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RESEARCH ARTICLE

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Network Architecture and Firm Performance: A Resources-Based View

Abstract Previous studies have investigated alliance networks primarily from two alternative views, a relational view that focuses on the "strength of strong/weak ties," or a structural view that refers to a firm's position and structural embeddedness. We posit a firm's network architecture, i.e., the portfolio of strong/weak ties, influences its conduct and performance. From a resource-based view, the network architecture itself could be a source of sustained competitive advantage. We argue that both network architecture and duration of a firm can enhance its performance. However, their effects and the interaction are contingent on different performance outputs. Using strategic alliance networks data from a survey of the manufacturing industry in China, we examine the performance implications of network architecture. Results suggest that benefits from networks may evolve with network duration, hence firms should search for optimal network configurations. By integrating an alliance portfolio, firms with dual network architectures can enjoy both the strengths of strong ties and weak ties and avoid the risks inherent in a pure strong/weak-tie network.

Keywords network architecture, alliance portfolio, dual network, duration

1 Introduction

The rapid proliferation of strategic alliances has been one of the most striking

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features of the business environment over the last two decades. This trend of multiple alliances with multiple partners has embedded firms in intricate webs of inter-firm networks (Koka and Prescott, 2002). The social network perspective has shown a significant impact of a firm's network embeddedness on performance. Previous studies have investigated the effects of inter-firm networks on firm performance primarily from two alternative views, a relational view that focuses on the "strength of ties" (Granovetter, 1973), or a structural view refers to firm's position and structural embeddedness (Burt, 1992).

However, prior research has produced inconsistent and confusing evidence of what network characteristics are most advantageous for firms. For example, firms can draw resources from a cohesive network of socially embedded ties (Coleman 1998; Walker, Kogut, and Shan, 1997), while the opposite view suggests that sparse networks rich in structural holes are more conducive to the long-term success of firms (Burt, 1992, 1997). Similarly, strong ties promote resources exchange and develop a governance mechanism based on trust (Uzzi, 1997; Bian, 1997), while weak ties contribute to diffusion of knowledge and novel information (Granovetter, 1973).

These opposing views may persist because a great majority of research has examined firm networks only from an atomistic view (Gulati, Nohria and Zaheer, 2000). Social network studies have primarily focused on the strength of ties or the structural positions in the network, while ignoring the value of actors in the network, which could be viewed as resources (Gulati, 1999). The resources in networks could serve as sources of sustainable competitive advantage (Kogut, 2000). Besides, most studies did not focus on the nature of inter-firm alliance and the constraint characteristics of inter-firm networks, which may be different from the individual social networks (Rowley, Behrens, and Krackhardt, 2000). In addition, from the notion of dynamic network constraints and benefits, the resource needs of firms from their networks may evolve with network duration (Hite and Hesterly, 2001). As a result, the effects of a specific network architecture may change over time.

To untangle the impact of alliance networks on firms' performance, this study moves beyond prior research that emphasized relational or structural aspects of network ties, and underscores instead the contribution of network architectures, which captures more directly the characteristics and endowments of firms' strategic alliance portfolio. By advancing Capaldo's (2007) original work, and expanding Bian and Huang's (2009) study of individual ties network, we examine three kinds of networks architecture, namely strong-tie network, weak-tie network and dual-tie network. Drawing upon the resources-based view

(RBV), we suggest that network architecture, which represents a firm's network membership and specific kind of alliance portfolio, can be viewed as an inimitable resource by itself, and will impact the firm's performance.

The primary objective of this study is to examine the effect of a firm's overall network architecture on its performance over time. We focus on two questions: What kind of network architecture is most advantageous for firms? And how do the structure patterns of network embeddedness, along with network duration, influence performance? As a result, we offer the following contributions. By integrating the RBV and social network perspectives, this study tries to explain why and how network architectures impact different levels of performance (i.e., return on assets (ROA) and new product development (NPD)) distinctively. A firm's alliance portfolio, being integrated into pervasive network architecture difference, interact with the network duration, which reflects a firm's capabilities to leverage its networks, could produce valuable benefits.

The paper is organized as follows. After reviewing the relevant literature, we set out methods and results of an empirical study of how three types of network influence firm performance, separately and interactively with network duration. To examine the differences of the three kinds of networks, we adopt two forms of organizational performance, ROA and new product development, to examine the asymmetric effect of networks. The final section contains conclusions and discussion, along with implications for managers and suggestions for further research.

2 Theory and Hypothesis

This study draws upon three streams of research, (1) the strategic alliance literature, (2) applications of social network theory, and (3) the emerging research on strategic networks invoking resource-based view.

2.1 Alliance Networks

The last two decades have witnessed a proliferation of strategic alliances among firms, as a result of technological development and globalization. The increasing importance of strategic alliances has been observed (Gulati, 1998; Gulati, Nohria and Zaheer, 2000). An alliance is a voluntary arrangement among firms that involve resources exchange, sharing, or co-development of products, services, or technologies (Gulati, 1998). Alliances can take different forms, including joint ventures, long-term marketing and licensing contracts, reciprocal trade agreements, R&D partnerships, and affiliation in researching consortia.

It is common for firms to enter into multiple alliances with a number of partners—a phenomenon that has been called an "alliance network" (Koka and Prescott, 2002). Studies of alliance networks have noted the role that these networks play in affecting the performance of member firms (Gulati et al., 2000).

2.2 Social Network Theories

Many studies of alliance networks have applied social network theories (e.g., Ahuja, 2000; Goerzen and Beamish, 2005; Koka and Prescott, 2002). Social network perspectives conceive of firms as interdependent, and emphasis on the patterns of relationships among interconnected firms and the network structures of inter-firm ties that provide firms with opportunities and constraints (Inkpen and Tsang, 2005). Several studies have examined how the alliances network affect firms' innovation output, new product development, or financial performance, drawing on social network theories (Ahuja, 2000; Rowley et al., 2000; Zaheer and Bell, 2005). Zaheer and Zaheer (1997) found that firms are highly alert when they create and utilize wide-ranging information networks with plentiful weak ties, high centrality, and a wide geographical scope, and that this capability can translate into superior performance. McEvily and Zaheer (1999) compared the inter-firm information networks of firms in geographical clusters and found that those networks with fewer structural holes tend to acquire fewer competitive capabilities. Tsai (2001) examined how the structure of social relations affects performance by considering the position of business units in the knowledge network. He argued that the most innovative and profitable actors are central.

Firms can enjoy certain benefits, referred to as social capital, by virtue of their membership in social networks (Portes, 1998). Social capital may promote firm performance by enhancing innovation (Ahuja, 2000; Tsai and Ghoshal, 1998), knowledge transfer (Burt, 1992; Inkpen and Tsang, 2005; Koka and Prescott, 2002), intellectual capital (Nahapiet and Ghoshal, 1998), and efficiency (Burt, 2000). Previous studies have mainly focused on two types of network embeddedness: relational and structural (Granovetter, 1985; Gulati, 1998). The former examines the nature of dyadic relationships, considering the role of inter-firm ties as a mechanism for gaining valuable information and resource (Granovatter, 1973; Uzzi, 1997), whereas the latter emphasizes the importance of the structural position in the network by considering properties such as structural holes (Burt, 1992), structural equivalence (Burt, 1987), and density (Coleman, 1988).

Nevertheless, the social network perspectives offer only a partial account of the performance implications of alliance networks. There are two major limitations: First, it focuses on network ties or structure while ignoring the differences in the inherent attributes of alliance. Second, it partially relies on interpersonal measurements such as emotional intensity and intimacy, which is not applicable for inter-firm alliances (Rowley et al., 2000).

2.3 Alliance Network as a Strategic Asset

Social network theories emphasize the value of external ties, whereas RBV focuses on the analysis of firms and their internal resources. RBV holds that resources that confer competitive advantage must be confined by the firm's boundaries (Barney, 1991; Wernerfelt, 1984). This assumption may be inconsistent with the nature of alliance networks (Lavie, 2006).

In recent years, a number of researchers have examined different aspects of a firm's network explicitly invoking RBV (such as McEvily and Zaheer, 1999; Lavie, 2006). For example, Gulati (1999) suggests that resources may inhere in the networks of embedded ties by providing them with valuable information, as a result, provides strategic advantage by allowing them to act quicker than rivals. These resources can be referred to as network resources that extend the opportunity set of the firm (Gulati, 1999). In view of a focal firm's given ego network of alliance, Kogut (2000) conceived of the network as a type of a valuable resource in and of itself. Some studies have considered the composition of alliance partners in the alliance network (Gulati, 1999; Lavie, 2007). For example, Rothaermel (2004) showed that biopharmaceutical firms facilitate new product development by leveraging their partners' assets. Stuart (2000) found that the technological innovativeness of partners contributes to the sales growth and innovation rates of semiconductor firms.

This stream of research focuses on the attributes of partners, different with the traditional social network analysis which concentrates on the quality of ties or the properties of the network structure (Lavie, 2007). These studies support the idea that alliance portfolios provide the focal firm with access to network resources (Gulati, 1999) that potentially enhance its performance.

2.4 Strategic Alliance and Network Architecture

For the purposes of examining inter-firms networks characterized by strategic alliance, Rowley et al. (2000) measured strength of ties by the frequency of

interaction between partners and their level of resource commitment to the relationship. Strong and weak ties serve different purposes, and entail a different set of alliance behaviors. They conceptualize strong and weak inter-firm ties as separate constructs, different in kind rather than degree, thereby capturing the strength of inter-firm relationships on the basis of alliance types. In this study, we expanded the relational view and RBV, and operationalized networks architecture based on inter-firm alliance portfolios. We also identified three kinds of network: strong-tie network, weak-tie- network and dual-tie network.

In the studies of personal contacts networks, Bian and Huang (2009) identified two kinds of distinct network resources, namely information and influence, whose flows are structurally constrained by the strengths of individual ties. Extending this argument, we believe that different alliance portfolios reflect different kinds of network resources. As a result, a firm network with specific alliance portfolio could provide specific kind of resources. Particularly, strong ties network is believed to provide firms with two primary advantages, material resources exchange and trust. First, strong ties are associated with the exchange of material resource and high-quality knowledge. Strong ties contribute to resource exchange (Uzzi, 1996). Second, strong ties serve as a social control mechanism, which governs partnership behaviors. In the development of strong ties, partners learn from each other and develop relational trust, norms of mutual gain, reciprocity, and a long-term perspective (Larson, 1992). These benefits gained from strong ties network could promote a focal firm's economic performance and long-term growth.

The advantages gained through weak ties network are different. Granovetter (1973) argued that weak ties can gain access to novel information. Weak ties are more likely than strong ties to be "local bridges" to distant others possessing unique information. The strength of weak ties argument is as much about structural embeddedness as it is about relational embeddedness. A weak tie can be beneficial, because it is more likely to embed an actor in a network with a sparse structure and more structural holes (Capaldo, 2007). In the domain of inter-firm relationships, weak ties have potential to foster and speed up innovation by connecting a focal firm to otherwise difficult-to-reach knowledge areas (Rogers, 2003). With a weak ties network, a firm is likely to take advantage of non-redundant contacts and network diversity (Burt, 1992), could enhance a firm's new product development.

Rowley et al. (2000) argued that both strong and weak ties could be beneficial to firms under different conditions, strong and weak ties have different qualities, which are advantageous for different purposes. Thus, strategic studies on

network need to include the search for optimal network configurations. While a firm is likely to have a mix of strong and weak ties, we argue it will benefit from a portfolio of ties. For example, a "dual network" —a network architecture wherein a small core of strong ties is integrated with a larger periphery of weak ties, may be more profitable for firms (Capaldo, 2007). We generate a hypothesis related to some of these conditions:

H1 Compared to those with only strong/weak ties network, firms with dual network are more likely to have higher performance.

2.5 Network Duration

Duration measures the amount of experience that firms have in dealing with each other, the resulting routines being described as relation-specific assets (Levinthal and Fichman, 1988). Drawing from previous studies, the benefit of network duration is related to the knowledge transfer and inter-firm trust. Through developing mechanisms to ease knowledge transfer and enhance trust, network duration promotes firm performance.

H2 Network duration will be positively associated with a firm's performance.

2.5.1 Trust

As relationships are network embeddedness (Granovetter, 1985; Uzzi, 1996, 1997, 1999), trust as a form of inter-firm bond is built up over time. Partners in long-lasting alliances have had enough time to develop mutual understanding, and thus conflicts that hamper relationship performance may be less likely (Lin & Germain, 1998; Martin, Swaminathan & Mitchel 1998). Although there are some studies show no statistical significance for this effects (e.g. Sako and Helper, 1998), Dyer and Chu (2000) found a positive association between link duration and the level of trust in buyer-supplier relationships in the automotive industry in the United States, Korea, and Turkey. As duration increased, it is of course possible that goodwill trust matters resulting from long or repeated interaction (Zaheer, McEvily, and Perrone, 1998). Such trust could contribute to a firm's ROA.

H2a Network duration is positively associated with a firm's return of asset.

2.5.2 Knowledge Transfer

With the notion that link duration is a primary determinant of the accumulation

of relation-specific assets, as link duration increases, firms in a network develop relation-specific routines so they become better able to share hard-to-transfer knowledge. Many examples of successful knowledge management have been argued to benefit from long-lasting inter-firm links (Asanuma, 1989). Therefore, we propose the following hypothesis:

H2b Network duration is positively associated with a firm's new product development.

2.6 Interaction

Capaldo (2007) framed inter-firm relationship as a three dimensional concept composed of a temporal dimension, a resource dimension, and a social dimension. Strong inter-firm ties are characterized by long time-frames and high resource commitments. The three variables that should be employed to express the strength of an inter-organizational relationship are, the relationship's overall duration, the frequency of collaboration, and the intensity of collaboration. The network architectures, based on the alliance portfolios, reflect the resource and social dimension, whereas the duration reflects the temporal dimension. They express separate, but equally relevant, aspects of the tie strength, and therefore need to be jointly taken into account. Previous studies argued that a firm's alliance management capability can be a source of competitive advantage (Dyer and Singh, 1998; Ireland et al., 2002). A firm's network management capability is built through accumulated alliance experience over time (Rothaermel and Deeds, 2006). This capability will influence the resources that firms gain from their networks.

From the notion of dynamic network constraints and benefits, the resource needs of firms from their networks may evolve with network duration (Hite and Hesterly, 2001). As a result, the effects of specific network architecture and duration may change over time. The benefits gained from network architecture are similar to the networks duration, as they both provide resources based on knowledge transfer and trust. As a result, there may be interaction effects between network architecture and network duration.

H3 The interaction between network architecture and network duration is significantly associated with a firm's performance.

H3a The interaction between strong ties networks and duration is negatively associated with a firm's return of asset.

H3b The interaction between weak ties networks and duration is negatively associated with a firm's new product development.

2.7 Network Size

Network size measures the number of members in a network in which a firm embeds. Burt (1992, 1997) argued network size as an aspect of network constraint affected the structural embeddedness of firm's network. A larger network means more structural holes and more social capital. Many studies at the level of individual customers support the value of network size, exhibiting so-called network effects. For example, Shankar and Bayus (2003) advanced the idea that a firm's customer network can be a strategic asset building on the RBV, and these effects are a function of networks size.

Other scholars examined how the size of a network affects the nature of intra-network social relations and knowledge transfer. For example, Hislop (2005) suggested that as network size increases, network density is likely to decrease, as it becomes much more problematic for the actors in such networks to retain strong ties with a significant proportion of the network's members.

2.8 Network Range

Network range is defined as the prevalence of ties that cross institutional, organizational, or social boundaries (Burt, 1992). Range points to the benefits associated with network connections that span important organizational boundaries. The network range, ties to different knowledge pools and cross boundaries, increases an actor's ability to share knowledge (Morrison, 2002; Reagans and McEvily, 2003).

It is clear that the knowledge transfer across a boundary can be beneficial for the recipient. However, such a transfer can also be problematic. From an absorptive capacity standpoint, this lack of common knowledge is likely to frustrate attempts to transfer knowledge across the boundary (Cohen and Levinthal, 1990; Tsai, 2001).

It is easy to transfer knowledge for people with networks characterized by range, because behaviors that ease knowledge transfer are part of their everyday network activity, which gives them a greater opportunity to learn how to convey complex ideas (Reagans and McEvily, 2003). Similarly, firm is likely to find it easy to transfer knowledge if it has experience considering multiple perspectives and different ways of framing what it knows. Network range is likely to promote performance by affecting firm's ability to promote knowledge transfer.

3 Methods

3.1 Sample

We tested the hypotheses using survey data from 270 manufacturing firms in China. Most of the firms were located in six cities (Shenzhen, Suzhou, Tianjin, Shenyang, Zhengzhou, and Xi'an), which represent typical regions in China, providing an appropriate setting for testing the effectiveness of ties in a complicated and volatile national conditions and economic environment.

3.2 Data Collection

We collected network data using egocentric techniques (Burt, 2002). We interviewed with a CEO ego-network questionnaire, and each respondent responded to a series of questions that generate a list of cooperative contacts. Next, the respondent described the types of their strategic ties based on categories adapted from Contractor and Lorange's (1988) scheme.

An English-language version of the questionnaire was prepared first, and then translated into Chinese. To confirm the consistency and accuracy, the Chinese version was back translated into English by two independent translators (Brislin, Lonner and Thorndike, 1973). Any conflicts were discussed by the researchers and translators until they reached agreement (Hoskisson et al., 2000).

Before the formal survey, we selected ten enterprises as pilot cases. The purpose of the pilot survey was to make the questionnaire more comprehensive, appropriate, and easy to understand. The pilot survey was processed by graduate students with the assistance of senior managers in the corporation. With the help and advice from respondents, we modified the questionnaires to reflect the characteristics of different industries, scales and ownership structures. This process helped improve the survey questionnaire. The final questionnaire was combined with the questions found in the preliminary survey and revised in detail.

The survey was administered through face-to-face interview and mail between July 2007 and January 2008. Data collection procedures were designed to ensure a meaningful response rate. With the help of local governments, the investigators contacted senior managers via telephone, solicited their cooperation, and made an appointment with them. Through interview, investigators usually selected CEO or a top official in charge of strategic planning and technology management as the key informant in each firm, because firms mainly rely on senior managers to maintain managerial ties. Each visit took one to two hours. The interviewers

informed the managers of the purpose of the project and the confidentiality of their responses and promised them a summary report in return for their participation. This process significantly increased the response rates.

The data collection phase was mainly completed in January 2008. A total of 600 questionnaires were distributed and 308 responses were returned, 38 of which were unusable because necessary data were missing. The 270 responses included in the study gave a final response rate of 45%.

3.3 Measures and Procedure

3.3.1 Ties Strength and Network Architecture

Granovetter (1973:1361) defined tie strength based on a "combination of the amount of time, the emotional intensity, the intimacy, and the reciprocal services which characterize the tie." However, this measure is not applicable to the inter-firm relationship for the purpose of examining inter-organizational networks (Rowley, Behrens and Krackhardt, 2000). To understand the inter-firm network, it is important to perform a more fine-grained analysis of inter-firm relationships. Several scholars have argued that the nature of weak and strong ties is different in kind as well as degree (Granovetter, 1985; Uzzi, 1996). Strong ties and weak ties serve different purposes and require a different set of alliance behaviors.

Rowley et al. (2000) conceptualized strong and weak inter-organizational ties as separate constructs, different in kind rather than degree. We followed their suggestion, categorized equity alliances, joint ventures, and non-equity cooperative (R&D) ventures as strong ties, while defining marketing agreements, and licensing and patent agreements as weak ties, thereby capturing the strength of inter-firm relationships on the basis of the interaction and resource commitment.

More specifically, strong ties networks include strong and cohesive ties such as equity ties, manufacturing joint ventures, and joint R&D projects; while weak ties networks include only weaker and more ties such as marketing and licensing agreements and standards, and training arrangements. Referring to networks which include both a large periphery of heterogeneous weak ties and a core of strong ties, we define them as dual ties networks.

We coded network architecture with three dummy variables, e.g., weak ties network = 1 when other types = 0 (In fact, there is a control variable, non-network = 1 when a firm reported no such inter-firm ties).

3.3.2 Duration

Duration was measured by an item capturing the number of years since the firm and its primacy partners began their business relationship in their networks at the time of measurement (e.g., Kotabe, Martin, and Domoto, 2003; Krishnan, 2006).

3.3.3 Firm Performance

We chose to measure performance from both financial and innovative dimensions by focusing on two variables: return on assets (ROA) and new product development (NPD). Since many Chinese managers view exact figures of performance as secrets, the comparative method is more effective for avoiding non-responses (Lau and Ngo, 2001). In particular, we examined the change ratios of ROA and new products numbers that a firm had introduced to the market in the past three years (1= decreased greatly, 7 = increased greatly).

3.3.4 Interactions

We created three variables to examine the effect of network ties with long-term duration in their network as follows. Take the variable "Weak ties network with Duration" as an example, first, to overcome potential co-linearity problem between the variables measuring the main effects and the interaction terms, we centered the Duration variable by subtracting the mean score from each individual value and adding a constant to Weak ties network. We then multiplied these variables (Aiken, West, and Reno, 1991) to create the variable "weak ties network with duration." The other two variables are the same.

3.3.5 Control Variable

Network range. We considered the importance of network range at the level of institutional areas. A firm that spreads its network connections across multinational boundaries bridges holes between actors in the broader community of knowledge. As a result, is easier to promote innovation and performance. We constructed a dummy variable to measured range, if there is a major abroad number in a firm's network, the range dummy was set equal to one.

Network size. We measured networks size as the number of actors within a network. This variable ranged from 1 to *n*, where *n* equals the number of players

in the network (Burt, 1992, 1997).

A dummy variable was utilized to capture differences between industries. The dummy variable was coded as 1 for high-tech industries and 0 otherwise. In addition, we controlled for firm size.

3.4 Data Analysis

We analyzed our data using ordinary least squares (OLS) regression. In order to examine separately the influence of main effects variables and interaction variables, we built three models. In Model 1, we modeled ROA solely as a function of our control variables, Firm size, Industry, Network Range and Network Size. In Model 2, we added our main effects variables: Strong network, weak network and Dual network. Lastly, in Model 3 we introduced our interaction effects to our main effects. For the comparative analysis, we used NPD as dependent variables and ran Model 4 to Model 6 in the same way. We examined all our models for co-linearity issues and concluded that co-linearity was not a significant concern.

As most of our data were collected from one single survey instrument and one single informant per corporation, there was a serious concern of common method bias and single informant bias. We used several procedural remedies such as reducing item ambiguity, separating scale items for the ties and new product development measures to mitigate these biases. Besides, we obtained data of several network data variables from secondary sources and from field interviews. These procedures and statistical remedies gave us confidence that neither common method nor single informant bias was a serious problem in our study.

4 Result

4.1 Result Description

In Table 1 we present descriptive statistics, including the mean values, standard deviations, and correlations for all the measured variables. The correlation matrix indicates a positive and statistically significant correlation between duration and performance. Among network architecture variables, we find that the correlation between dual network and performance is most significant. Besides, the weak ties network is negatively correlated with ROA while the strong ties network is negatively correlated with NPD although not very significantly.

Table 2 displays standardized coefficients for the independent variables to

able 1 Means, Standard Deviations, and Correlation Coefficients (N=270)

	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11	12
1. NPD	4.66	1.490	—											
2. ROA	4.53	1.362	0.446***	—										
3. Firm size	2.795	0.888	0.105	0.137*	—									
4. Industry	0.23	0.421	0.198**	0.079	0.126*	—								
5. Network range	0.20	0.401	0.197**	0.187**	0.253***	0.211***	—							
6. Network size	7.60	14.774	0.163**	0.242***	0.246***	0.120*	0.181**	—						
7. Strong network	0.20	0.403	–0.124*	0.161**	–0.002	–0.101	0.092	–0.110	—					
8. Dual network	0.14	0.348	0.230***	0.344***	0.161**	0.058	0.197**	0.248***	–0.205**	—				
9. Weak network	0.54	0.499	0.148*	–0.152*	–0.056	0.057	–0.138*	0.044	–0.553***	–0.421***	—			
10. Duration	2.55	0.970	0.185**	0.306***	0.189**	–0.018	0.214***	0.134*	0.084	0.189**	–0.081	—		
11. Strong network * Duration	0.032	0.433	0.008	–0.024	0.044	0.032	–0.021	–0.009	0.148*	–0.030	–0.082	0.449***	—	
12. Dual network * Duration	0.063	0.348	0.168**	0.264***	–0.009	0.026	0.169**	0.167**	–0.092	0.450***	–0.211***	0.371***	–0.014	—
13. Weak network * Duration	–0.040	0.687	0.017	0.152*	0.163**	–0.050	0.136*	0.058	0.030	0.015	–0.054	0.711***	0.004	0.015

Note: *** indicates $p < 0.001$, ** indicates $p < 0.01$, * indicates $p < 0.05$.

show the relative importance of each on ROA and NPD, as well as the adjusted R^2. In all six models, the adjusted R^2 is significant. Below, we detail our hypothesis tests.

Table 2 Results of Regressions for ROA and NPD

	ROA			NPD		
	Model 1 Controls only	Model 2 Adding Main fects	Model 3 Adding Interactions	Model 4 Controls only	Model 5 Adding Main fects	Model 6 Adding Interactions
Firm size	0.051	0.000	0.004	0.024	–0.003	0.001
Industry	0.020	0.062	0.078	0.152*	0.148*	0.152**
Network range	0.135*	0.020	–0.010	0.139*	0.104	0.091
Network size	0.203**	0.121*	0.117*	0.114+	0.015	0.015
Strong network		0.426***	0.402***		0.203*	0.150
Dual network		0.483***	0.414***		0.407***	0.337***
Weak network		0.295**	0.236*		0.446***	0.371***
Duration		0.183**	0.432**		0.106	0.387*
Strong network * Duration			–0.247**			–0.150
Dual network * Duration			–0.016			–0.055
Weak network * Duration			–0.162			–0.252*
Adjusted R^2	0.069	0.262	0.284	0.065	0.182	0.188
F-test	6.017***	12.916***	10.703***	5.637***	8.463***	6.655***

Note: *** indicates $p < 0.001$, ** indicates $p < 0.01$, * indicates $p < 0.05$, + indicates $p < 0.1$.

4.2 Tests of Hypotheses

4.2.1 Main Effect

We found support for H1, which examines the effects of dual network on firm performance. The standardized coefficient for performance is positive and significant both in the main effects model and in the overall model (Model 2, $\beta = 0.483$; $p < 0.001$; Model 3, $\beta = 0.414$; $p < 0.001$; Model 5, $\beta = 0.407$; $p < 0.001$; Model 6, $\beta = 0.337$; $p < 0.001$). For ROA，the positive effect of strong network ($\beta = 0.426$, $p < 0.001$) is stronger than weak network ($\beta = 0.295$, $p < 0.01$); For NPD，the positive effect of weak network ($\beta = 0.446$, $p < 0.001$) is stronger than strong network ($\beta = 0.203$, $p < 0.05$). In H2, we predicted a positive effect of duration on firm performance. Hypothesis 2a was supported (Model 2, $\beta = 0.183$; $p < 0.01$). However, H2b was not significantly supported for NPD (Model 5, $\beta = 0.106$; $p < 0.1$).

4.2.2 Interaction Effect

In Hypothesis 3a we examined the interaction of strong network architecture with duration on ROA. Our data support it (Model 3, $\beta = -0.247$; $p < 0.01$; Model 6). In Hypothesis 3b we examined the interaction of weak network architecture with duration on NPD, it is supported, too (Model 6, $\beta = -0.252$; $p < 0.05$). All these interactions are negatively associated with the firm's performance.

4.2.3 Control Variables

Examining the regression coefficients for our control variables (Firm Size, Industry, Network range and Network size), we found significant positive relationships between network size and ROA (Model 1, $\beta = 0.203$; $p < 0.01$; Model 2, $\beta = 0.121$; $p < 0.05$; Model 3, $\beta = 0.117$, $p < 0.05$) while not significant relationships between networks size and NPD. Besides, we found significant positive relationships between industry and NPD (Model 4, $\beta = 0.152$; $p < 0.05$; Model 2, $\beta = 0.148$; $p < 0.05$; Model 3, $\beta = 0.152$, $p < 0.01$).

5 Discussion

Research in inter-firms networks, especially studies using a social network perspective, primarily focuses on inter-firm relationship and network structure (Granovetter, 1985; Burt, 1992). Recent developments in the field, such as strategic networks perspective, highlight the views that the network of relationships which firms embedded in, can serve both as resources themselves as well as conduits for accessing external resources and capabilities (Gulati et al., 2000).

By combining the RBV and network theory, we gain a fuller and richer explanation to firm-level outcomes. In this paper, we suggest the assumption that a superior network architecture, which is a structural combination of varying inter-firms ties, can be viewed as a key source of competitive advantage. Moreover, by examining how network characteristics combine with network duration to influence performance, we suggest, the resources that a firm needs and the benefit that network provides, will evolve with duration.

5.1 Findings

As predicted, we found that it is important to consider the entire network

characteristics when explaining performance outcomes. Specifically, the results confirmed our baseline hypothesis that firms with superior network architecture perform better than do others. Although strong ties network and weak ties network positively affect firms performance, only firms with a dual network perform the best.

The findings supported the direct effect of strong network on ROA. Thus, our results confirmed prior research by Uzzi (1997), Bian (1997) and others that strong ties which are associated with the fine-grained information exchanges and trust-based governance enhances firm performance.

Additionally, our result showed that there is a significant correlation between weak ties network and new product development. This result supported the argument of "strength of weak ties" (Granovetter, 1973; Hansen, 1999), namely weak ties can promote the transfer of simple knowledge and novel information, thus serve as a source of innovation.

The most interesting and surprising finding in our study is the complex results for either the direct role of duration or the interaction with ties network variables. For new product development and ROA, the effects of duration are both positive. However, the interactive effect of duration and weak ties network is negative on new product, and the interactive effect of duration and strong ties network is negative on new product development. Given some previous empirical research and theoretical reasoning, as duration influences firm's alliance experience and may enhance the capabilities to govern the network, this was an unexpected result. One plausible explanation is that our measure of duration, which is a static measure of lasting period, can not reflect the nature of dynamic networks. Another possible explanation is that this negative correlation reflects substitution effects between duration and relational embeddedness, which have similar mechanisms to influence performance.

5.2 Contributions

This paper provides several implications on inter-firm networks studies. As previous studies primarily focus on the ties and structures embedded in network, using a perspective of RBV, we suggest that network architecture, which represents the resource nature of networks, can be viewed as an inimitable resource by itself, and will impact the firm's performance.

By advancing Capaldo's (2007) original work, and expanding Bian and Huang's (2009) study of individual ties network, we identify three kinds of networks architecture, namely strong-tie-networks, weak-tie-network and a

dual-tie network. Our study adds an implication to RBV research, which tends to exclude resources beyond the boundaries of the firm.

This paper confirms the "strengths of a dual network." We explain why and how dual ties network positively impacts on performance. Firms can enjoy both the strengths of strong ties and weak ties as well as avoid the risk inherent in a pure strong ties network or weak ties network. Firm could gain a competitive advantage leveraging a dual network.

Besides, we find that the network duration, as an indicator of firm's alliance experience and capabilities to govern the networks, significantly influence firm performance. Duration interact with the network architectures, could produce valuable implications.

5.3 Implication and Limitation

Our study provides several important implications for researchers and practitioners alike. Broadly speaking, it highlights the strategic value of viewing the pattern of a firm's network holistically, such as the network architecture. Firms could acquire resources and capabilities from its networks. However, it is neither enough for managers to focus their attention on building strong inter-firm relationships such as alliances to gain trust-based cooperation and resources, nor is it sufficient for them to structure their network to capture the information benefits from structural holes and weak ties. Rather, managers must pay attention to the entire networks architecture and structural characteristics.

There are several limitations in this paper, too. First, our data were collected from a large survey using egocentric techniques, thus it is difficult to define the network boundaries with this methods. Second, we measured ROA and NPD variables by the change ratios, and used them as proxies of performance. They are both subjective data from survey and not a perfect measurement. Finally, we used duration as an indicator of firm's alliance capability, it is not perfect to study the interaction between the benefits that network provide and the capabilities that firms have developed.

6 Conclusion

In this paper, we argue for a need in inter-firm networks research to go beyond a single structural or relational view and account for a holistic perspective, which, as predicted by the RBV and a strategic network perspective, exert an influence on firm performance. Network research focuses on the "network resources," which firms gain from their network, or the "relational capabilities" from the

networks embeddedness. However, they may overlook the entire networks characteristics and thus miss a large source of variance in performance.

By showing that firms perform better when they occupy superior network architecture, namely dual networks, we demonstrate the value of firm network itself as a source of sustained competitive advantage. As we predicted, we found that it is important to consider the entire network structural characteristics and network constraint when explaining the effects of network on firm performance.

We also argued for the "strengths of a dual network." On the one hand, strong ties provide trust and relational resource, especially in the Chinese context (Luo, 2007; Park, and Luo, 2001), on the other hand, a large number of weak ties avoid the risks of being locked in a restricted number of strong ties, interestingly and consistently with previous research (Capaldo, 2007).

In summary, firms can enjoy both the strengths of strong ties and weak ties while avoiding the risk inherent in all-strong/weak-tie networks. Firms could gain sustained competitive advantages by leveraging dual ties networks.

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