Vertical integration, firm’s technological capability scope, and innovative performance

Hsiu-Ling Li
National Taiwan University

ABSTRACT

This paper investigates how firm’s vertical integration decision affects its scope of technological capability, and innovative performance. The focal findings show that the scope of technological capability mediates the relationship between vertical integration and firm’s innovative performance; however, vertical integration decision per se does not affect firm’s innovative performance directly. The results also imply that the scope of technological capability of a firm possesses is positively related to firm’s innovative performance. This finding further testifies the knowledge-based perspective that technological knowledge is a valuable resource of the firm. In addition, the findings indicate that vertical integration may lead to narrow scope of firm’s technological capability. However, firm’s internationalization and available (or unabsorbed) slack resource respectively moderate the relation between vertical integration and the scope of technological capability. It moderately helps a vertically integrated firm to access external knowledge, and efficiently broadens the scope of firm’s technological capability. In other words, a vertically integrated firm may have coordinative advantages to coordinate either international market knowledge or financial resources, and further to build up new technological capability or strengthen the existing capability.
INTRODUCTION

The field of strategic management is interested in describing why firms differ in their investment choices and subsequent performance (Rumelt et al., 1994). Though there is widespread consensus on the importance of firm’s vertical integration decisions, it remains unclear whether or how these boundary decisions affect various dimensions of firm performance (Leiblein et al., 2002). Besides, much research has measured firm performance by observing its innovative capability or knowledge capacity; however, the relationship between vertical integration strategy and innovative performance is not broadly discussed yet and the result is also unclear. On one hand, Armour and Teece (1980) argue that vertical integration can facilitate the transfer of technical information, and can facilitate the implementation of new processes or the introduction of new products when complex inter-stage interdependencies are involved. On the other hand, some authors suggested that vertical integration may raise the heights of exit barriers and creates inflexibilities, and may impede firm innovation (Harrigan, 1980; Mascarenhas, 1985). Therefore, the relation between vertical integration and firm’s innovative performance should be elaborated more.

Nevertheless, much of the research assesses comparative perspectives on the performance implications of firm’s vertical integration decisions (Leiblein et al., 2002), or undertakes a comparative examination of how firms organize efficiently to solve different types of problems related to technological development (Macher, 2006). Furthermore, Jacobides and Winter (2005) have argued that the process of capability development depends on how integrated a firm is. In other words, firm’s vertical scope is related to its technological capability development. However, rare research has discussed the impact of vertical integration on firm’s technological capability development such as the scope of technological capability, and little empirical research has gone on to examine the relation between vertical integration, technological capability development, and innovative performance. Thus, the
purpose of this paper is to clarify whether firm’s innovative performance is influenced by vertical integration decision directly, and whether the scope of technological capability affects the relation between vertical integration and innovative performance. Central to the argument is the idea that technological capability building is a critical factor for a firm, and it links the effect of a firm’s boundary decision to innovative performance.

Additionally, among the literature on innovation, some studies explained firm’s innovative behavior from the internal point of view, such as firm’s general characteristics, firm’s structure, resources, strategies, and top management team (Acs & Audretsch, 1988; Bertschek & Entorf, 1996; Love & Ashcroft, 1999; Greve, 2003; Galende & de la Fuente, 2003; Zahra, 1993; Tsai, 2001; Cohen & Levinthal, 1990; Landry et al., 2002; Romijn & Albaladejo, 2002; Tallman & Li, 1996; Hitt et al., 1996; Chen, 1996; Koeller, 1995; Francois et al., 2002; Darroch & McNaughton, 2002; Jung et al., 2003). More importantly, innovation processes can be viewed as resource transformation processes (Nonaka, 1991). New learning, such as innovation, is the stocks and flows of a firm’s combinative capabilities (Kogut & Zander, 1992) that generate new ideas and artifacts from existing knowledge (Mahoney, 1995). Nelson (1991) suggests that firm’s dynamic capabilities to generate and gain from innovation are the source of durable, not easily imitable differences among firms. In other words, a firm may achieve rents not because it has better resources, but rather the firm’s core competencies involve making better use of its resources (Penrose, 1959). The resource accumulation process may help cultivate a firm’s core competencies (Prahalad & Hamel, 1990). Furthermore, the accumulation of resources created a base for organizational learning; conversely, organizational learning and new organizational forms allowed firms to increase their rate of resource accumulation (Mahoney, 1995). An optimal growth of the firm involves a balance between exploitation of existing resources and development of new resources and capabilities (Penrose, 1959; Rubin, 1973; Wernerfelt & Montgomery, 1988). As cited above, a
firm’s resources accumulation and capability development process are interrelated to firm’s strategy. However, little research examines the interactive effect of a firm’s strategy and resources on its innovative capability development. In this paper, I suggest the importance of external learning mechanism in firm’s innovative capability development. In other words, though vertical integration can facilitate knowledge transfer between the separate stages; it further needs the external learning mechanism to accumulate a firm’s knowledge base and to enhance firm’s innovative capability development. First, internationalization is possible source for a firm to access external knowledge and facilitate firm innovation. I propose that firm’s internationalization has an influence on the relation between vertical integration and the scope of technological capability. Second, slack resources may be another factor to affect the relation between vertical integration and the scope of technological capability since slack has been viewed as creating funding opportunities for innovation (Herold et al., 2006). Therefore, I also propose that firm’s slack resources may moderate the relation between vertical integration and the scope of technological capability. In brief, this study suggests that firm’s internationalization and slack resources may respectively moderate the effect of vertical integration on the scope of technological capability.

Using the quality of patents as measure of innovative performance, the main contribution of this paper is to clarify the relationship between vertical integration and firm’s innovative performance; moreover, this paper also focuses on a “process” perspective to investigate the effect of vertical integration on a firm’s technological capability development, and subsequent performance. This study provides evidence for the mediating role of the scope of technological capability. In addition, this paper also contributes to the literature on organizational learning. This study further investigates the importance of external learning mechanism to firm’s technological capability, and found the interaction for vertical integration
and firm’s internationalization to the scope of firm’s technological capability is significant and positive. Also the interaction for vertical integration and available slack resource to the scope of firm’s technological capability is significantly positive; though recovery slack is insignificant.

THEORETICAL BACKGROUND AND HYPOTHESES

Vertical integration and firm’s technological capability development

The decision to outsource or vertically integrate a value-chain activity represents a complex choice facing a firm’s managers, and has long been a central research topic in strategic management. Integration requires management to commit significant resources and to accumulate resources necessary to generate or maintain a competitive advantage (Dierickx & Cool, 1989). The integration decision represents a large, difficult-to-reverse investment that directly affects firms’ capabilities and property rights; however, vertical integration may enhance firm performance, because of the coordination benefits associated with internalization (Leiblein et al., 2002).

Within the knowledge-based view, firms develop new knowledge important to competitive advantage from unique combinations of existing knowledge (Fleming, 2001; Nelson & Winter, 1982). Much research has examined how the choice of organization influences knowledge exchange and protection (Conner & Prahalad, 1996; Grant, 1996; Kogut & Zander, 1992; Monteverde, 1995). Macher (2006) further investigates how firms efficiently organize to develop and transfer knowledge related to technological development, and finds that integrated manufacturers achieve performance advantages for problems that are complex and ill structured, whereas specialized manufacturers realize performance advantages for problems that are simple and well structured. Moreover, the boundary of a firm also shapes firm’s incentives to invest in capability improvement (Jacobides & Winter, 2005), and then
influences firm’s technological capability. Jacobides & Winter (2005) point out that larger scale, conferred by previous success in the market place, motivates investments to further enhance productivity. They also mention that for a firm with asymmetric capabilities, these incentives operate more strongly in its areas of existing strength, creating a self-reinforcing dynamic of specialization. Meanwhile, based on different knowledge base, a firm has different points of reference, and different means of searching its competitive environment as it improves its business practices. Thus, the capacity to absorb new productive knowledge arising externally (Cohen & Levinthal, 1990) depends on firm’s scope. The boundary of a firm affects the nature of the knowledge accumulation and capability development process (Jacobides & Winter, 2005). This highlights it is necessary to investigate the relation between vertical integration and firm’s capability development.

In terms of the impact of vertical integration on firm’s technological capability development, Williamson (1975) argues that vertical integration in the presence of technological similarities in various stages of the production process can be expected to reduce the transactional dilemmas by relieving the condition of information asymmetry and by attenuating the incentives for opportunities behavior. Besides, vertical integration can facilitate the implementation of new processes or the introduction of new products when complex inter-stage interdependencies are involved (Armour & Teece, 1980) because vertical integration enables investment expectations at the various stages to be rapidly brought to convergence (Williamson, 1975). Moreover, Diez-Vial (2007) confirms that a firm makes an integration decision due to the similarity between capabilities of different stages, and so the firm can exploit the skills, knowledge and experience. Therefore, I propose that vertical integration may lead to narrow scope of a firm’s technological capability. In other words, vertically integrated firms are likely to be more specialization in technological development.

_Hypothesis 1: Vertical integration decision is negatively related to the scope of_
The effect of internationalization on vertical integration decision and firm’s technological capability development

External knowledge sources play an important role in innovation activities (Caloghirou et al., 2004). Cohen and Levinthal (1990) have acknowledged the close relationship between learning and innovation; and have argued that the ability to acquire and utilize knowledge effectively is argued to be critical for the firm’s innovation activities and performance. Therefore, the literature on innovation usually sees organizational learning as promoting comparative innovative efficiency (Susana Perez Lopez et al., 2005), and the firms that are able to learn about customers, competitors and regulators stand a better chance of sensing and acting upon events and trends in the marketplace (Tippins & Sohi, 2003).

In addition, Cantwell (1995) developed a theory of the MNC in which innovation and technological accumulation are used strategically to enhance the firm’s competitive advantages. The MNC can be seen as a network of innovators, and its network is likely to facilitate the transfer of knowledge and innovation within and across countries (Zanfei, 2000; Frenz, Girardone, & Ietto-Gillies, 2005). Furthermore, much literature has provided the evidence that foreign subsidiaries play a very important role by acquiring and creating valuable knowledge locally and by contributing to the knowledge base of the entire MNC (Almeida & Phene, 2004; Mu, Gnyawali, & Hatfield, 2007), and Sher and Yang (2005) argue that a firm will strengthen its innovative capability through internal development supplemented by external network linkage. As valuable knowledge is dispersed worldwide, the ability to learn from diverse international environments is a critical source of competitive advantage (Doz et al., 2001).

Thus, internationalization may facilitate a vertically integrated firm to access external
knowledge, and efficiently broadens the scope of firm’s technological capability. In other words, a vertically integrated firm may have coordinative advantages to coordinate international market knowledge, and further to build up new technological capability or strengthen the existing capability. In this paper, I suggest that the level of internationalization of a firm may moderate the relationship between vertical integration decision and the scope of a firm’s technological capability.

Hypothesis 2: The level of firm’s internationalization positively moderates the relationship between vertical integration decision and the scope of technological capability. Under high internationalization, such a negative relationship between vertical integration decision and technological specialization will be attenuated.

The effect of firm’s slack resources on vertical integration decision and firm’s technological capability development

Organizational slack is one possible source of funding for innovation, and it has been argued to have a positive impact on innovation productivity for several reasons. First, slack leads to the easing of managerial controls (Cyert & March, 1963; Nohria & Gulati, 1996) which allows managers more discretion as to whether the firm should pursue new projects. Second, slack involves resources that can be used during times of distress. On the other hand, slack has also been argued to have negative effects on firm innovation (Child, 1972; Nohria & Gulati, 1996; Palmer & Wiseman, 1999) because managers may use less risky such as product or market diversification (Denis, Denis, & Sarin, 1999; Jensen, 1986). However, Geiger and Makri (2006) argue that in the case of high-technology firms, the role of slack in innovation will be a positive one. And the authors also argue that organizational slack can facilitate exploitation of existing technologies as well as exploration of new ones leading to a more broadly diversified technology portfolio. Thus, financial resources are probably the most necessary element in ensuring the translation of creative ideas into new processes, products or
services (Herold, Jayaraman, & Narayanaswamy, 2006).

As cited above, I suggest that a firm’s slack resources may moderate the effect of vertical integration decision on the scope of firm’s technological capability. The interaction for vertical integration and slack resources may broaden the scope of a firm’s technological capability.

Hypothesis 3: A firm’s slack resources positively moderate the relationship between vertical integration decision and the scope of technological capability. Under high slack resources, such a negative relationship between vertical integration decision and the scope of technological capability will be attenuated.

The mediating effect of the scope of technological capability on vertical integration decision and firm’s innovative performance

The effect of technological capability on firm performance has been broadly discussed (Jaffe, 1986; Cockburn & Griliches, 1988; Henderson & Cockburn, 1994; DeCarolis & Deeds, 1999; Coombs & Bierly, 2006). From the resource-based view of the firm, innovative capability is seen as critical to a firm achieving strategic competitiveness (Conner, 1991) because innovations enables a firm to offer a greater variety of valuable, rare, inimitable, and differentiated products, and therefore lead firms to higher financial performance (Barney, 1991; Hitt et al., 1994; Zahra et al., 2000). The dynamic capabilities approach, though similar to the resource-based view, places more emphasis on learning and innovation (Nelson & Winter, 1982; Teece et al., 1997); and shifts the focus from looking at a stock of technological capabilities to focusing more on the flow of technological capabilities (Coombs & Bierly, 2006). Besides, the development of technological capabilities is also at the heart of the knowledge-based approach. The underlying assumption of the knowledge-based approach is that knowledge is the principle productive resource of the organization (Kogut & Zander,
Thus, a firm’s technological capabilities are more likely to be a firm’s preeminent source of sustainable competitive advantage. However, the ability to learn and continually improve the firm’s technological capability is path dependent in the sense that development of future technological capability is constrained by the firm’s current capabilities, as well as its learning routines (Teece et al., 1997). Therefore, the scope of a firm’s technological capability may have an impact on firm innovative performance. Additionally, as cited above, vertical integration decision may guide a firm’s resources investment and accumulation, and further form technological capabilities. For instance, Armour and Teece (1980) provide the evidence that vertical integration increases the expected value of R&D activities and can stimulate R&D investment. In other words, vertical integration decision may influence a firm’s innovative performance by the change of the scope of technological capability.

Thus, in this paper I propose that the scope of technological capability mediates the relationship between vertical integration decision and firm’s innovative performance. Moreover, knowledge-based view emphasizes the importance of knowledge to create and sustain competitive advantage, and firm’s primary objective is to create valuable and new knowledge. Here, I suggest that broader scope of technological capability may lead to better innovative performance.

**Hypothesis 4:** The scope of a firm’s technological capability mediates the relationship between vertical integration decision and firm’s innovative performance.

**Hypothesis 5:** Broader scope of a firm’s technological capability is positively related to firm’s innovative performance.

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Insert Figure 1 about Here

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10
METHOD

Data and Sample

As mentioned above, this paper is to investigate the effect of vertical integration decision on a firm’s technological capability development and subsequent innovative performance. I conduct the empirical investigation using a panel dataset (cross-sectional time series) of the U.S. information technology industry from 1998 to 2004. The sample of firms and segment data were drawn from the Compustat database, and patent data was drawn from the USPTO database. The classification corresponds to the SIC codes between 3570 and 3578 (or NAICS code 334). The data were screened for all firms with the segment data in this sector and at least two years above, yielding 82 unique companies across the seven year spans with unbalanced panel data. Due to the missing value of some variables, observations are reduced.

Measures

Dependent variable

The scope of a firm’s technological capability

In this paper, the variable the scope of technological capability has been constructed based on a Herfindahl index of concentration. For each firm its technological portfolio is calculated in the following way.

\[ \sum_j \left( \frac{N_{ij}}{N_i} \right)^2 \times \left( \frac{N_i}{N_i - 1} \right) \]

Let \( N_{ij} \) denote the number of patents that the \( i \)th firm holds in category \( j \). \( N_i \) denote \( i \)th firm has \( N_i \) patents in the analyzed period, and each patent can be assigned to a technological field. Here I use a non-biased estimator referenced by Hall (2002). Furthermore, since higher values imply narrower scope of technological capability, I take the negative of this value.\(^1\)

Firm innovative performance: Patent citations

\(^1\) Although higher values reflect narrower scope of technological capability, to ease interpretation of the results, I reversed the sign of the scope of technological capability measure so that higher values indicate broad scope of technological capability, and smaller values indicate narrow scope of technological capability.
The literature on innovation has a long history of struggling with the measurement of firm’s innovative performance. The available measures such as R&D inputs, patent counts, patent citations, or counts of new product announcements and more specific survey-based measurements have been used in trying to capture a firm’s innovative performance (Hagedoorn & Cloodt, 2003). Some authors suggested that patents are reasonably reliable indicators of innovative performance and are generally better measures of the output of R&D activities than R&D spending (Griliches, 1990; Sampson, 2004). However, simple patent counts do not accurately capture the value of a firm’s innovation; thus, in this paper I assign a weight to each patent using citations made by later patents. This measure captures the quality of patents, that is, the importance of patents. I measure each firm’s innovative performance via the logarithm of the number of patent citations.

**Independent variables**

**Vertical integration**

As mentioned by Harrigan (1985), vertical integration strategy is a multi-dimensional concept. Different measurements of vertical integration, each measuring a specific dimension, can yield complementary insights into a complex phenomenon (Mpoyi and Bullington, 2004). In this paper, I measure vertical integration using a dummy variable to indicate vertical integration status of a firm. I examined the primary and secondary businesses of a firm’s majority business in the Compustat segment database. This dummy variable equals one when SSIC1 and SSIC2 did not fall in the same 2-digit SIC, whether forward or backward (Davis and Duhaime, 1992).

**Slack resources**

In the most common typology, researchers distinguish between available, recoverable, and potential slack resources (Bourgeois, 1981; Bourgeois & Singh, 1983; Singh, 1986). Of the three types of slack, Herold et al. (2006) point out that potential slack is the least likely to play
a major part in the internal funding thought to be important for funding R&D activities since it is not a current resource. Thus, I include available and recovery slack into the study. First, available slack that are not yet committed for particular allocation, is measured by profit margin (the ratio of net income to sales) (Bourgeois and Singh, 1983; Moses, 1992). Second, recovery slack, that has absorbed into the system but may be recovered (Bourgeois and Singh, 1983), is measured by the ratio of selling, general, and administrative expenses and working capital to sales.

The level of internationalization

In prior research, proxies of degree of internationalization include foreign sales as a percentage of total sales (FSTS), foreign assets as a percentage of total assets (FATA), and the number of foreign subsidiaries. However, much literature used FSTS as the estimator of the degree of internationalization (see Sullivan, 1994). Since the IT industry is mature and highly globalization, I used firm’s foreign sales to total sales of as the proxy for the level of internationalization.

Control variables

Firm size

Firm size is often viewed as an indicator of scale economies and market power; however, a great empirical disparity can also be observed. Regarding the literature on innovation, arguments exist both supporting a large size and a small size (Love & Ashcroft, 1999; MacPherson, 1998; Arundel & Kabla, 1998). I use the logarithm of sales to measure the firm size.

Prior performance

Firm past performance will possibly influence the firm’s strategic decision and need to be controlled. In this paper, firm prior performance is measured by the firm’s return on assets (ROA) with one-year lagged variable.
**Level of diversification**

Some studies suggested that diversification may be related to firm innovation. Thus, I use total entropy to capture level of firm diversification (Jacquemin and Berry, 1979; Palepu 1985). This measure is calculated, from Compustat’s line of business database, as below.

\[
\text{Total Entropy} = \frac{\sum_{i=1}^{N} S_i \ln(1/S_i)}{N},
\]

where \( S_i \) is the share of a firm’s total sales in 4-digit SIC industry \( I \) and \( N \) is the number of 4-digit SIC industries in which the firm operates.

**R&D intensity**

According to Penrose (1959), tangible and intangible assets are both important for corporate growth. One available measure of firm’s investment in intangible assets is R&D expenditures. Theory and evidence also suggested R&D investment relates to firm innovation (Cohen & Levinthal, 1990; Landry et al., 2002), and R&D is a major approach of internal learning of the firm. In this paper, R&D intensity is the logarithm of the ratio of R&D expenditures to a firm’s total number of employees.

**Advertising intensity**

In addition to internal learning, external learning such as advertising, monitoring of competitors, and gathering customer needs (Francois et al., 2002; Darroch & McNaughton, 2002) is also important for firms to generate new knowledge and innovation. In this paper, advertising intensity is the logarithm of the ratio of advertising expenditures to a firm’s total number of employees.

**Alliance**

Alliance is one of external sources for a firm to access the resource and may have an impact on a firm’s innovative capability and performance. So it needs to be controlled. I use a dummy variable to capture a firm’s alliance activity, based on the synopses of alliance activity provided by the SDC database. This dummy equals one when the firm has alliance activities.
in the analyzed period.

Annual time dummies
I include the time dummies for 1999-2004 to control for the effect of citation truncation, when predicting innovative performance.

Data Analysis
This paper specifies two models for the investigation of the scope of a firm’s technological capability and subsequent innovative performance. First, I adopt the Tobit regression model to analyze the relation between vertical integration strategy and the scope of a firm’s technological capability, due to the observations of the dependent variable are censored. Second, regarding a firm’s innovative performance, I assign a weight to each patent using citations made by subsequent patents to capture the value of innovation. Since patents are naturally bounded at zero and non-patented firms would be calculated into zero, this model would be more possibly fitted for the non-linear model. Thus, I apply the negative binomial model to examine the relationship between vertical integration and firm’s innovative performance, and further to verify the mediating role of the scope of a firm’s technological capability. In addition, I also include time dummy variables into this model to control for the effect of citation truncation since the number of patent citations would be influenced by the citation spans.

RESULTS
Table 1 presents the descriptive statistics and correlations for all variables in this study. The correlation matrix appears that the collinearity among the variables is low, except for the interaction terms. Furthermore, I checked the VIFs and found the values are very low (less than 5). Additionally, most t values are large and significant in this paper; the findings suggest that multi-collinearity is not a big problem in this paper.
The relationship between vertical integration decision and the scope of a firm’s technological capability

Table 2 displays the results of tobit regression analysis on the research Hypothesis 1, 2, and 3. Model 1 included the control variables and main effects only, and Model 2 reveals that vertical integration is negative and significant. It shows that vertical integration decision may promote a firm’s technological capability to be specialized, that is, the scope of a firm’s technological capability is narrow. The finding provides a support for Hypothesis 1. In Model 3 and Model 4, I introduce the interaction terms respectively to assess the moderating effects on the relation between vertical integration decision and the scope of a firm’s technological capability. Model 3 shows that the interaction for vertical integration and the level of a firm’s internationalization on the scope of technological capability is positive and significant. The result provides a support for Hypothesis 2. It means that although vertical integration strategy may narrow the scope of a firm’s technological capability, however, higher internationalization may be likely to neutralize the negative effect of vertical integration on the scope of firm’s technological capability, and further to broaden a firm’s technological scope. Model 4 shows that the interaction for vertical integration and slack resources on the scope of technological capability are mixed results. Available slack significantly and positively moderates the relation between vertical integration and the scope of a firm’s technological capability; and recovery slack positively moderates the relationship between vertical integration and the scope of technological capability, but insignificantly. The findings provide a partial support for Hypothesis 3.
The mediating effect of the scope of a firm’s technological capability on vertical integration and firm’s innovative performance

Table 3 displays the result of the negative binomial regression analysis on the research Hypothesis 4 and 5. Hypothesis 4 predicts that the scope of a firm’s technological capability mediates the relationship between vertical integration decision and firm’s innovative performance. As predicted above, vertical integration decision is related to the scope of a firm’s technological capability. Model 1 in Table 3 shows that vertical integration decision has a significant, positive value when predicting firm’s innovative performance. As shown in Model 2 in Table 3, when the scope of a firm’s technological capability is included, its effect on firm’s innovative performance is significant and positive; however, the effect of vertical integration decision on firm’s innovative performance is insignificant. Therefore, the scope of a firm’s technological capability mediates the relation between vertical integration strategy and firm’s innovative performance. The result provides a support for Hypothesis 4. And, the scope of technological capability is positively related to firm’s innovative performance. The result also provides support for Hypothesis 5. From this model, it appears that if a vertically integrated firm would be likely to have better innovative performance, only when firm’s technological scope is broad.

To summarize the results from Table 2 and Table 3, first, the result reveals that vertical integration decision has a significant impact on the scope of a firm’s technological capability.
In other words, vertically integrated firms may be more likely to build their capability in specific technological fields, and lead to a narrow scope of technological capability. Second, I also found there is a significant interaction between vertical integration decision and the level of firm’s internationalization when predicting the scope of a firm’s technological capability. As for slack resources, the result shows that available slack significantly moderates the relationship between vertical integration decision and the scope of a firm’s technological capability; however, recovery slack is insignificant. Third, in terms of the relationship between vertical integration and firm’s innovative performance, I found that though vertical integration is significant related to firm’s innovative performance; however, I also found the scope of a firm’s technological capability mediates its relation. This result reveals that vertical integration strategy does not affect firm’s innovative performance directly.

**DISCUSSION**

The empirical results provide the evidences that vertical integration decision is related to the scope of a firm’s technological capability. More importantly, the results further indicate that the influence of vertical integration strategy on a firm’s innovative performance is mediated by the scope of technological capability. This finding verifies the argument by Leiblein et al. (2002) that governance decisions per se do not significantly influence technological performance directly. This paper goes step further to explore the mediating role of the scope of technological capability. In other words, this paper points to the value of technological capability development process perspective to examine the relationship between vertical integration, the scope of technological capability, and innovative performance. This is the major contribution of this paper.

Moreover, another contribution of this paper is to investigate the moderating effect of the level of internationalization and slack resources on the relationship between vertical integration and the scope of a firm’s technological capability. The findings reveal that the
interaction for vertical integration and firm’s internationalization and interaction for vertical integration and available slack to the scope of technological capability are positive and significant. Exactly speaking, vertical integration decision efficiently stimulates R&D investment and increases a firm’s absorptive capacity; at the same time, it provides the opportunity for a firm to absorb external knowledge to expand firm’s technology base, and contribute to broaden the scope of a firm’s technological capability.

Nevertheless, there are some limitations in this paper. First, regarding the measure of vertical integration, this paper uses a dummy variable to indicate whether vertical integration occurred within a firm. And I found that vertical integration do play an important role in firm’s technological capability development and innovation activities no matter what level of vertical integration. Future research can continue on this issue toward better and more refined measures. Second, in this paper, I merely focus on one industry for investigating the effect of vertical integration on the scope of technological capability and firm’s innovative performance. To further generalize the explanations, multiple industries will be needed. This can be a direction of future research.

**CONCLUSION**

This study aims to provide a more find-grained understanding of vertical integration strategy and its impact on the scope of technological capability, and innovative performance, using a “process” perspective. The focal findings show that the scope of technological capability is not only related to firm’s innovative performance, but also mediates the relation between vertical integration and firm’s innovative performance. The results imply that the broader scope of technological capability of a firm possesses, the better innovative performance it may facilitate. It further testifies the knowledge-based perspective that technological knowledge is a valuable resource of the firm.

Moreover, the findings also indicate that a firm’s internationalization and available (or
unabsorbed) slack resource moderate the relation between vertical integration and the scope of technological capability. It suggests the importance of external knowledge sources and firms need to have a solid coordination mechanism to coordinate its external resources, and further to build up new capability or strengthen the existing capability. Internationalization moderately helps a firm to access external knowledge, and efficiently broadens the firm’s knowledge base. In addition, slack resource may facilitate firms to guide innovation programs, whether external or internal programs. In other words, the interactions for vertical integration and firm’s internationalization, and the interaction for vertical integration and slack resource may facilitate a firm to balance the relationship between exploitation and exploration learning, and to broaden firm’s technological scope.
FIGURE 1
The framework of this study

- Internationalization
- Slack resources
- Vertical integration decision
- The scope of firm’s technological capability
- Innovative performance
### TABLE 1

**Descriptive Statistics and Correlations**

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<th>4</th>
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<td>0.6915**</td>
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<td>55.3337</td>
<td>0.1848**</td>
<td>0.1839**</td>
<td>0.4868**</td>
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<td>log(RDI)</td>
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<td>0.9795</td>
<td>0.1602**</td>
<td>0.0862</td>
<td>-0.0032</td>
<td>-0.1460**</td>
<td>0.0056</td>
<td>1.0000</td>
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<tr>
<td>log(ADI)</td>
<td>1.3448</td>
<td>1.4275</td>
<td>0.1459*</td>
<td>0.1766**</td>
<td>0.1754**</td>
<td>-0.0213</td>
<td>-0.0180</td>
<td>0.1038</td>
<td>1.0000</td>
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<tr>
<td>Available Slack</td>
<td>-0.1912</td>
<td>1.0001</td>
<td>-0.0039</td>
<td>0.0086</td>
<td>0.3444**</td>
<td>0.6179**</td>
<td>0.0635</td>
<td>-0.1430*</td>
<td>-0.0077</td>
<td>1.0000</td>
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<tr>
<td>Recovery Slack</td>
<td>0.4528</td>
<td>0.8467</td>
<td>0.0190</td>
<td>-0.0111</td>
<td>-0.3619**</td>
<td>-0.6339**</td>
<td>-0.0378</td>
<td>0.1873**</td>
<td>-0.0493</td>
<td>-0.9537**</td>
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<tr>
<td>Alliances</td>
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<td>0.4378</td>
<td>0.4507**</td>
<td>0.4681**</td>
<td>0.4574**</td>
<td>0.1472**</td>
<td>0.1814**</td>
<td>0.0762</td>
<td>0.1912**</td>
<td>-0.0213</td>
<td>0.0569</td>
<td>1.0000</td>
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<tr>
<td>FSTS</td>
<td>0.3759</td>
<td>0.2424</td>
<td>0.3660**</td>
<td>0.3430**</td>
<td>0.3847**</td>
<td>0.1655**</td>
<td>0.1501**</td>
<td>-0.0170</td>
<td>-0.1302</td>
<td>0.1332*</td>
<td>-0.1379*</td>
<td>0.1668**</td>
<td>1.0000</td>
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<tr>
<td>VI</td>
<td>0.6333</td>
<td>0.4824</td>
<td>-0.1198**</td>
<td>-0.1212*</td>
<td>-0.1009*</td>
<td>-0.0224</td>
<td>-0.0793</td>
<td>-0.0545</td>
<td>0.1532*</td>
<td>-0.0845</td>
<td>0.1084</td>
<td>0.0233</td>
<td>-0.0306</td>
<td>1.0000</td>
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</table>

Note: * Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed).
### TABLE 2

Results of the Tobit Regression Analysis

<table>
<thead>
<tr>
<th>Dependent Variable: Scope of technological capability</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>log(Sales)</td>
<td>0.1681**</td>
<td>0.2054**</td>
<td>0.1927**</td>
<td>0.1614**</td>
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<td></td>
<td>(0.0237)</td>
<td>(0.0172)</td>
<td>(0.0183)</td>
<td>(0.0189)</td>
</tr>
<tr>
<td>Prior Performance</td>
<td>-0.0004</td>
<td>-0.0004</td>
<td>-0.0008+</td>
<td>-0.0005</td>
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<tr>
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<td>(0.0005)</td>
<td>(0.0005)</td>
<td>(0.0004)</td>
<td>(0.0004)</td>
</tr>
<tr>
<td>DT</td>
<td>0.1152**</td>
<td>0.0173</td>
<td>0.0407</td>
<td>0.1043*</td>
</tr>
<tr>
<td></td>
<td>(0.0416)</td>
<td>(0.0399)</td>
<td>(0.0422)</td>
<td>(0.0409)</td>
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<tr>
<td>log(RDI)</td>
<td>-0.0077</td>
<td>-0.0195</td>
<td>-0.0454**</td>
<td>-0.0078</td>
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<td>(0.0206)</td>
<td>(0.0170)</td>
<td>(0.0168)</td>
<td>(0.0159)</td>
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<tr>
<td>log(ADI)</td>
<td>0.0069</td>
<td>-0.0108</td>
<td>-0.0028</td>
<td>-0.0240**</td>
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<td>(0.0102)</td>
<td>(0.0089)</td>
<td>(0.0090)</td>
<td>(0.0091)</td>
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<td>Available Slack</td>
<td>0.0846</td>
<td>0.0661</td>
<td>0.0488</td>
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<td>(0.0554)</td>
<td>(0.0522)</td>
<td>(0.0509)</td>
<td>(0.0660)</td>
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<tr>
<td>Recovery Slack</td>
<td>0.1253</td>
<td>0.0732</td>
<td>0.1245+</td>
<td>0.2097+</td>
</tr>
<tr>
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<td>(0.0824)</td>
<td>(0.0695)</td>
<td>(0.0693)</td>
<td>(0.1142)</td>
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<td>Alliances</td>
<td>0.0174</td>
<td>0.0286</td>
<td>0.0162</td>
<td>0.0160</td>
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<tr>
<td></td>
<td>(0.0253)</td>
<td>(0.0236)</td>
<td>(0.0228)</td>
<td>(0.0227)</td>
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<tr>
<td>FSTS</td>
<td>0.3128**</td>
<td>0.2519**</td>
<td>0.0776</td>
<td>0.1997**</td>
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<td>(0.0834)</td>
<td>(0.0729)</td>
<td>(0.0897)</td>
<td>(0.0668)</td>
</tr>
<tr>
<td>VI</td>
<td>-0.0624**</td>
<td>-0.2362**</td>
<td>-0.0901+</td>
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<tr>
<td></td>
<td>(0.0237)</td>
<td>(0.0522)</td>
<td>(0.0475)</td>
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<tr>
<td>VI x FSTS</td>
<td>0.3642**</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.1174)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>VI x Available</td>
<td></td>
<td>0.2893**</td>
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<tr>
<td></td>
<td></td>
<td>(0.1045)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VI x Recovery</td>
<td></td>
<td>0.0483</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.1343)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-1.3332**</td>
<td>-1.2624**</td>
<td>-1.0708**</td>
<td>-1.1500**</td>
</tr>
<tr>
<td></td>
<td>(0.1021)</td>
<td>(0.0732)</td>
<td>(0.0823)</td>
<td>(0.0816)</td>
</tr>
<tr>
<td>Wald chi-square</td>
<td>259.95</td>
<td>521.58</td>
<td>446.45</td>
<td>403.44</td>
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<tr>
<td>Model significance</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>152</td>
<td>152</td>
<td>152</td>
<td>152</td>
</tr>
</tbody>
</table>

Standard errors in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
N=152 due to the missing value
### TABLE 3

**Results of Negative Binomial Regression Analysis**

<table>
<thead>
<tr>
<th>Dependent variable: log(Patent citations)</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>log(Sales)</td>
<td>0.8195** (0.1287)</td>
<td>0.6121** (0.1536)</td>
</tr>
<tr>
<td>Prior Performance</td>
<td>-0.0025 (0.0034)</td>
<td>-0.0016 (0.0035)</td>
</tr>
<tr>
<td>DT</td>
<td>-0.1332 (0.3058)</td>
<td>-0.1846 (0.3019)</td>
</tr>
<tr>
<td>log(RDI)</td>
<td>0.1684 (0.1064)</td>
<td>0.1753+ (0.1056)</td>
</tr>
<tr>
<td>log(ADI)</td>
<td>-0.1278* (0.0597)</td>
<td>-0.1187* (0.0605)</td>
</tr>
<tr>
<td>Available Slack</td>
<td>-0.3052 (0.4036)</td>
<td>-0.3282 (0.4061)</td>
</tr>
<tr>
<td>Recovery Slack</td>
<td>0.8275+ (0.4407)</td>
<td>0.5265 (0.4594)</td>
</tr>
<tr>
<td>Alliances</td>
<td>0.1183 (0.1533)</td>
<td>0.0711 (0.1538)</td>
</tr>
<tr>
<td>FSTS</td>
<td>0.4155 (0.3949)</td>
<td>0.3117 (0.4066)</td>
</tr>
<tr>
<td>VI</td>
<td>0.3203* (0.1560)</td>
<td>0.2550 (0.1593)</td>
</tr>
<tr>
<td>Scope</td>
<td>0.8588* (0.3344)</td>
<td></td>
</tr>
<tr>
<td>Year99</td>
<td>-0.0196 (0.2614)</td>
<td>-0.0013 (0.2604)</td>
</tr>
<tr>
<td>Year00</td>
<td>-0.0801 (0.2563)</td>
<td>-0.0559 (0.2585)</td>
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<td>Year01</td>
<td>-0.1410 (0.2627)</td>
<td>-0.1261 (0.2617)</td>
</tr>
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<td>Year02</td>
<td>-0.2192 (0.2646)</td>
<td>-0.2624 (0.2646)</td>
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<td>Year03</td>
<td>-0.3458 (0.2651)</td>
<td>-0.3642 (0.2654)</td>
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<td>Year04</td>
<td>-0.6766* (0.2811)</td>
<td>-0.6238* (0.2828)</td>
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<tr>
<td>Constant</td>
<td>6.4432 (13.9585)</td>
<td>7.9416 (15.2569)</td>
</tr>
</tbody>
</table>

Log likelihood: -178.47024, -175.13467
Wald chi-square: 69.84, 72.27
Model significance: Yes, Yes

Standard errors in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
REFERENCES


Cockburn, I. & Griliches, Z. 1988. Industry effects and appropriability measures in the stock


