1. Network structural capability	0.939 (0.910)	4.419	1.437	(0.877)				
2. Network relational capability	0.951 (0.944)	4.558	1.209	0.483**	(0.850)			
3. Type of innovation network	0.897 (0.932)	3.995	1.809	−0.152*	−0.063	(0.942)		
4. Innovation performance	0.955 (0.892)	4.386	1.406	0.754**	0.604**	−0.131	(0.906)	
5. Age of firm	–	15.84	29.509	0.213**	0.009	−0.086	0.028	na
6. Size of firm	–	2.422	0.823	0.329**	0.302**	0.042	0.257**	0.255**

Notes: $n = 211$. Values in the diagonal cells are square roots of AVE. *$p < 0.05$; **$p < 0.01$

Table I. Means, standard deviations, correlations and scale reliabilities

Variables	Model I	Model II	Model III	Model IV	Model V	Model VI
Constant	3.332***	4.685***	4.678***	4.697***	4.652***	4.665***
Age of firm	−0.010	−0.158*	−0.165*	−0.142*	−0.166*	−0.129
Size of firm	0.444***	0.017	0.027	0.005	0.035	0.007
Network structural capability		0.617***	0.613***	0.601***	0.617***	0.601***
Network relational capability		0.364***	0.364***	0.369***	0.355***	0.357***
Type of innovation network			−0.023	−0.026	−0.025	−0.031
Network structural capability × Type of innovation network				0.048*		0.077***
Network relational capability × Type of innovation network					−0.054*	−0.090***
R^2	0.066	0.653	0.654	0.663	0.662	0.682
Adjusted R^2	0.057	0.647	0.646	0.654	0.652	0.671
ΔR^2	0.066	0.587	0.001	0.009	0.008	0.028
ΔF	7.331***	97.105***	0.493	5.536*	4.753*	8.822***

Notes: $n = 211$. Dependent variable: innovation performance. *$p < 0.05$; ***$p < 0.001$

Table II. Results of regression analysis: moderating effects of the type of network

network capability were positive and significant ($p < 0.001$), indicating that both network capabilities contributed to innovation performance. Thus, both *H1* and *H2* were supported.

Model VI, containing all of the variables, was considerably improved in comparison with Models III–V; the change in R^2 from Model III (0.654) to Model VI (0.682) was also significant ($\Delta R^2 = 0.028$, $\Delta F = 8.822$, $p < 0.001$). This demonstrated the superior ability of Model VI to explain the moderating effect of the type of innovation network on the relationship between network capability and innovation performance. The regression coefficient of the interaction term, Network structural capability × Type of innovation network, was positive and significant ($\beta = 0.077$, $p < 0.001$). This implies that when an innovation network is oriented toward exploration, network structural capability will have a greater impact on innovation performance, thus supporting *H3*. The regression coefficient of the interaction term, Network relational capability × Type of innovation network, was negative and significant ($\beta = -0.090$, $p < 0.001$). This implies that when an innovation network is oriented toward exploitation (i.e. less explorative), network relational capability will have a greater impact on innovation performance, thus supporting *H4*.

To better understand the effects of the interactions discussed above, the interaction effects were plotted in graphs, as shown in Figure 1, with the use of one standard deviation above and below the mean to capture the high and low levels of the type of innovation network. These results provided further support of *H3* and *H4*.

5. Discussions and conclusion

In an innovation network, a firm's network capabilities serve as enablers of value appropriation from a network. The empirical results of this study show that each type of network capability has a positive impact on a firm's innovation performance. Previous studies, drawing from both social network theory and strategic management theory, have argued that interconnected firms are superior to independent firms. By integrating these two theoretical areas, and identifying the precise source of a networked firm's competitive advantage, the concept of network resources (Dyer and Singh, 1998; Gulati, 1999; Gulati *et al.*, 2000) corroborates this argument. Moreover, the results of the current study further extend this insight by suggesting that network capability enables firms to generate rents that are latent within network resources. The finding of this study is consistent with that of Ritter (1999) and Ritter *et al.* (2002), which suggested that possessing network management capabilities improves a firm's innovation performance.

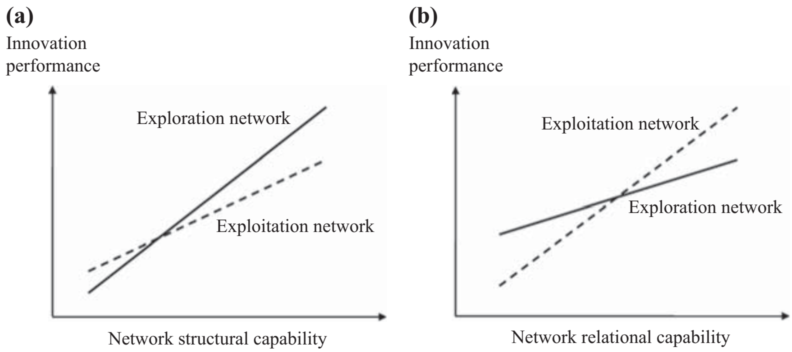

Figure 1.
Interaction results

Notes: To illustrate the direction and magnitude of effects, the mean values of network relational capability in (a) and the mean value of network structural capability in (b) were used

More specifically, this study assesses the role of the type of innovation network as a critical mechanism underlying the innovation benefits derived from network capabilities. This study provides empirical support for these findings by focusing attention on the different types of innovation networks. First, the results suggest that a firm with higher levels of network structural and relational capabilities will evidence superior innovation performance, regardless of whether it is in an explorative or an exploitative network. This finding is at odds with the arguments of Granovetter (1973) and Burt (1992) on "weak ties" and "the structural hole," respectively. It also contrasts with the argument made by Rowley *et al.* (2000). Based on their empirical study of American networked firms in the steel (exploitative) and semiconductor (explorative) industries, they contended that a combination of dense and strong ties provided few additional benefits, since creating and maintaining these ties incurred high costs. This study alternatively suggests that firms within the Chinese high-tech industry require high levels of both network structural capability and network relational capability to establish dense and strong ties with their partners. This, in turn, would improve their innovation performance.

This argument, however, is consistent with that of Coleman (1988) concerning the benefits accrued from both dense and strong ties. Some recent research has also made similar suggestions. For example, Krackhardt (1992) contended that strong ties are more accessible and willing to be helpful, so strong ties lead to greater knowledge exchange. Based on their empirical research, Reagans and McEvily (2003) further suggested that the transfer of different types of knowledge through strong ties is relatively easier than the transfer through weak ties. This indicates that strong ties are more beneficial than weak ones with respect to a firm's innovation activities. This can be reasonably applied to high-tech firms in China. On the one hand, high-tech firms are naturally with high level of technological collaboration. On the other hand, most of them are relatively young, and the level of interaction among firms is quite low. Many Chinese high-tech firms are now at a point where they are more interested in improving inter-firm cooperation and coordination than considering the cost of maintaining these ties.

This study suggested that the impact of network capabilities on performance exerts via an intermediate effect of capabilities on network configurations. It conforms to the extant research (see Niesten and Jolink, 2015). Based on a literature review, Niesten and Jolink (2015) unveiled a same explanatory mechanism for the impact of network management capabilities on performance. In addition, the results of a relevant study, which identified some antecedents of network capabilities (please see Fang *et al.*, 2014), would also alleviate the possibility of presence of reverse causality.

Second, the empirical results from the Chinese high-tech industry further suggest that the positive effects of network structural capability (which leads to a dense network) are connected to a firm's particular purpose. When a focal firm faces an uncertain environment and focuses on explorative innovation, network structural capability is closely related to superior innovation performance. When the level of network structural capability increases, the performance of firms within an exploration-oriented network improves more rapidly than the performance of those located within an exploitation-oriented network (indicated by a slope of 0.740 vs 0.468, see Figure 1(a)). The most plausible explanation for this is that it is indeed more important for exploration-oriented firms than for exploitation-oriented firms to obtain new knowledge and ideas and additional opportunities through the seeking of new partnerships within the network. A dense innovation network, which results from a firm's high level of structural capability, is the best option for providing these inputs. This conclusion is consistent with that made by Gilsing and Nooteboom (2005), which argued that a higher network density and range would be more effective in improving performance for explorative learning than for exploitative learning.

Third, previous studies have suggested that weak ties promote the transfer of codified information or explicit knowledge, while strong ties are better suited for the transfer of non-codified information or tacit knowledge (Hansen, 1999; Uzzi and Lancaster, 2003). This study provides new insight into this issue. The empirical findings presented here suggest that the extent of the positive relationship between network relational capability and innovation performance depends on the focal firm's standpoint regarding innovation. When a focal firm focuses on exploitative innovation, this positive relationship becomes more significant. The line increases more sharply for exploitation, with a slope of 0.509, compared with that of 0.191 for exploration (see Figure 1(b)). This finding indicates that high-level relational capability is more important for exploitation-oriented firms than for exploration-oriented firms. To engage in exploitative innovation, firms need strong and long-enduring ties for transferring existing knowledge and technologies, because exploitative learning focuses on the specific information being transferred through close and stable relationships. However, Hansen *et al.* (2001) found empirically that strong ties are more beneficial in exploration tasks. The main reasonable explanation for this discrepancy is that they used Project Completion Time as performance in the study because getting immediate access to network contacts is very important in their research context; while exploration in this study focuses on broad searches for new knowledge to make radical innovation, thus speed is less critical. Obviously, further studies are needed to clarify this contingent effect of tie strength.

In conclusion, this study offers a theoretical contribution to strategic management theory by suggesting that network capability plays an important role in unlocking the potential value of network resources. The study also highlights the ways in which a networked firm appropriates value from an innovation network according to its strategic purpose, and thus provides a more dynamic perspective for understanding performance differences across firms situated within the same network. The implications of this study – that a firm can enhance the value of its ego network by shaping network configurations, rather than by passively reaping the benefits from existing relationships with partners – may also contribute to social network theory. And this empirical study on innovation activities in the firms of China would contribute to, as Ambrosini and Bowman (2009) suggested, a contingency approach to dynamic capabilities. Although high levels of both network structural capability and relational capability are beneficial, a full and meaningful understanding can only be attained if they are studied in conjunction with the type of innovation network under consideration. Within the existing literature, studies have found that different types of impact are produced by dense and sparse network structures (structural embeddedness) when firms are situated within explorative or exploitative networks (e.g. Rowley *et al.*, 2000; Gilsing and Nooteboom, 2005). Researchers have also suggested that weak and strong ties (relational embeddedness) provide diverse benefits according to the changes of context. These arguments are challenging responses to those of "the structural hole" (Burt, 1992) and "the strength of weak ties" (Granovetter, 1973). This study advances the contingent approach by comparing the different degrees of the importance of a dense structure (structural embeddedness) and strong ties (relational embeddedness). Consequently, it offers a new, general complementary perspective, as well as new evidence in support of the contingency-based argument within social network research.

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Appendix

Construct	Survey measures	Source of scale
Network structural capability	We have a strong ability to find, evaluate and select appropriate partners We have a strong ability to identify potential innovation partners through various organizations (e.g. chambers of commerce, consultants, industry associations and government organizations), or by attending industrial fairs and exhibitions We have a strong ability to maintain and possess a larger number of partners compared to our competitors We have a strong ability to establish diversified network partnerships (e.g. with universities, research institutes, software companies, important supplier or customers) We have a strong ability to create and achieve high-density networks with our partners (i.e. a large number of structurally equivalent peers, e.g. dyads vs triads) We have a high percentage of established partnerships for all potential partners	Ritter *et al.* (2002) and Gilsing and Nooteboom (2005)
Network relational capability	We have a strong ability to develop and foster mutual trust, support, shared profits, rewards and risks with our partners We are able to keep frequently interaction with our main partners (on average): 1 = once every 3 months or more; 2 = once every two months; 3 = once a month; 4 = twice a month; 5 = once a week; 6 = twice a week; 7 = once a day Our working relationship with main partners is able to keep close Our interaction with main partners is able to keep deep We have a strong ability to maintain a long-term partnership with our network partners We are able to work out constructive solutions when there are conflicts with our innovation partners Our collaborative relationships with our main partners are able to last for a long time We have a strong ability to establish common norms along with a shared value system with our main partners The way of interaction with our partners is easily acceptable by them	Hansen (1999), Ritter *et al.* (2002), Reagans and McEvily (2003), Levin and Cross (2004) and Gilsing and Nooteboom (2005)
Type of innovation network	We face a high degree of environmental uncertainty (e.g. high environmental complexity, low predictability and high frequency of change) We learn from our partners for novel technology rather than existing knowledge/information	Rowley *et al.* (2000) and Rothaermel (2001)
Innovation performance	Our firm often leads the industry in introducing new products/services	Deshpandé *et al.* (1993), Arundel and Kabla (1998), Ahuja (2000),

(*continued*)

Table AI. Table survey measures

Construct	Survey measures	Source of scale
	Our firm often leads the industry in adopting new technologies Compared with our main competitors, our product improvement and innovation receives a better market response Our products use state-of-art technologies and processes The success rate of our product innovation is higher than for our main competitors Compared with our main competitors, we have more granted patents and/or registered software copyrights	Ritter and Gemünden (2004), Bell (2005)

Table AI.

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