Accumulation of knowledge capabilities:
The perspective of knowledge-based view and network theory

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Abstract
Studying network structures and network content from knowledge-based view and network theory, we conceptualize a framework of knowledge network. Our approach defines sequences as the set of network structure, knowledge heterogeneous, and knowledge cognition a firm coordinates with partners to accumulate knowledge capabilities. Using a sample of 144 high-technology firms in Taiwan, we empirically identify three critical factors of knowledge network and demonstrate their relationships that the firm can facilitate its innovative performance by considering the effect of knowledge cognition. The network structure can provide us with significant insight about the circulation of knowledge within a firm’s relationships if we also disclose the content of the network. In short, while knowledge flow within a firm’s relationships are discussed with regard to the network structure and content, the ability of the firm to manage and benefit from such knowledge becomes the critical issues in network research. We discuss the implications of these findings for research on the accumulation of knowledge capabilities.

Keywords: knowledge networks, knowledge flow, knowledge-based view, network theory, innovative performance

Introduction
In spite of the growing consensus that network structures do matter [1,2], the specific effects on innovative performance of network content that is exchanged between firms remain unclear. In the literature on social networks, a debate has arisen over the content of inter-organizational relationships that can appropriately be regarded as comprising beneficial activities [3,4]. With regard to network content, inter-organizational relationships are viewed as the strategic decisions by which firms coordinate their exchange activities to create value and access various resources held by other firms [4]. Clarifying the implications of why to cooperate, what to exchange, and how to connect with firms for enhanced innovative performance is critical to our understanding of network research according to two aspects. First, our study addresses an important question, unanswered in prior research, concerning the relationship between the structure of the network and the content of the network in which a firm cooperates with others for reserving knowledge and exchanging resources to acquire heterogeneous knowledge. Second, it is critical to know how firms cooperate and exchange knowledge in the conventional sense. A social networking approach to organizational innovation, with consideration of factors related to knowledge flow in network content is lacking.

In line with previous research, we explore knowledge networks and the characteristics of network structures, such as whether the firm occupies the central position or fills a social gap. We also explore network content that is focused purely on inter-organizational cooperation and heterogeneous knowledge accessed from partners [4,5,6,7].

Network structure: How firms channel the structural characteristics
The structural characteristics of networks emphasize the strategic benefits and advantages that firms derive from their relationships. This perspective considers the consequences of variation in the linkage of a firm’s industrial position [8,9,10] and the effect of disconnected contacts which is most systematically explained by Burt’s [11] research on structural holes [12,13]. Occupying a central location in the industrial network gives the firm a competitive advantage for resources and power. Central firms are likely to access knowledge and be exposed to critical new developments sooner than less central firms [14]. Moreover, a structural hole between two firms increases the likelihood of diverse views and an increase in the number of gaps in a firm’s network means that the knowledge available to the firm increases [11,13]. Consequently, we can consider that:

Hypothesis 1: The position a firm occupies in the network will correlate positively with its level of knowledge cognition in terms of searching for and acquiring such knowledge.

Network content from the perspective of a knowledge-based view of the firm
From the perspective of a knowledge-based view of the firm, the structure is composed of static knowledge capital and dynamic knowledge flow (e.g., [6,7]). The mechanisms of knowledge capital and how a firm can utilize it are unexplored from the perspective of network content. We will begin with a careful explanation of the concept and then identify network content from the knowledge perspective for the purpose of networking and what to access.

Knowledge heterogeneity: Network content and what firms choose to exchange
Knowledge heterogeneity is defined as that diverse knowledge, know-how and expertise to which the firm has access through its network partners. From the knowledge-based view of the firm, competitive advantages are likely to arise from the knowledge which it utilizes to add value to the product outcome and development. By acquiring knowledge from partners, a firm can leverage its R&D expenditure, not only to improve product development [15], but also to obtain a greater understanding of its technology and knowledge [16]. The firm can add heterogeneous knowledge to its existing
knowledge and increase its understanding by gaining access to different technological and knowledge fields from diverse partners [17]. This suggests the following:

Hypothesis 2: A high level of heterogeneous knowledge that a firm accesses from its different partners will correlate positively with the level of its knowledge cognition and how it searches for and acquires knowledge.

Knowledge cognition: Factors influencing why firms cooperate on the network

Knowledge cognition is defined as the firm’s understanding and recognition of the knowledge which has been acquired from partners in the network and which serves to increase the firm’s knowledge capital. Encouraging knowledge cognition will improve not only the attainment of knowledge and thus be associated with an increase in organizational learning [18] and searching [19], but could also raise the knowledge capital of the firm [17]. The advantage of searching behavior is that firms are alerted to new ideas for wealth creation in its stores and utilities [19]. Organizational searching not only increases the number of a firm’s new technologies or products, but also enriches the knowledge capital with regard to understanding and recognizing knowledge by adding distinctive new variations. Moreover, Cohen and Levinthal [20] suggest that a firm’s ability to recognize the value of new, different knowledge and apply it to development is important to its innovative capabilities. The advantage of organizational learning is that it improves organizational performance by absorbing and acquiring knowledge from the external environment and enriches a firm’s knowledge cognition for understanding and recognizing knowledge from different sources. Consequently, we propose:

Hypothesis 3: A high level of knowledge cognition, accessed by searching and with knowledge learned from the network, will show a positive correlation with a firm’s high level of performance and innovation.

Methodology

Research setting

We chose to conduct our research in Taiwan’s high-tech industry for several reasons. Both primary and secondary data were gathered for the analysis. To gather our secondary data, the sample that we analyzed included Taiwan’s high-tech firms which were incorporated in the Association of Industries in Science Parks (ASIP) and the Taiwan Stock Exchange Corporation (TWSE) in 2009.

We established knowledge network data which were defined as the connection between the focal firm and its stockholders by using three main steps to identify linkage boundaries. Linkages between the focal firm and its stockholders would establish and represent the knowledge network boundary [21]. Finally, a snowball method was used to follow leads to build the knowledge network boundary [22]. The snowball-round generated 180 additional firms after five turns. In total, we acquired 344 firms for primary data mailing. Each high-tech firm only received one questionnaire to complete. Responses were received from 144 of the 344 firms we surveyed (41.86% response rate).

Dependent variable

In line with previous studies, we measured innovative performance in terms of patent creation, that is, the average number of patents granted annually to a firm’s employees (e.g., [9,12,23]). The average patent granted was 0.162 for each firm in this research.

Independent variables

Network structure: Network centrality and structural holes. The network structure variables, that is, network centrality and structural holes, were calculated from a full structural adjacency matrix, constructed by combining ego network data and information from cited contacts. The UCINET v6.221 program will simply find the structure matrix made by network data [24].

Knowledge heterogeneity. Knowledge heterogeneity was measured by using Cummings and Teng’s [25] two-item scale. Knowledge heterogeneity was defined as the degree of heterogeneous knowledge of the focal firm, compared with its partners. Cronbach’s alpha for this scale was .710.

Knowledge cognition: Knowledge searching and organizational learning. Knowledge cognition refers to how technology is acquired and comprehended within the firm. We can identify two dimensions for measurement of knowledge cognition: behavior of knowledge searching and organizational learning. Knowledge searching has to do with the systematic search by the firm to identify new ideas and skills for increasing the perception of knowledge and technology [19]. Adapting the work of Patel and Fiet [19], three items were used to measure knowledge searching. Cronbach’s alpha for this scale was .706. The other dimension of knowledge cognition, the behavior of organizational learning, specifies that the firm can absorb specific knowledge, technology and skills from network partners (inter-organization) and employees (intra-organization). According to Wu and Cavusgil [26], Chen et al. [27], and Huber [28], there are five items that can be used to measure organizational learning. The Cronbach alpha for this scale was .838.

Control variables

Firm size and firm age. We controlled for firm size by calculating the logarithm of the firm’s total number of employees, and we controlled for the firm’s age by calculating the logarithm of years since the firm was founded. Foreign patenting experiences and R&D expenditure. With dummy variables, we controlled for a firm with foreign patents issued from foreign countries. In addition, we also controlled for the firm’s R&D expenditure by calculating the logarithm of the firm’s R&D expenditure in the focal year. Financial performance. We included a firm’s performance measure, earnings per share (EPS), to control for the possibility that financial performance affects innovation. Knowledge complexity and knowledge tacitness. Simonin [29] considered that more complex technological systems or knowledge maps produce higher levels of ambiguity and, therefore, restrain knowledge transfer between the firm and its partners. Moreover, Simonin [29] suggested that causal ambiguity can be a barrier to imitation as well as complexity and tacitness can lead to ambiguity. Therefore, we controlled
them. Network relationships and network density. We used five items to measure the strength of ties between the firm and its partners from Chen and Wang [1] and Yli-renko et al. [30]. Furthermore, we also controlled for the overall density of the network with the variable network density, calculated for each firm’s network.

Results

Measure validity and reliability

The measures were validated by confirmatory factor analysis (CFA) using AMOS 16.0 for Windows. Formative constructs which measured secondary data do not require inclusion in the analysis and, moreover, the construct was not under any dimensions when conducting CFA. Therefore, two constructs are incorporated into the CFA: knowledge searching and organizational learning with regard to knowledge cognition (see TABLE 1).

<table>
<thead>
<tr>
<th>Factors (Composite reliability; CR)</th>
<th>Average variance extracted; AVE</th>
<th>S.F.L.</th>
<th>S.E.</th>
<th>C.R.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge searching (CR = 0.75 / AVE = 0.51)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. We have engaged in deliberate systematic search……………..</td>
<td>.93</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>2. For us, identifying business opportunities has involved several learning steps over time rather than a one-time process.</td>
<td>.70</td>
<td>.05</td>
<td>9.75***</td>
<td></td>
</tr>
<tr>
<td>3. Best business ideas just come (reversed)……………………</td>
<td>.78</td>
<td>.06</td>
<td>11.95***</td>
<td></td>
</tr>
<tr>
<td>Organizational learning (CR = 0.83 / AVE = 0.51)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Learning in the firm is viewed as key to organizational survival………………………</td>
<td>.93</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>2. The sense around here is that employee learning is an investment, not an expense……………………</td>
<td>.89</td>
<td>.06</td>
<td>17.16***</td>
<td></td>
</tr>
<tr>
<td>3. We strongly encourage the incorporation of fresh ideas and knowledge into the workplace…………………………</td>
<td>.86</td>
<td>.06</td>
<td>15.54***</td>
<td></td>
</tr>
<tr>
<td>4. We send employees to relevant exhibitions/conferences.</td>
<td>.78</td>
<td>.06</td>
<td>12.32***</td>
<td></td>
</tr>
<tr>
<td>5. We use information from competitors to improve our process or production……………………</td>
<td>.75</td>
<td>.07</td>
<td>11.55***</td>
<td></td>
</tr>
</tbody>
</table>

The overall disposition of the CFA model fit index χ²-value was 27.6 (with a degree of freedom of 19) and the p-value was .10. The goodness-of-fit index (GFI) was .953, adjusted goodness-of-fit (AGFI) was .910, root mean square error of approximation (RMSEA) was .059, normed fit index (NFI) was .936, Tucker-Lewis index (TLI) was .968, and comparative fit index (CFI) was .979. In TABLE 1, the standardized factor loadings (S.F.L.) of items on their given constructs are statistically significant (p < 0.05) and above 0.5, which demonstrates convergent validity. Moreover, the degree to which measures of distinct constructs differ indicates discriminant validity [31]. These constructs demonstrated discriminant validity as the average variance extracted (AVE) for each pair of constructs was found to be greater than their squared correlations [32]. TABLE 2 summarizes the descriptive statistics and correlations among the constructs used for testing the hypotheses.

Hypothesis testing

Using the covariance matrix resulting from the CFA of the measurement model as input, the hypotheses were assessed via SEM. The test results are presented in TABLE 3. The results show that the overall disposition of the model fit index χ²-value was 58.599 (df = 46), with a p-value of .101. The GFI was .930, AGFI was .881, RMSEA was .048, NFI was .938, TLI was .979, and CFI was .986. These indicators showed that the model-fit indexes had an excellent overall disposition.
TABLE 2: Results of hypotheses testing\(^a,b\)

<table>
<thead>
<tr>
<th>Control variables</th>
<th>Path</th>
<th>Estimate</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm size</td>
<td>→</td>
<td>−0.108**</td>
<td>−2.745</td>
</tr>
<tr>
<td>Firm age</td>
<td>→</td>
<td>−0.007</td>
<td>−2.247</td>
</tr>
<tr>
<td>Patenting experiences</td>
<td>→</td>
<td>−0.056</td>
<td>−2.805</td>
</tr>
<tr>
<td>R&amp;D expenditure</td>
<td>→</td>
<td>0.001</td>
<td>0.600</td>
</tr>
<tr>
<td>Financial performance</td>
<td>→</td>
<td>−0.011</td>
<td>−1.547</td>
</tr>
<tr>
<td>Knowledge complexity</td>
<td>→</td>
<td>0.255*</td>
<td>1.994</td>
</tr>
<tr>
<td>Knowledge tacitness</td>
<td>→</td>
<td>0.031</td>
<td>0.510</td>
</tr>
<tr>
<td>Network relationships</td>
<td>→</td>
<td>−3.34***</td>
<td>−3.453</td>
</tr>
<tr>
<td>Network density</td>
<td>→</td>
<td>0.001</td>
<td>1.515</td>
</tr>
</tbody>
</table>

Independent/Dependent variables

| Network centrality | Knowledge searching H1 | → | 0.162*** | 4.176   |
| Network centrality | Organizational learning H1 | → | 0.149*** | 3.808   |
| Network centrality | Innovative performance | → | 0.084    | 0.486   |
| Structural holes   | Knowledge searching H1 | → | 0.053*** | 4.282   |
| Structural holes   | Organizational learning H1 | → | 0.043*** | 3.803   |
| Structural holes   | Innovative performance | → | 0.002    | 0.108   |
| Knowledge heterogeneity | Knowledge searching H2 | → | 0.101*** | 4.028   |
| Knowledge heterogeneity | Organizational learning H2 | → | 0.180*   | 2.117   |
| Knowledge heterogeneity | Innovative performance | → | 0.009    | 0.938   |
| Knowledge searching | Innovative performance H3 | → | 0.190*   | 2.234   |
| Organizational learning | Innovative performance H3 | → | 0.120*   | 1.074   |

\(^a\) N = 144 firms
\(^b\) Path coefficients are standardized.

*P<0.05; **p<0.01; ***p<0.001

Discussion

The purpose of this research was to develop an understanding of the influence of the knowledge network on innovative performance. Using two social network approaches and building on social network theory from a knowledge-based view, we assessed how both the structural characteristics and the content of a network, within which the flow of knowledge is embedded, contributes to a firm’s performance. We aimed to provide different network approaches, using social network theory and knowledge-based view, and then evaluate the channeling, exchange and circulation of knowledge within firms’ relationships. Our findings are consistent with previous studies on network structure which indicate that it performs a critical role in organizational performance [4,12,13,33]. A firm embedded in a network is likely to benefit according to the position it occupies in the industrial network, specifically network centrality and structural holes. However, our results reflect a previously established concept: network content also matters. Drawing on network content and exploring the concept from knowledge-based view, the heterogeneous knowledge to which firms are exposed is a critical element in increasing firms’ knowledge cognition. Knowledge cognition and the process whereby firms understand and store knowledge in their knowledge base are important components in innovative performance.

It is not only the network structure that is an importance factor in delivering knowledge in the network. The knowledge heterogeneity and knowledge cognition which are the manifestation of network content are also critical for the exchange of diverse knowledge and the cooperation with partners. When both network approaches: network structure and network content, are considered it can be established that they complement each other but can also have an independent effect.

Limitations and directions for future research

First, both academic researchers and managers may benefit from a more comprehensive outlook stemming from the conceptual framework of this study; this can be obtained by considering the contexts of different countries. Second, while we assessed knowledge heterogeneity by using a five-point Likert scale, future studies should consider developing a more reliable measure of knowledge heterogeneity. Establishing objective measures of knowledge heterogeneity such as assessing well-established heterogeneity with a Herfindahl index of difference in types of partners [2] or technological distance calculations [34] could be used in the future as another means of evaluating the knowledge heterogeneity between firms.

References


