Full Length Research Paper

Network dynamics and innovative performance: The moderating effects of network resources

Kuen-Shiou Yang¹ and Chen-Yu Lin²*

¹Institute of Sociology, Academia Sinica, Taiwan.
²Department of International Trade, Feng Chia University, Taiwan.

Accepted 27 October, 2011

This research is aimed to employ a dynamic network perspective in order to understand how firms, which are positioning in a dynamic network, enhance their innovative performance by taking structural movement. Unlike conventional social network articles focusing on the influence of structural effect, this research highlighted the importance of how alters’ attributes have a great effect on the relationship between firms’ network structure and innovative performance. Based on a sample of 117 global high-tech firms, this research first examined how firms’ structural movement in dynamic networks enhances their innovative performance. This paper then tested the moderating effect of network resources on the relationships between network dynamics and innovative performance. Our findings suggested that when firms move into more prominent and strategic position in dynamic networks, their innovative performance will be enhanced. Also, the results suggested that firms with abundant network resources will strengthen the effect of network dynamics on firms’ innovative performance.

Key words: Network dynamics, innovative performance, network resources, social capital.

INTRODUCTION

Many managers realize that continuous innovative performance is critical to ensure long-term competitiveness and even the survival of firms. Especially for firms that positioned in the fast-changing and hyper-competitive high-tech industry, accessing and exchanging necessary knowledge resources to enhance their innovative performance is vitally important. Innovation, however, can be seen as the results of accumulated knowledge, which need not only the contribution from a firm’s research and development (R and D) departments, but also networks that lead to an increasing interaction between different actors represent a platform for exchanging knowledge resources with other firms. Accordingly, it is necessary for high-tech firms to enhance their linkage to different knowledge resources that enable them to share information, products, as well as support for these resources are owned by partners.

Abundant prior research has proven that external relationships, also called social networks, help firms to access necessary resources such as useful information to enhance their capabilities (Burt, 1992; Stuart et al., 1999; Uzzi, 1996) and then to achieve better economic performance (Gulati et al., 2000; Mowery et al., 1996; Zaheer and Bell, 2005). And there are relatively few studies addressing the role of inter-organizational relationships or inter-firm cooperation for enhancing firms’ innovative performance. For example, Tsai (2001) found that the business units’ connectivity in the network is positively correlated with the innovation and performance of the unit. Zeng et al. (2010) proven that inter-firm cooperation has the most significantly positive impact on the innovation performance of small and medium-sized enterprises.

Lately, the development of network dynamics has opened up new perspectives for analyzing the role social networks have for innovation. Network dynamics focuses on the changes in network structures, relations and resources over time. Specifically, innovation can take place in many different ways - through products, processes, or the positioning of the firm (Francis and Bessant, 2005).

Social networks provide different positions with different opportunities and constraints of actions, Thus, some firms might move to better positions that contain better opportunities and less constraint of accessing knowledge...
resources than other firms when the structure of networks changes. Theoretically, if one firm can get improvement of locating in prominent and strategic position than before, it will have more opportunities to increase its innovative performance.

This research aims to understand how firms’ movements in dynamic networks have influence on their innovative performance. As indicated above, although many studies have acknowledged the significant effect of social networks on performance outcomes, a review of literature reveals that there is almost no research focusing on the correlation between network dynamics and firms’ innovative performance. Furthermore, this paper also discusses the attributes of linked alters, and network resources moderating the structural effect of network dynamics on their consequences. Network resources are owned by its partners yet can be potentially accessed by the focal firm through its ties to these partners (Gnyawali and Madhavan, 2001; Gulati, 1999; Lavie, 2006, 2007). Through these linked resources, firms can directly and/or indirectly enhance their internal resources and then benefit their innovation.

The paper is structured as follows: First we explain the notion of network dynamics and network resources that have influence on innovative performance. Our research hypotheses are then formulated and finally we use a sample of 117 global high-tech firms to analyze the causal relation between firm factors (network dynamic and network resources) and innovative performance.

THEORY AND HYPOTHESES

Social networks and innovation

Literature on innovation reveals that, over the last two decades, there has been a fundamental change in how firms undertake innovative activities. In detail, traditionally firms’ research and development (R and D ) departments have been seen as the most important source of innovation, but recently innovation has been treated as a process which results from various interactions among different actors (Doloreux, 2004). The development of social network analysis has opened up new opportunities for analyzing the role social networks have for learning and innovation (Björk and Magnusson, 2009).

The firms may not only benefit from novelty of information, knowledge and resource, but develop an understanding on the quality of possible exchange partners and potential allies (Powell et al., 1996; Uzzi, 1996), threats, opportunities and trends of the industry and other industries. The above opportunities allow firms to learning to develop and respond to competitive pressure from the industries. Therefore, when firms are more prominent in the network and rich in structural holes, they will have more opportunities to leverage and access novel and strategic purpose information, knowledge and resources, and then foster their innovation (Burt, 1992; Tsai, 2001). In other words, when firms are more active, easier to interact with others and bridge more structural holes, they will get more chances and resources for innovation than those have no such prominent positions.

Several existing studies have showed the positive correlation between firms’ social networks and their innovative performance with different evidence. For example, using data from Italian firms, Cainelli and Gelderman (2007) referred to the notion of social capital as networking and indicated that R and D and firms’ social capital arisen as complementary driving forces of innovation outputs.

Tsai (2001) found that the business units’ connectivity in the network is positively correlated with the innovation and performance of the unit.

Network dynamics and firms’ innovative performance

In the past few years, the development of network dynamics has provided a new perspective for analyzing the correlation between network positions and innovative performance. While different network positions represent different opportunities for a unit to access new knowledge that is critical to developing new products or innovative ideas, network dynamics focuses on the changes of focal firm’s positions over time. This paper defines network dynamics as the position changes of the firm through the dynamic networks.

Theoretically, an organizational unit’s network position reveals its ability to access external information and knowledge (Tsai, 2001) so when one firm changes its positions in a network, it will gain different opportunities of accessing resources it needs and of course, it also encounters different constraints from the networks.

Social network scholars have identified various measurements of firms’ positions in networks. Among these measurements, degree centrality, closeness centrality and structural hole are three of most critical indexes for prominent and strategic position (Burt, 2002; Wasserman and Faust, 1994). First, degree centrality refers to the number of direct connections to a focal actor and it is the simplest and most straightforward measurement for the degree of activity of an actor in a network. An actor with a high degree centrality is “where the action is” in the network. This measure thus focuses on the most visible actor in the network. If an actor has a high degree centrality, it should be recognized by others as a major channel of relation information, indeed, a crucial cog in the network (Wasserman and Faust, 1994). Schilling and Phelps (2007), the more firms can be reached by any path from a given firm, the more knowledge that firm can potentially access. Thus, firms maintained more either formal alliances or informal connections with their partners than before will have better innovative performance.

Second, closeness centrality focuses on how close an
actor is to all the others in the sets of actors, based on the idea that an actor is central if it can quickly interact with all the others (Wasserman and Faust, 1994). Closeness centrality can be defined as the inverse of the average geodesic distance between the focal actor and all other actors in a network. This measure refers to the freedom from the control by others and the efficiency of communicating with others. Theoretically, the diffusion of information and knowledge occurs more rapidly and with more integrity in networks with short average path lengths than in networks with longer paths (Watts, 1999). Therefore, when a firm can interact with other firms with shorter geo-distance, it can respond to technology transformation more efficiently and make decision process more quickly. In other words, a firm that is connected to other firms by a shorter average path can reach more information quickly than a firm that is connected by longer paths (Schilling and Phelps, 2007). Thus, it is reasonable for this research to hypothesis that when firms interact with other firms more efficiently and quickly, they will gain more chances of innovation than those taking more time to respond to others.

Finally, structural holes is the absence of a link between two contacts that are both linked to an actor, evolve over time (Burt, 2002). Clearly, a structural hole exists when actor A has a relationship with B and C, while B and C are not connected to each other and are only connected through A. A will possess advantages benefiting its structural hole position, including information filter and control advantage and control advantage for being a broker. Many insightful findings indicate that actors bridging structural holes perform better than those not so positioned (Burt, 1992, 2000; McEvily and Zaheer, 1999). When a firm is rich in bridging structural holes, it has more opportunities to access novel information, knowledge and resources from remote or unique parts of the network and to exploit them for its advantage.

A firm may not only benefit from novelty of information, knowledge and resources, but from developing an understanding on the quality of possible exchange partners and potential allies, threats, opportunities and trends of the industry (Uzzi, 1996; Powell et al., 1996). The above opportunities allow a firm to have responded to competitive pressure from the industries. Therefore, when firms are rich in structural holes, they will have more opportunities to leverage and access novel and strategic purpose information, knowledge and resources and then foster their innovation.

In other words, when firms bridge more structural holes, they will get more chances for innovation than those with redundant connections. From these discussions, it is reasoning to hypothesize that as firms bridge more structural holes than before, they might have advantage in innovation.

From the above reasoning, we infer that if firms can get improvement of communication opportunities, greater communication efficiency and more richness of structural holes in dynamic networks, they could gain more opportunities to improve their innovation. Those succeeding in improving their prominent and strategic position in dynamic networks will have more opportunities to innovate than those not getting such improvement of positions. Based on the above reasoning, we hypothesize as follows.

**Hypothesis 1**

Firms getting improvement in prominent and strategic position in dynamic networks will have better innovative performance than those not getting such improvement.

- **H1a**: Firms with more alliances with other firms than before will have better innovative performance.
- **H1b**: Firms with shorter communication distance, geo-distance, with other firms than before will have better innovative performance.
- **H1c**: Firms bridging more structural holes than before will have better innovative performance.

**Network resources**

When a firm embedded in a network, its partners’ assets can be potentially accessed by the focal firm through its ties to these partners (Gnyawali and Madhavan, 2001; Gulati, 1999; Lavie, 2006, 2007). In other words, firms can tap into sources of know-how and gain fast access to new technologies from partners’ assistance. These tangible and/or intangible assets including their human resources, financial assets, marketing efforts, R and D investments and reputation all can be defined as network resources (Lavie, 2007). Lavie (2006, 2007) summarizes three value-creation mechanisms that network resources accessed or leveraged by firms.

1. Network resources can generate value from accessing complementary assets.
2. Network resources can generate value from resource combinations.
3. Network resources can generate value from enhancing the value of focal firm’s internal resource or provide it with opportunities to internalize external resources.

In sum, network resources can benefit focal firm’s internal resources and capabilities by various ways. This comes to the insight that the effectiveness of the position changes of focal firm partially depends on the partners’ technological capabilities. For instance, when focal firms link to partners with complementary assets and/or new technologies, they have more opportunities to access and leverage the resources to enhance their capability of innovation by taking a movement of their positions in...
networks. In contrast, as the focal firm command fewer network resources, having less support form partners, it has less chance to access necessary information and to undertake innovatory activities, even though it moves to a better position in a network. Based on the discussion above, we hypothesize as follows.

**Hypothesis 2**

Firms’ network resources moderate the effect of network dynamics on innovative performance.

- H2a: Firms’ network resources moderate the relationship of H1a.
- H2b: Firms’ abundant network resources moderate the relationship of H1b.
- H2c: Firms’ abundant network resources moderate relationship of H1c.

**METHODS**

We established our sample from the global high-tech industry firms listed in the Asia Pacific Equity Research – Tech Hardware Supply Chain published by Morgan and Tech Files: Global Supply Chain published by Citigroup. After reconfirming with the industry experts, including general managers of the firms of security investment trust, purchasing and R and D managers and product managers of IC assembly and test, IC design, IC manufacturing firms and firms with end product, we got a sample of 117 global high-tech firms which can be mainly divided into three value chain sectors including semiconductor, component and End-Product.

We then got the data of strategic alliance events of cooperation in joint production, research and development and infrastructure investment of our sample from Securities Data Company where the longitudinal data from 1998 - 2007 in 3-year moving window to construct dynamic alliance networks. We also gather the profiles and financial data of sample firms from COMPSTAT, their websites and patent data from the United States Patent and Trademark Office (USPTO) for our dependent and moderating variables.

**Innovative performance**

Hagedoorn and Cloodt (2003) claim that innovative performance can be defined either in the narrow or broader sense. In the narrow sense, innovative performance refers to results for companies in terms of the degree to which they actually introduce inventions into production. However, it includes the measurement of all stages from R and D to patenting and new product introduction. In this research, we use the boarder definition of innovative performance and define it as the achievement of firms in terms of ideas, sketches, processes, products, systems and models of new devices (Ernst, 2001; Freeman and Soete, 1997). These innovative activities are frequently measured in patents where raw counts of patents are taken as the actual measure (Hagedoorn and Cloodt, 2003).

After getting annual raw patent counts of each sample firms, we make the patent-difference by the number of patents at time T minus the number in previous period and then be divided such difference by the number of patent in previous time period as the measurement of innovative performance. In other words, we measure the innovative performance in quantity to see how much the magnitude of improvement that the firm performs on innovation.

**Network dynamics**

Network dynamics is changes in network structures, relations, and resources over time (Batjargal, 2010). When actors have the ability to access prominent or and strategic position, they will benefit more than those not in such position in a network. In this research, we proposed three kinds of position changes (that is, communication activity change, communication efficiency change, and bridge change) in social networks to describe network dynamics (Burt, 2002; Wasserman and Faust, 1994). We make the following measurements.

**Communication activity change**

The first measure of a firm’s prominence is its degree of centrality which measures the activeness and communications of an actor in the network. Once an actor is more active and/or has more communications with the others, it will be more central in the network. We generate the measurement of degree centrality by UCINET (Borgatti et al., 2002) and make the difference of measurement of time T minus of previous time period and then take the difference as “communication activity change”.

**Communication efficiency change**

The second measurement of a firm’s prominence is its closeness centrality which measures the efficiency of communication of an actor in the network (Wasserman and Faust, 1994). Once an actor can communicate with others efficiently and/or quickly, this will reflect the advantage of timeliness of response. We generate the measurement of closeness centrality by UCINET and make the difference of measurement of time T minus of previous time period and then take the difference as “communication efficiency change”.

**Bridge change**

The last measurement of strategic position is structural holes. The network constraint can effectively measure an actor’s lack of access to structural holes (Burt, 1992). The formula of constraint is as followed:

\[ p_{ij} = \sum p_{iq}p_{jq} , q \neq i , j \]  

Where pij equals to the strength of direct ties from i to j, and \( \sum p_{iq}p_{jq} \) is the sum of the indirect tie strength from i to j via all q. We then calculate the access to structural hole as one minus the actor’s constraint score. Therefore, the structural holes can be measured as follows:

\[ 1 - (p_{ij} + \sum p_{iq}p_{jq}) , q \neq i , j \]  

We also generate the measurement of structural holes by UCINET and make the difference of measurement of time T minus of previous time period and then take the difference as “bridge change”.

**Network resources**

Network resources are valuable assets that can be potentially accessed by the focal firm through its ties to its linked partners.
Table 1. Means, standard deviations and correlations.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Std</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Innovative performance</td>
<td>0.0218</td>
<td>0.7798</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. RD Input change</td>
<td>0.0010</td>
<td>0.0021</td>
<td>.403**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Firm Size change</td>
<td>0.1885</td>
<td>0.3850</td>
<td>.112</td>
<td>.407**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Communication activity change</td>
<td>3.8611</td>
<td>0.4112</td>
<td>.398**</td>
<td>.312**</td>
<td>.101</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Communication efficiency change</td>
<td>0.1138</td>
<td>0.4631</td>
<td>.098</td>
<td>.132</td>
<td>.098</td>
<td>.221*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Bridge change</td>
<td>0.5697</td>
<td>0.0359</td>
<td>.289**</td>
<td>.223*</td>
<td>.135</td>
<td>.353**</td>
<td>.142</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>7. Network resources</td>
<td>3.193</td>
<td>3.192</td>
<td>.297</td>
<td>.212</td>
<td>.221</td>
<td>.312</td>
<td>.188</td>
<td>.231</td>
<td>1</td>
</tr>
</tbody>
</table>

*: P <0.05 ; **: P<0.01

A growing body of literature has attempted to check the validity of the Schumpeterian hypothesis that large firms are more innovative than small firms (Cohen and Levin, 1989; Kamien and Schwartz, 1983). It is generally assumed that because of the existence of economies of scale and scope in R and D activities, bigger firms lead innovation and diffusion processes (Buzzachi, 1995). Given this, when firms increase their scale, they have more sales volume to reduce fixed cost invested in innovation. We make the difference of the number of employee of time T and previous time period and then divide such difference by the previous period as the measurement “firm size change” as one of our control variable.

Main effects: Network dynamics on innovative performance

The results of this research suggest that Hypothesis 1, which examined the effects of firms’ improvement in positions of the dynamic networks on firms’ innovative performance, is partially supported. This paper provides empirical support for H_{1a} and H_{1c}, but not for H_{1b}. In detail, H_{1a} asserting that firms with more alliances with their suppliers and buyers than before will have better innovative performance and this is supported in the result.

The standardized coefficients of communication activity change are all positive and significant on innovative performance in Model 2 (β=0.260, p <0.01) and Model 3 (β=0.182, p <0.05). Though H_{1b} predicts a positive effect of communication efficiency change on innovative performance, we do not find statistical support in Model 2 and 3 (Model 2, β=0.015, p > 0.1; Model 3, β=0.039, p > 0.1). Thus, H_{1b} suggesting that firms with shorter
Table 2. Results of regression analysis.

<table>
<thead>
<tr>
<th>Dependent variable: Innovative performance</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD input change</td>
<td>0.328***</td>
<td>0.318***</td>
<td>0.292***</td>
</tr>
<tr>
<td>Firm size change</td>
<td>0.026</td>
<td>0.061</td>
<td>0.093</td>
</tr>
<tr>
<td>Communication activity change (CAC)</td>
<td>0.260***</td>
<td>0.182**</td>
<td></td>
</tr>
<tr>
<td>Communication efficiency change (CEC)</td>
<td>0.015</td>
<td>0.039</td>
<td></td>
</tr>
<tr>
<td>Bridge change (BC)</td>
<td>0.137*</td>
<td>0.118*</td>
<td></td>
</tr>
<tr>
<td>Network resource (NR)</td>
<td></td>
<td>0.121*</td>
<td>0.222***</td>
</tr>
<tr>
<td>NR*CAC</td>
<td></td>
<td>0.074</td>
<td></td>
</tr>
<tr>
<td>NR*CEC</td>
<td></td>
<td>0.040</td>
<td></td>
</tr>
<tr>
<td>NR*BC</td>
<td></td>
<td></td>
<td>0.418***</td>
</tr>
<tr>
<td>Adj-R²</td>
<td>0.152***</td>
<td>0.337***</td>
<td>0.418***</td>
</tr>
<tr>
<td>n</td>
<td>117</td>
<td>117</td>
<td>117</td>
</tr>
</tbody>
</table>

* P <0.1, ** P<0.05, ***P<0.01.

communication distance, geo-distance, with other firms than before will have better innovative performance is not supported. Finally, H₁c states that firms bridging more structural holes than before will have better innovative performance and this is supported in the result. We find a significant effect of bridge change on innovative performance where are positive and significant in Model 2 (β=0.137, p <0.1) and Model 3 (β=0.118, p <0.1). The results indicate that when firms improve in connecting with more partners and bridging more structural holes between others in dynamic networks than before, they will benefit their innovative performance.

**Moderating effect of network resources**

This research postulates that the variable, network resources, moderates the effect of network dynamics on innovative performance. We follow the procedures suggested by Baron and Kenny (1986) to test the moderating effects. A moderating effect exists when the following two conditions are satisfied: (1) The interaction of independent (that is, network dynamics) and moderator variable (that is, network resources) is significant; (2) the moderator variable is uncorrelated with both the predictor and the criterion (the dependent variable) to provide a clearly interpretable interaction term.

In order to test the moderating effect, we first transform the variables as mean-centered to minimize multicollinearity between the main effect and interaction effect. Then this research tests the interaction effect in Model 3. H₂ states that firms’ network resources moderate the effect of network dynamics on innovative performance is partly supported in the result. In detail, H₂a stating that firms’ network resources moderate the relationship of H₁a is supported (NR*CAC, β=0.222, p <0.01).

H₂b and H₂c, however, are not supported and the results can be seen in Model 3 (NR*CEC, β=.074, p> 0.1; NR*BC, β=.040, p > 0.1).

Finally, we found different results of two control variables. While R and D Input Change is positively significant in all models, firm size change is not significant. We can conclude that firms with more R and D expenditure are more likely to get higher innovative performance. But there is no evidence to support the argument that the change of firm size has influence on firms’ innovative performance.

**DISCUSSION AND CONCLUSION**

For high-tech firms, obtaining necessary resources from partners in a network is a critical determinant of their long-term competitiveness because related studies have proven that there is a positive correlation between firms’ network connections and firms’ economic performance (Gulati et al., 2000; Mowery et al., 1996; Zaheer and Bell, 2005) and innovative performance (Ahuja, 2000; Tsai, 2001; Zeng et al., 2010). Though it is well known that networks are dynamic, how do firms take movement in dynamic networks and how the movement contributes to their improvement of innovative performance has not been discussed yet. In this research, therefore, we focus on the role of firms’ movement in dynamic networks and its effect on the firms’ innovative performance.

The research findings suggest that when firms get improvement in their prominent and strategic position in dynamic networks, they can enhance their innovative performance. But this argument does not apply to all kinds of movement. Specifically, this research identifies three kinds of prominent and strategic position (that is, degree centrality, closeness centrality and structural hole) and argues that when firms move close to above positions, they will have more benefits than others.

The findings suggest that when firms tie to forge more alliances with other firms than before, they will gain higher innovative performance. This result is consistent
with Schilling and Phelps' (2007) finding that a focal firm connects to a wide range of firms will have greater innovative output than those do not exhibit this characteristic in networks. This finding also indirectly supports previous findings that the more active the firm is, the greater the quality and the wider the variety of information and resources they can access (e.g. Galaskiewicz, 1979; Rogers, 2003; Von Hippel, 1988).

Our research finding suggests that though a firm that is connected to partners via a short average path, the advantage of speed and/or time-reducing does not promise the benefits of innovative performance. The research results, however, do show a positive correlation between communication efficiency and firms' innovative performance.

The last structural property, structural hole, measures the leveraging and control advantages of those firms located in such strategic position. The findings show that when firms bridge more structural holes than before, they get higher chances of innovative performance than those with redundant connections. This result is consistent with most existing studies that argued actors bridging structural holes perform better than those not so positioned (Burt, 1992, 2000; McEvily and Zaheer, 1999). We reconfirm that what influence firms' innovative performance are the changes of their direct linkages, communication activity change, and the strategic relationships among the linkages, bridge change.

The research results also suggest that the degree of network resources moderates the effect of network dynamics on innovative performance. This research considers the attribute of the linked partners since network resources are resources can be potentially accessed by focal firm and are owned by its partners (Gnyawali and Madhavan, 2001; Gulati, 1998; Lavie, 2006, 2007). When firms link to different others, they can potentially access and leverage the resources owned by partners differently. Therefore, it contributes differently to the structural effect on innovative performance.

The research findings suggest that network resources influence the structural advantages on innovative performance is focal firms' direct link to others, not strategic links between others (that is, the bridge) and efficiency to all the others (that is, the communication efficiency). In other words, direct links to the others reflects the channels and chances of direct access to the linked resources and through these direct links will benefit the structural advantage. The linked resource through firms' strategic and the other prominent links, the structural hole and closeness centrality, will not benefit the structural advantage.

**LIMITATION AND FUTURE RESEARCH**

Our study has some limitations that imply a number of future research directions. First, in this research, network dynamics focuses on firms' improvement in positions and the attributes of actors at individual level. Other levels of structural properties including meso and macro level could be incorporated for future researches. At the meso level, future research can investigate how structure equivalence influence innovative performance. What different strategic groups based on structure equivalent model would make firms improve innovation? What mechanism could differentiate the performance of between-groups even within-groups? At the macro level, future research can study the influences of network density and centralization on innovative performance. What does the dynamic change of density and centralization imply?

Other research may also study the effects of network dynamics based on the whole network like tie formation and broken on innovative performance. Other structural effects including structural balance and transitivity could also be studied (Choi and Wu, 2009). Would balanced triadic firms foster higher innovative performance, if so what are the mechanisms? Would transitive firms perform better on innovative performance than intransitive ones?

Finally, we do not study the mechanisms of network dynamics, how firms change their positions and/or make a move in dynamic networks. Existing research studying dynamic networks mostly focuses on network evolution. The study on mechanisms of above network evolution like event effects (Doreian, 2002; Madhavan et al., 1998), environmental factors (Koka et al., 2006) and strategies (Powell et al., 2005) may be insightful to discuss how firms move in dynamic networks. Moreover, the study on the mechanisms incorporating different levels of structural properties such as micro, meso, and macro levels could also be interesting.

**REFERENCES**


