Firms' Innovative Performance: The Mediating Role of Innovative Collaborations

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Firms' Innovative Performance: The Mediating Role of Innovative Collaborations

Abstract

While existing studies have provided many insightful discussions on the antecedents to innovative collaborations and the benefits of collaborative behavior, few studies have focused on the mediating role of innovative collaborations in enhancing the firm's technological innovative performance. In this paper, we investigate the mediating role of the firm's innovative collaborations in the relation between government innovation support and the firm's product and process innovation intensities. As a mediating factor in the innovation process, innovative collaborations form part of the innovative inputs that contribute to the firm's product and process innovation intensities. Using arguments derived from the resource-based theory, we found that while receipts of government innovation support help increase the firm's level of innovative inputs as observed in its collaboration intensity, it is equally important for firms to internalize management practices that encourage maximum leverage of government innovation support for pursuits of innovative collaborations. In a similar vein, while innovative collaborations are necessary for realizing innovative outputs including product and process innovations, it is not a sufficient condition for achieving strong innovative performance. The firm's internal capabilities as observed in its learning, R&D, resource allocation, manufacturing, marketing, organizing, and strategic planning abilities have a positive influence on the relationship between innovative collaborations and innovative outputs.

Keywords: Innovative Performance; Innovative Collaboration; Firm's Contextual Factors

Introduction

The OECD report in 1998 highlighted that almost all industrialized economies have utilized taxpayers' money to expand the technological capabilities of small and medium-sized enterprises (OECD, 1998). Given the huge annual investments by governments on innovation support programs such as the provision of R&D grants, subsidies, loans, tax incentives, as well as technological assistance, there is a resultant increase in demand for evaluation studies to identify the effectiveness of those programs and to justify its continuation. Evidence from the existing literature demonstrates that the impact of government innovation support is potentially large, encompassing tangible effects including the firm's R&D and innovation spending intensities (Leyden and Link, 1992), as well as intangible outcomes such as the firm's innovative collaborative behavior (Sakakibara, 1997).

However, little is known about the interaction effects between government innovation support and the firm's endogenous factors on the firm's collaborative behavior. Bozeman and Link (1983) highlighted that most evaluation-based studies treat the firm as a unitary actor and fail to consider organizational factors that may have an impact on the firm's innovative performance. Indeed, results from a recent empirical study by Wong and He (2003) highlighted the need for further micro-level studies that adopt an integrative view of firm-level innovation. The authors argued that the impact of government innovation support on the recipient firms is laterally influenced by organizational contextual factors, and if the moderating effects of these contextual variables are omitted from the impact analyses, the effects of government support may be obscured.

The potential interactive effects between government innovation support and the firm's endogenous is important because, while, government innovation support may provide firms with the knowledge and competence to engage in collaborations, the internal practices and capabilities of the firm itself must be conducive for government innovation support to be successful. Following this view, our study draws on the concepts from the resource-based view (RBV) of firms to offer an integrative analysis of the impact of government innovation support and the firm's contextual factors on the recipient firm's innovative collaborative behavior. More specifically, our study examines the mediating role of innovative collaborations on the relationship between government innovation support and the firm's technological innovative performance. The RBV of firm is an appropriate theoretical framework for studying the complementary effects of firms' capabilities and resources on its innovative performance because it addresses the question of how firms utilize external resources such as government support in conjunction with its internal resources and capabilities to enhance its innovative inputs and outputs.

Figure 1 presents the theoretical model of our study, which depicts innovation as a logically sequential and possibly continuous process that can be subdivided into a series of functionally separate but interacting and interdependent states. The overall pattern of the innovation can be thought of as a complex net of innovation paths, both intra-firm and extra-firm, linking together the various internal and external resources of the firm. The model presented in our study depicts the influence of the firm's internal and external resources on its level of innovative inputs and outputs. The main thrust of our study is that while government innovation support significantly influences the firm's innovative performance, the bundling of government innovation support with the firm's internal resources and capabilities provides the key to higher innovative performance. External resources in the form of government innovation support are regarded as a necessary but not a sufficient stimulus that affects the firm's innovative collaborative behavior. Government support must be matched by the firm's internal resources and capabilities if the support received is to be effective. Our model suggests that the firm's innovative inputs i.e. innovative collaborations mediates the relationship between government innovation support and the firm's innovative outputs.

Insert Figure 1 about here

Literature Review

The firm is seen as a unit of economic analysis that attracts inputs, transforms throughputs and produces outputs. Innovation inputs are regarded as proxies for outputs in the innovation process e.g. product and process innovations (Buisseret et al., 1995). Innovation inputs comprise of a wide range of hard and soft factors, often including the firm's level of R&D spending and innovative collaborations (Audretsch, 2004), which contribute to the firm's success in product and process innovations. Vonortas (1997) in particular, found that innovative collaborations enhance the innovation activities of the co-operation partners and increase the probability of realizing new products (Vonortas, 1997). Innovation outputs are essentially the end product in the technological innovation process (Schumpeter, 1934). Audretch (2004) emphasized the value of measuring the innovative activities of small-medium sized firms using the firm's level of innovative outputs. He emphasized that in most small-medium sized enterprises (SMEs), investments in innovative inputs may be insignificant and thus may not provide an accurate account of the firm's innovative contributions. Therefore, by focusing on the SMEs' innovative outputs including new products and new production processes, researchers are able to clearly identify the firm's innovative contributions.

Using the complementarities approach as a foundation, our study develops a framework for testing complementarities in an innovation setting. As defined by Mohmen and Röller (2005), "complementarity between a set of variables means that the marginal returns to one variable increases in the level of any other variable". The complementarities perspective constitutes the starting point for examining the inter-linkages and interrelatedness of the various factors that influence the firm's level of innovativeness. It paves a way for us to comprehend the intuitive ideas of synergies and systems effects, i.e. that "the whole is more than the sum of its parts". To understand the extent of complementarities in an innovation process, the resource-based view (RBV) of firms is used to tease out the factors that have been postulated to act together and reinforce each other in the process of influencing innovation outcomes. The RBV of firm defines firms in terms of its constituent resources and capabilities (Barney, 1991; Prahalad and Hamel, 1990). Researchers have argued that the interaction or interplay between resources will yield significant rents and benefits (Porter, 1996; Robertson, 1996). The resources and capabilities that a firm possesses are valuable only when used in conjunction with other resources and capabilities, which the firm has access to. The RBV lends great importance to the understanding of firms' technological innovative behavior as it delineates that firms' technological innovative performance originates from its possession of heterogeneous and idiosyncratic resources, which are not readily available in the open market for sale (Hauknes, 1999). The resource-based theory (Barney, 1991; Prahalad and Hamel, 1990) stresses the importance of the firm's internal resources and capabilities in the formulation of organizational strategies, and it views firms as unique bundles of resources yielding sustainable above normal profits. The RBV approach bases the strengths of the firm on two concepts; resources and capabilities. Resources are those intangible and tangible assets linked to the firm in a temporal way whereas capabilities are the ways of accomplishing activities based on available resources (Grant, 1991; Wernerfelt, 1984). More specifically, tangible resources are those that can be seen and quantified while intangible resources are those that do not appear in the financial statements of firms (Grant, 1991, p 119) such as management skills, employees know-how (Hall, 1993, p 609), and organizational culture (Barney, 1986). Capabilities are the capacity to use those resources effectively and efficiently to achieve the desired end. The resource-based logic can be used to help firms gain technological advantage by enhancing their understanding of the types of resources and capabilities that lead to strong innovative performance, and by ensuring that they nurture and maintain those resources and capabilities that form its core technological competence.

Building on the existing RBV studies that are largely "introspective" and mainly downplay the importance of external variables (Porter, 1996), our study incorporates the influence of external resources in the form of government innovation support on the firm's innovative behavior. The benefits of government innovation support include intangible outcomes such as the firm's ability to collaborate with external parties. Innovative collaboration is defined as the participation in joint R&D and other technological innovation projects with external parties such as suppliers, competitors, customers, and universities (Belderbos et al., 2004). Innovation collaboration is an important support factor in the firm's innovation process because it allows the exchange of tacit knowledge through personal face-to-face interactions (Lundvall and Borrás, 1998). Government innovation provides firms with the knowledge and competence to undertake collaborations. As a valuable external resource to the firm, it enhances the firm's ability to identify potential collaborators and assess their capability and reliability. With strong government support, firms are able to prove its collaborative credentials to potential partners. Furthermore, receipts of government support or public money conveys positive signals to potential investors that the firm is technologically capable.

One of the primary roles attributed to government innovation support has been funding (Tripsas et al., 1995). Funding helps defray the high costs associated with innovative collaborations. Collaborative innovations often involve high levels of asset specificity. When a firm performs part of a research project, the knowledge it gains may be useless unless it is combined with work from other firms. The level of uncertainty in the innovation process is also high and the absolute level of innovative outputs is difficult to predict. The frequency of interactions in innovative collaborations may be high, which may result in costly coordination. Therefore, by providing a pool of funds for collaboration projects, governments can encourage firms to collaborate in a specified technological area.

Additionally, government innovation support helps firms decrease the costs of potential opportunistic behavior, which is a major barrier to the formation of innovative collaborations (Porter and Fuller, 1986). The transaction cost framework delineates that the potential for opportunism increases the costs of engaging in collaborative arrangements (Tripsas et al., 1995). Transaction costs of opportunistic behavior involve both the ex-ante and ex-post costs (Porter and Fuller, 1986). In structuring collaborative work, potential partners must reach agreement over a wide variety of issues before finally deciding to work together. According to Tripsas et al., (1995), the four key areas of conflicts, which firms must attempt to resolve in ex-ante negotiations are the control of ownership, the distribution of research contributions and results, the goals of the collaboration, and the protection of proprietary technology. Disputes often emerge over who will have control in a collaborative venture, and in any collaboration, rules for how much each firm should contribute, and for how profits are shared are difficult to establish. Guidelines for who controls the day-to-day management of various pieces of the project are important, since allocations are likely to change throughout the course of the project. Moreover, it is crucial for partners to have common operational goals for a collaboration to succeed. The desire of potential partners to protect proprietary technology could also be a major obstacle to collaboration. The ex-post transaction costs of collaborative R&D include the costs of renegotiating and the monitoring of collaborative research progress. Since the outcomes of innovations are highly uncertain, much of the ex-ante contracting, which takes place is destined to be incomplete, and requires follow-ups. Monitoring the progress of collaborative research projects is also difficult because the results of innovation have some public good characteristics. Thus information can be transferred to other parties without the transferee losing it. Agreements to keep certain technologies private are therefore, difficult to monitor and enforce, and once they are violated, damage control is difficult.

Governments could also reduce the costs of opportunistic behavior through institutional mechanisms such as the legal framework for cooperative actions (Tripsas et al., 1995). By shifting aspects of the institutional environment such as property rights, contract law, and the reputation effects of uncertainty, governments could reduce the transaction costs of potential opportunisms and encourage innovative collaborations. Thus government innovation support provides the impetus for innovative collaborations by alleviating the potential barriers and difficulties that firms may encounter in their collaborative efforts. Nevertheless, while external resources in the form of government innovation support will encourage firms to increase their innovative inputs in the form of innovative collaborations, the management practices of the firm itself must be supportive of innovative collaborations. As there is greater need for firms to reduce risks associated with innovations and to be able to fully leverage on the support received from governments, it is important for them to internalize practices that allow maximum flexibility for opportunity exploitation. In this respect, the firm's entrepreneurial management practices, an internal resource to the firm have a crucial role to play in encouraging firms to take advantage of the government innovation support received for their innovative collaboration pursuits. An entrepreneurial management style has been regarded as the informal organizational institution that help shapes the innovative behavior of firms (Stevenson, 1983) as it provides a favorable environment for enhancing absorptive capabilities and information sharing. Given that innovation is not an ad hoc internal process, but one that has direction and purpose, firms require an eclectic base of managerial competencies that support its investment in innovative inputs, including its collaborative efforts (Beaver, 2001).

An entrepreneurial-managed firm is driven by the opportunities that exist in the environment and not the resources that may be required to exploit the opportunities, it attempts to commit small amounts of resources in a multi-step manner, which allows them to stop and change direction, if and when circumstances change, it has a flat management structure, which is sufficiently flexible to create an environment where employees are free to seek and exploit opportunities, it desires rapid growth, encourages and rewards risk-taking, and has a culture that is entrepreneurially-driven and comfortable with aggressive new ideas. These entrepreneurial management practices play a crucial role in determining how government innovation support should be effectively leveraged upon because an entrepreneurially-driven firm is more open to changes and thus will be able to recognize and better utilize the support received from government. While external resources in the form of government innovation support will encourage firms to increase their innovative inputs in the form of innovative collaborations, the management practices of the firm itself must be supportive of collaborative actions.

Furthermore, existing studies have established that the firm's innovative performance cannot be improved directly by government innovation support (Kaufmann and Tödtling, 2002; Wong and He, 2003). Government support does not impact the firm's innovative outputs directly. Based on the input-output model of the firm's innovative behavior, the influence of government innovation support on the firm's innovative outputs is observed to take effect through the firm's innovative inputs. Hence, innovative inputs such as the firm's innovative collaborations act as mediators between government innovation support and the firm's innovative outputs including its product and process innovations.

Based on the above discussion, we hypothesize the following:

H1: Among firms that received strong *government innovation support*, stronger emphasis on an *entrepreneurial management style* will be associated with higher *innovative collaborations*.

H2: *Innovative collaboration* mediates the relationship between *government innovation support* and *product innovation*.

H3: *Innovative collaboration* mediates the relationship between *government innovation support* and *process innovation*.

The benefits of innovation collaboration to firms are many. Innovative collaborations can potentially help firms gain technological power, move quickly into new markets and technologies, and create options for future technological investments. Furthermore, the resources firms acquire through collaborations can enable them to gain differentiable product technologies that outweigh the disadvantages of collaboration formations. In the absence of collaboration, knowledge spillovers to competing firms are considered involuntary, as they increase the knowledge stock of competing firms and may weaken the firm's relative technological position. The existence of the involuntary spillovers reduces the effectiveness of the firms' innovative efforts as they cannot appropriate all of the returns, and this may result in lower levels of innovative outputs. Collaboration with external parties in innovation is a crucial way for firms to make external resources usable. It offers possibilities of efficient knowledge transfer, resource exchange, and organizational learning. Complementary assets and resources can be combined and pooled, thus generating synergies and cross-fertilization effects. Firms also engaged in joint innovation because it allows the utilization of external resources for their own purposes directly and systematically (Becker and Dietz, 2004). Collaborations in innovation within well-organized networks enhance the innovation activities of the co-operation partners, which increases the probability of realizing new products (Vonortas, 1997). Joint innovation projects are also used to complement internal resources in the innovation process, thus enhancing the firm's innovative outputs.

From a resource-based perspective, firms enter into innovative collaboration arrangements with external parties including their customers, suppliers, competitors, and universities because they do not have internally, all of the necessary resources and/or because they wish to reduce the risks associated with innovation (Tether, 2002). Collaborations with customers provide complementary knowledge and user technical know-how to firms (Shaw, 1994). It also provides an understanding of user behavior that can be important for refinements to the innovation. Collaborations with customers are important to reduce the risks associated with market introductions of innovations (Von Hippel, 1988). When products are novel and complex and hence, require adaptations by customers, collaborations may be essential to ensure that the products remain competitive. Tidd et al. (1997) explained that overall strategic considerations, including joint learning and trust are important reasons why firms collaborate with suppliers. Collaborations with suppliers are often related to the tendency to focus on core businesses through outsourcing, while closely collaborating with suppliers to guarantee quality improvements to innovative inputs, aimed at further cost reductions (Belderbos et al., 2004). Studies have established that the extensive involvement by suppliers in product and process development will help buyers achieve faster product development cycles, lower input costs and stronger product competitiveness (Kotabe et al., 2003). Through collaborations with competitors, competing firms will be able to build an understanding of each other's strengths and weaknesses. They may find areas where their strengths are complementary for the development of a new range of products or services (Tether, 2002). As these strengths reflect competencies that can be difficult, time-consuming and costly to develop, it makes sense to collaborate rather than seek to replicate the other's strengths, especially in the face of other competitors, who have all the required competencies.

Universities and government research institutes are important contributors to the supply of new scientific and technological knowledge (Nelson, 1993), and thus are important collaborators for firms. Collaborations with universities and research institutes are generally aimed at innovations that may open up entire new markets or market segments (Tether, 2002). Through collaborations with universities, firms are able to take advantage of leading edge academic research and gain insights into cutting edge technologies.

Innovative collaborations improve the strategic position of firms in competitive markets by providing resources from their collaborators to enable them to share costs and risks. Such resources give firms a cushion to weather business downturns and other setbacks, and ensure a more even and predictable resource flow (Baum and Oliver, 1991). Collaborations also provide financial resources that enable cost-and risk-sharing with other firms (Miner et al., 1990). Additionally, it helps firms obtain the needed skill-based resources quickly (Hamel et al., 1989), which is especially important for tacit skills, which may be slow to develop in-house and difficult to buy. The benefits of collaboration are probably more relevant for SMEs as they are less capable of searching for and using codified knowledge, which forces them to rely more on personal ways of transferring this knowledge and on learning by doing or interacting i.e. collaborating. Collaborations may be used by firms to reduce the difficulties they encounter with their innovation activities including the financial risk of innovation, organizational inadequacies such as lack of skilled technical personnel, difficulties with regulations or standards, customers' responsiveness to innovation, and lack of information on technologies and/or markets. The mitigation for these difficulties will enhance the firm's ability to generate new products and production processes.

While the benefits of innovative collaborations will help firms develop new products and new processes, the firm's internal capabilities will moderate the relationship between innovative collaborations and the firm's product and process innovations. Studies have found that in many SMEs, the firm's internal capabilities in the strategic, organizational, and technological domains are weak (Kaufmann and Tödtling, 2002). These deficiencies may hinder the ability of firms to transform their innovative inputs into innovative outputs. The successful conversion of innovative collaborations into product and process innovations requires firms to have an all-rounded capability in the respective organizational functions. Successful technological innovation depends not only on technological capability, but on other internal capabilities such as manufacturing, marketing, organization, strategic planning, learning, and resources allocation. Given the inherent technological challenges encountered by many SMEs, those who are able to develop strong capabilities in these areas are probably more likely to effectively exploit the full potential of its resources to generate new products and production processes. A critical defining feature of RBV is that it is a capability-based explanation of performance differences, rather than one relying on market power or collusion (Barney, 1991). As the firm is defined by what it knows, and its knowledge determines what it can do and how to do it, it becomes important to include the capabilities view of the firm when studying the firm's technological innovative behavior.

Burgleman et al.(2004) explained that the firm's internal capabilities in areas such as R&D, resources allocation, manufacturing, marketing, organizing, strategic planning, and overall learning are important internal resources that influence the firm's innovative performance. The authors defined *learning capability* as the firm's ability to identify, assimilate, and exploit knowledge from the environment, and *R&D capability* as the ability to integrate R&D strategy, implement R&D projects, and manage R&D expenditure. *Resources allocation capability* was defined as the firm's ability to acquire and allocate capital, expertise and technology in the innovation process. While *manufacturing capability* was referred to as the firm's ability to transform R&D investments into products, *marketing capability* was referred to as the firm's ability to publicize and sell products based on consumer needs and the competitive environment. *Organizing capability* was referred to as the firm's ability to secure organizational harmony and good management practices. *Strategic planning capability* was defined as the firm's ability to identify its internal strengths, weaknesses, external opportunities and threats. The functional approach adopted by Burgleman et al. (2004), except learning capability, represents the various functional areas in the organization i.e. R&D, manufacturing, marketing, organizing, resource allocation, and strategic planning

The ultimate value of the firm's innovative collaborations in its ability to translate into innovative outputs, including its product and process innovation is contingent upon its internal capabilities in areas such as manufacturing, marketing, organization, strategic planning, and resource allocation. The firm's internal capabilities positively influence the processes related to the translation of innovation inputs to innovative outputs. Firms can leverage on its strong internal capabilities to effectively and efficiently transform the benefits of innovative collaborations into new products and production processes.

Thus we hypothesize the following:

H4: Among firms with high levels of *innovative collaborations*, stronger *internal capabilities* will be associated with higher levels of *product innovation*.

H5: Among firms with high levels of *innovative collaborations*, stronger *internal capabilities* will be associated with higher levels of *process innovation*.

Methods

Sample

The target population was manufacturing SMEs from the electronics, chemicals, transport engineering, biomedical sciences, precision engineering, and general manufacturing industries in Singapore. The firm is a suitable unit of analysis because it is at the firm level that decisions about the commitment of resources to innovation and innovative strategy of the firm are made. It is also at the firm level that the benefits of innovation are enjoyed in terms of cost reductions and development of new products and new processes (Wakelin, 1998). The performance of SMEs has been an interest for policy makers and researchers alike given its significant contribution to a nation's economic growth (Soete and Stephan, 2004). Governments in the advanced market economies have increasingly placed greater emphasis on measures to support small and medium sized manufacturing firms. This is based on the belief that small and medium sized firms are important vehicles for the creation for new jobs, for regional economic regeneration and for enhancing national rates of technological innovation (Acs and Yeung, 1999). Although small-medium firms predominate in countries throughout the world, they have received little consideration from resource-based theorists. While the general emphasis on large firms is understandable in that the weight of each in the economy is often substantial, the combined weight of small-medium firms is also substantial (Fu and Robertson, 2000). SMEs are able to react quickly to keep abreast of fast changing market requirements and to take advantage of new opportunities. As with their larger counterparts, the degree of technological involvement by small-medium firms varies greatly, from the lowest to the very highest levels. Thus the inquiry into the technological performance of small firms requires careful consideration of a multitude of factors, ranging from government support received to the firm's internal practices and capabilities to its innovative collaborative intensity.

The sampling frame for our study was constructed from the 2004 Singapore's Census of Manufacturing Activities (EDB, 2006). The targeted sample of 7,799 firms represented more than three quarters of the population of manufacturing SMEs in the electronics, chemicals, precision engineering, transport engineering, biomedical sciences, and general manufacturing industries. Data for this study was collected in 3 phases. First phase was conducted in October 2005, while the second and third phases were conducted in April 2006 and October 2006 respectively. Essentially, the second and third phases were conducted 6 months and 12 months respectively from the first phase. A total of 7,799 questionnaires were mailed to the CEOs of the targeted firms in October 2005. A total of 749 valid responses were received from these targeted firms, which yielded a response rate of 9.6% for the first phase. The response rates for the first phase varied slightly between industries, ranging from 7.2% for biomedicals manufacturing to 11.3% for transport engineering. During the second phase in April 2006, only a shorter version of the questionnaire that consists of 3 questions on the firm's product and process innovation intensity and its innovative collaborative intensity was mailed to all the 749 valid respondents identified at the first phase of the survey. A total of 740 CEOs returned the completed questionnaires during the second phase, yielding a response rate of 9.5% of the total targeted sample of 7,799 companies. Similarly, we followed the same cohort of respondents from the first phase through the third phase of the survey in October 2006. The 3 questions that were used during the second phase were mailed to the 740 CEOs during the third phase. 722 respondents completed the survey questions during this phase, yielding a response rate of 9.3% of the total targeted sample of 7,799 companies.

In order to control for the possibility that some of the sampled firms may have engaged in little or no technological innovation, a filter question was asked to ascertain if the firm had engaged in an innovative activity. Following OECD-EUROSTAT's (1997) definition, firms were regarded as active in innovations if they had introduced at least one of the following during the last three years: (1) a product new to the business or a substantially improved product (product innovation); (2) a new or substantially improved production process through new equipment or re-engineering (process innovation). This resulted in 331, 322, and 314 cases of innovating firms during the first, second, and third phases of the survey respectively.

Data Analysis Method

We were interested in predicting the mediating effects of the firm's innovative collaborations on the relationship between government innovation support and the firm's product and process innovation intensities. Given that measures of the firm's innovative collaborations, product and process innovation intensities were represented by ordinal values, hierarchical ordinal logistic regression was used to test the study's hypotheses. Ordinal models take into account the ordered classifications of the dependent variables (Long and Freese, 2006), and specifically, hierarchical ordinal logistic regressions examine the amount of variance explained by the base model (control variables only), the main-effects model (controls and independent variables), and the full model (controls, independent variables, and hypothesized interactions).

Variables

Dependent variables

The dependent variables for our study were the firm's innovative outputs i.e. its product and process innovation intensities. Product innovation intensity was measured as the percentage of the firm's total annual sales that consists of new/improved products introduced over the last 3 years, while process innovation intensity was measured as the percentage of the firm's annual production volume that consist of new/improved processes introduced over the last 3 years. Past studies by Hollenstein (1996) and He and Wong (2004) have used similar operationalizations of the firm's product and process innovation intensities.

Independent variable

Government innovation support was measured using Li and Atuahene-Gima's (2001) four item measures of the extent of government support. Examples of questions are "Please indicate the extent to which in the last 3 years government and its agencies have implemented policies and programs that have been beneficial to your firm's operations" and "Please indicate the extent to which in the last 3 years government and its agencies have provided needed technology information and technical support to your firm". All four items were measured on a 5-point Likert scale ranging from 1 = to no extent to 5 = to a great extent. Cronbach alpha for government innovation support is 0.74.

Moderating variables

Entrepreneurial management practices were operationalized using Brown et al.'s (2001) six dimensions of entrepreneurial management such as strategic orientation, resource orientation, management structure, reward philosophy, growth orientation, and entrepreneurial culture. Each of these dimensions consists of sub-attributes that were measured on a 10-point bipolar scale. Cronbach alpha for entrepreneurial management is 0.77. Internal capabilities were operationalized using Yam et al.'s (2004) seven dimensions of firms' capabilities such as learning capability, R&D capability, resource allocation capability, manufacturing capability, marketing capability, organizing capability, and strategic planning capability. Each of these dimensions consists of sub-attributes that were measured on a 7-point Likert scale. Cronbach alpha for organizational capabilities is 0.75.

Mediating variable

Innovative collaboration was operationalized as the firm's collaboration intensity with external parties including customers, suppliers, R&D institutes, and competitors, and was measured on a 5-point Likert scale ranging from 1 = no cooperation at all to 5 = intense cooperation. Examples of questions on the firms' collaboration intensity with external parties are "How intensely do you cooperate with the R&D institutes and universities in Singapore in your innovation activities (e.g. product innovation or process innovation)?" and "How intensely do you cooperate with your customers and buyers in your innovation activities?" Cronbach alpha for innovative collaboration is 0.79.

Control variables

The control variables used in our study were categorized into two groups i.e. the innovation environment and the firm's demographic factors. Environmental factors have been found to have an influence on the firm's innovative behavior. Firms obtain various inputs from their environment, process them, and ultimately generate new products and/or services (Baldridge and Burnham, 2005). Innovation environment was operationalized using 14 items, which were measured on a 5-point Likert scale. An example of question on the firm's innovation environment was "How do you assess the current business environment in Singapore in terms of openness of customers for innovation?" The firm's demographic factors were measured using five variables such as its industrial sector, firm size, ownership status, government-linked status, and average sales growth rate in the last 3 years. Due to different technological dynamism such as technological opportunity and appropriability regimes inherent in different industries, industrial sectors play an influential role in determining the level of organization innovation (Cohen and Levin, 1989). The six manufacturing sectors were used as industrial dummies. It has been long observed that innovation is correlated to the size of the firm - the larger the firm, the greater the number of innovations it produces (Fritsch and Meschede, 2001). One measure of firm's size is the total number of employees in the firm. To compensate for skewness, the firm's size was represented by the log of total employment in 2005. Singapore is well-known for its high influx of foreign MNCs. These MNCs are resource rich, have better international innovation networks, and are more likely to engage in innovation and R&D related activities than local firms (Janne, 2002). Foreign ownership was represented by a dichotomous variable, 1 if foreign owned (<30% local ownership), 0 if otherwise. Evidence in the existing literature also indicates a positive link between innovation and sales growth, where firms with strong sales growth are likely the ones who are highly innovative (Rudma, 2001). Sales growth was measured by the compounded average sales growth rate from 2002-2005, with 2002 as the base year.

Results

Table 1 shows the correlation values for the study's variables. Government innovation support was significantly correlated with innovative collaboration (r = 0.15; $p < 0.05$). Additionally, innovative collaboration was also found to be statistically correlated with product innovation (r = 0.22; $p < 0.05$) and process innovation (r = 0.21; $p < 0.05$). The independent variable, government innovation support was significantly correlated with product innovation (r = 0.13; $p < 0.10$) and process innovation (r = 0.16; $p < 0.10$). The correlation coefficients among all other variables were statistically non-significant at the 5% level and none of the variance inflation factors (VIFs) for the variables was greater than 2, which was below the guideline of 10 by Chatterjee and Price (1991). Thus it was unlikely that multicollinearity among the independent variables affected the findings.

Insert Table 1 about here

Table 2 presents the results of the hierarchical ordinal logistic regressions predicting the moderating impact of the firm's entrepreneurial management practices on the government innovation support and innovative collaboration relationship (hypothesis 1), the mediating effects of innovative collaboration on the relationship between government innovation support and product innovation (hypothesis 2), and the moderating impact of the firm's internal capabilities on the innovative collaboration and product innovation relationship (hypothesis 4). Model 1 is a baseline model consisting of control variables. The results indicate that an environment conducive for innovation ($p < 0.05$) and the precision engineering ($p < 0.10$), general manufacturing ($p < 0.10$) and "others" (electronics, transport engineering, and biomedical sciences; $p < 0.10$) industries have a positive effect on the firm's innovative collaboration intensity. Models 2 and 3 present the results for testing the interactive effects between government innovation support and the firm's entrepreneurial management practices on its innovative collaboration intensity. The results show that government innovation support and the firm's entrepreneurial management practices have significant positive interactive effects on its innovative collaboration intensity (0.818; $p < 0.01$). The pseudo R2 increased to 33% in Model 3 from 15% in Model 1. These findings provided support for hypothesis 1, which states that among firms that received strong government innovation support; stronger emphasis on an entrepreneurial management style will be associated with higher innovative collaborations.

Insert Table 2 about here

To test whether innovative collaboration intensity mediates the relationship between government innovation support and product innovation (hypothesis 2), we followed the framework outlined by Kohler and Mathieu (1993). As observed in Model 3, the mediating variable, innovative collaboration was regressed onto the control, government innovation support, entrepreneurial management, and the interactive variables of government innovation support and entrepreneurial management. In model 4, product innovation was regressed onto the control variables, government innovation support and entrepreneurial management variables, while in model 5, product innovation was regressed onto the control, government innovation support, entrepreneurial management, and the interactive variables of government innovation support and entrepreneurial management. Models 6 and 7 involved regressing product innovation onto innovative collaboration, organizational capabilities, and interactive variables of innovative collaboration and organizational capabilities. In Model 8, we added to Model 7, the control, government innovation support, entrepreneurial management, and interactive variables of government innovation support and entrepreneurial management.

For a mediating relationship to exist, 4 conditions must hold: 1) The independent variable/s must affect the mediator. In Model 3, the impact of government innovation support on innovative collaboration was statistically significant (0.492; $p < 0.05$). Similarly, the interactive effects of government innovation support and entrepreneurial management were statistically significant at 1%; 2) The independent variable/s must affect the dependent variable. In Model 5, government innovation support has a statistically significant relationship on product innovation (0.228; $p < 0.05$). By the same token, the interactive effects between government innovation support and entrepreneurial management were statistically significant at 5%; 3) The mediator must affect the dependent variable. The results in Model 7 highlight the positive influence of innovative collaboration on product innovation (0.448; $p < 0.05$). In addition, a statistically significant interactive effect between innovative collaboration and organizational capabilities was observed in Model 7 (0.599; $p < 0.01$); 4) Lastly, if the independent variable/s is not significant in Model 8, full mediation effects were observed. On the other hand, if the independent variables are significant, then there were partial mediation effects. The results in Table 2 show that the 4 conditions were fully met, thus providing support for hypothesis 2, which states that innovative collaboration mediates the relationship between government innovation support and product innovation. The statistically significant interactive effects between innovative collaboration intensity and organizational capabilities (0.601; $p < 0.01$) provided support for hypothesis 4, which states that among firms with high levels of innovative collaborations, stronger internal capabilities will be associated with higher levels of product innovation. The interactive effects models i.e. Models 3 ($r2 = 33\%$; $p < 0.01$), 7 ($r2 = 24\%$; $p < 0.01$) and 8 ($r2 = 29\%$; $p < 0.01$) explained a significant amount of variance over and above the base model, Model 1 ($r2 = 15\%$; $p < 0.05$). The full model (Model 8) explained a significant amount of the variance ($r2 = 29\%$) over and above the main effects model i.e. Models 2 ($r2 = 24\%$; $p < 0.01$), 4 ($r2 = 8\%$; $p < 0.05$), and 6 ($r2 = 13\%$; $p < 0.01$).

Table 3 presents the results of the hierarchical ordinal logistic regressions predicting the mediating effects of innovative collaboration on the relationship between government innovation support and process innovation (Hypothesis 3), and the moderating impact of the firm's internal capabilities on the innovative collaboration and process innovation relationship (Hypothesis 5). Model 1 is a baseline model consisting of control variables. Similarly, to test whether innovative collaboration mediates the relationship between government innovation support and process innovation, we followed the framework outlined by Kohler and Mathieu (1993). As observed in Model 3, the mediating variable, innovative collaboration was regressed onto the control, government innovation support, entrepreneurial management, and the interactive variables of government innovation support and entrepreneurial management. In model 4, process innovation was regressed onto the control, government innovation support, and entrepreneurial management variables, while in model 5, process innovation was regressed onto the control, government innovation support, entrepreneurial management, and the interactive variables of government innovation support and entrepreneurial management. Models 6 and 7 involved regressing process innovation onto innovative collaboration (mediating variable), organizational capabilities, and the interactive variables of innovative collaboration and organizational capabilities. In Model 8, we added to Model 7, the control, government innovation support, entrepreneurial management, and the interactive variables of government innovation support and entrepreneurial management.

Insert Table 3 about here

In Model 3, the impact of government innovation support on innovative collaboration was statistically significant (0.492; $p < 0.05$). Similarly, the interactive effects between government innovation support and entrepreneurial management were statistically significant at 1%. In Model 5, the impact of government innovation support on process innovation is statistically significant ($\beta = 0.188$; $p < 0.05$). By the same token, the interactive effects between government innovation support and entrepreneurial management on process innovation were statistically significant ($\beta = 0.195$; $p < 0.05$). The results in Model 7 highlight the positive influence of innovative collaboration on process innovation (0.250; $p < 0.05$). In addition, a statistically significant interactive effect between innovative collaboration and organizational capabilities was observed in Model 7 (0.385; $p < 0.01$). The results in Table 3 show that the independent variables i.e. government innovation support and entrepreneurial management have a positive influence on both innovative collaboration (Model 3) and process innovation (Model 5) but when the mediating variable i.e. innovative collaboration was introduced into the full model (Model 8), the significant effects of the independent variables on process innovation dissipate. Additionally innovative collaboration was found to have a statistically significant impact on process innovation (Model 8). These results provided full support for hypothesis 3, which states that innovative collaboration mediates the relationship between government innovation support and process innovation. The statistically significant interactive effects between innovative collaboration and organizational capabilities (0.390; $p < 0.01$) provided support for hypothesis 5, which states that among firms with high levels of innovative collaboration, stronger internal capabilities will be associated with higher levels of process innovation. The full model (Model 8) explained a significant amount of the variance ($r2 = 28\%$; $p < 0.01$) over and above the main effects model i.e. Models 4 ($r2 = 7\%$; $p < 0.05$), and 6 ($r2 = 21\%$; $p < 0.05$). Consistent with the findings on the mediating effects of innovative collaboration on the relationship between government innovation support and product innovation, the hypothesized mediating effect of innovative collaboration on the government innovation support-process innovation relationship was fully supported.

Discussion and Implications

The RBV theory helps us identify the key innovation success factors in terms of the firm's resources and capabilities. RBV postulates that a firm's performance is largely dependent on its resources. Resources are assets or inputs to the production process that a firm owns, controls, or has access to, which give it an enabling capacity to enhance its efficiency or effectiveness (Hunt and Morgan, 1997). RBV distinguishes between intangible resources, which are developed over time (e.g. established management practices, culture) and knowledge-based resources, which involve the organizing principles, skills, and processes that direct organizational action (Kogut and Zander, 1992). We found that government innovation support, a form of external resource, and the firm's internal resources i.e. entrepreneurial management practices and functional capabilities have a significant impact on the firm's innovative outputs i.e. product and process innovations through the mediating influence of the firm's innovative inputs i.e. innovation collaboration intensity. Our study's findings highlight the moderating influence of the firm's entrepreneurial management practices on the government innovation support-innovative collaboration linkage. An entrepreneurial management style, which consists of opportunity-driven strategies, multi-staged resource allocation procedures, flexible management structures, reward systems that emphasize the ability of individuals to pursue opportunities, growth-oriented strategies, and an entrepreneurial culture helps ensure that government innovation support received are optimally utilized and leveraged upon for collaborative efforts. The results of our study emphasize the importance of an entrepreneurial management style as a way of achieving maximum value from external support received from government. Entrepreneurial management had a positive impact on the firm's ability to facilitate the strategic utilization of government innovation support for enhancing the firm's level of innovation collaborations. Similarly, the findings highlight the value of a strong internal capability in the various functional areas for innovative inputs to be converted into innovative outputs.

Understanding the inter-linkages between government support and the firm's management practices and capabilities is important to successfully manage firms' innovative performance. The central finding is that government innovation support may have little effect if firm-level factors are not changed at the same time. For example, what are the benefits of offering government support to enhance firms' innovative performance if firms themselves do not possess the required management practices and internal capabilities? Indeed, it is often argued that innovation is a complex outcome, influenced by many factors that are interrelated. More importantly, the interrelatedness of those factors is often described as one that is complementary, that is, the factors act together and reinforced each other (Dosi, 1998). Overall, findings from our study suggest important areas for improving the effectiveness of government innovation support in terms of identifying the types of resources and capabilities SMEs should possess in order to complement the innovation support received from government. Innovation support received from government is found to have a marked effect on SMEs' innovative performance but only for firms with entrepreneurial management practices and strong functional capabilities in R&D, resources allocation, manufacturing, marketing, organizing, strategic planning, and overall learning. Government support can make significant and certainly necessary contributions to revive the innovative efforts of SMEs, although these efforts would have to be strongly reinforced by managerial commitments and capabilities.

This is important from a managerial perspective because capabilities can be adapted or improved over time, and management practices can be changed to incorporate new learning. Thus management must be willing to look inside the firms and examine its internal resources and capabilities to ensure that the core competencies and practices are in place for its technological development. Governments on the other hand should encourage industrial firms to adopt pro-entrepreneurial management practices through its myriad policies and support programs. As discussed earlier, entrepreneurial management is a management style that encourages the entrepreneurial spirit, and that promotes opportunity-seeking behavior among employees (Stevenson and Jarrillo, 1986). Organizations with a pro-entrepreneurial management style encourage risk-taking and opportunities seeking among members in the organizations, which are important for exploiting the innovation support available from governments. In a similar vein, government innovation support can be oriented towards improving the firm's internal capabilities in areas such as manufacturing, marketing, organization, strategic planning, and allocation of resources to help convert innovative inputs into innovative outputs.

Future studies may consider extending the lag periods of the different survey phases to provide greater time lag for the effects of the independent and moderating variables to take place. Longer time gaps among the survey phases will more effectively tease out the effects of the explanatory variables including government innovation support, entrepreneurial management practices, the firm's internal capabilities and innovative collaborations on the firm's innovative performance. Additionally, it will be interesting for future research to examine the impact of different types of government support on the firm's innovative behavior - for example, the impact of government financial support, technical support, and advisory support on the firm's innovative collaborations, and examine if there are any differences in the impact of these supports on the firm's level of innovative outputs. Similarly, future research can differentiate between radical and incremental innovations, and analyze if the influence of government innovation support, entrepreneurial management practices, the firm's internal capabilities and innovative collaborations is consistent across the different types of innovations.

Conclusion

Although the potential contributions of governments are important, and indeed necessary, they are not sufficient to ensure that firms innovate successfully because the magnitude of achievements is jointly determined by managerial practices and capabilities. According to Gold (1986), there are many examples of governmentally dominated efforts to develop the innovative capacity of firms but most of these have achieved mediocre results at best. Gold argued that this may be due in part to the fact that governmental officers commonly lack the detailed knowledge of the distinctive problems, opportunities, and needed responsive measures applicable to each firm, and the tendency of government innovation support policies to underestimate the value of the firm's management practices. Innovation collaboration intensity is highest when strong government innovation support is matched with strong levels of entrepreneurial management practices. By the same token, product and process innovation intensities are highest when high levels of innovative collaborations are matched with strong levels of internal capabilities.

Our study provides a unified conceptualization on the nature and scope of firms' innovative performance. A distinction is drawn between innovative inputs, innovative outputs, internal resources, external resources, and internal capabilities. An interactive model is presented, which relates innovative inputs, the firm's resources, internal capabilities, and innovative outputs. The findings of this study represent the first step toward closing the analytical gap in the existing literature on the potential interactions between government support and firm's internal attributes, and their joint effects on the firm's innovative performance. The results confirmed the hypothesized interactive effects between government support and firms' contextual factors. While receipts of government support encourage firms to increase their innovative inputs, it is equally important for firms to have entrepreneurial-oriented management practices that support the investments in innovative inputs. In a similar vein, while innovative inputs are necessary for realizing innovative outputs, it is not a sufficient condition for achieving strong innovative performance. The firm's internal capabilities as observed in its learning, R&D, resource allocation, manufacturing, marketing, organizing, and strategic planning abilities have a positive influence on the relationship between innovation inputs and innovative outputs. The main thrust of our study is that while government innovation support significantly influences the firm's collaborative behavior, the bundling of government support with the firm's internal resources and capabilities provides the key to successful conversion of collaborative efforts innovative outputs.

The results, taken together, highlight that government innovation support is not a panacea for promoting innovativeness among firms, and it is not a sufficient factor for enhancing the firm's innovative performance. The direct contribution of government innovation support to the firm's level of innovative inputs, and the indirect contribution to its level of innovative outputs present a strong policy argument in favor of government support, suggesting that, if combined with pro-entrepreneurial management practices and strong capabilities in the firm's functional areas, government innovation support is a critical external resource that helps firms achieve strong innovative performance.

There is only so much that government can do to assist firms in their innovative pursuits. Whether or not government support results in higher levels of innovation intensities among firms depends on the extent to which the recipient firms contribute to the innovation process through its entrepreneurial management practices and overall internal capabilities. This concurs with Wong and He's (2003) emphasis that "how much a firm can gain from public support programs also depend on the firm itself". Government innovation support that aims to enhance the firm's innovation intensity will be helpful for entrepreneurial driven firms, but less useful or maybe even counterproductive for firms who are less entrepreneurial. Both the firm's internal and external resources need to be integrated to realize the maximum level of innovative inputs and outputs. It is difficult to isolate the effects of government innovation support on the firm's innovative behavior, from the effects of other firm-level factors. The firm's entrepreneurial management practices and internal capabilities complement the innovation support received from government to influence the level of its innovative inputs and outputs. The argument is that for government innovation support to be effective, recipients of such support must possess the adequate internal capabilities and management practices that promote innovativeness. In light of these findings, policy makers should channel their resources selectively, and extend assistance to firms that possess the required resources and capabilities to contribute productively in the innovation process.

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Figure 1. Constituents of Resource-Based Model of Firm's Innovative Behavior

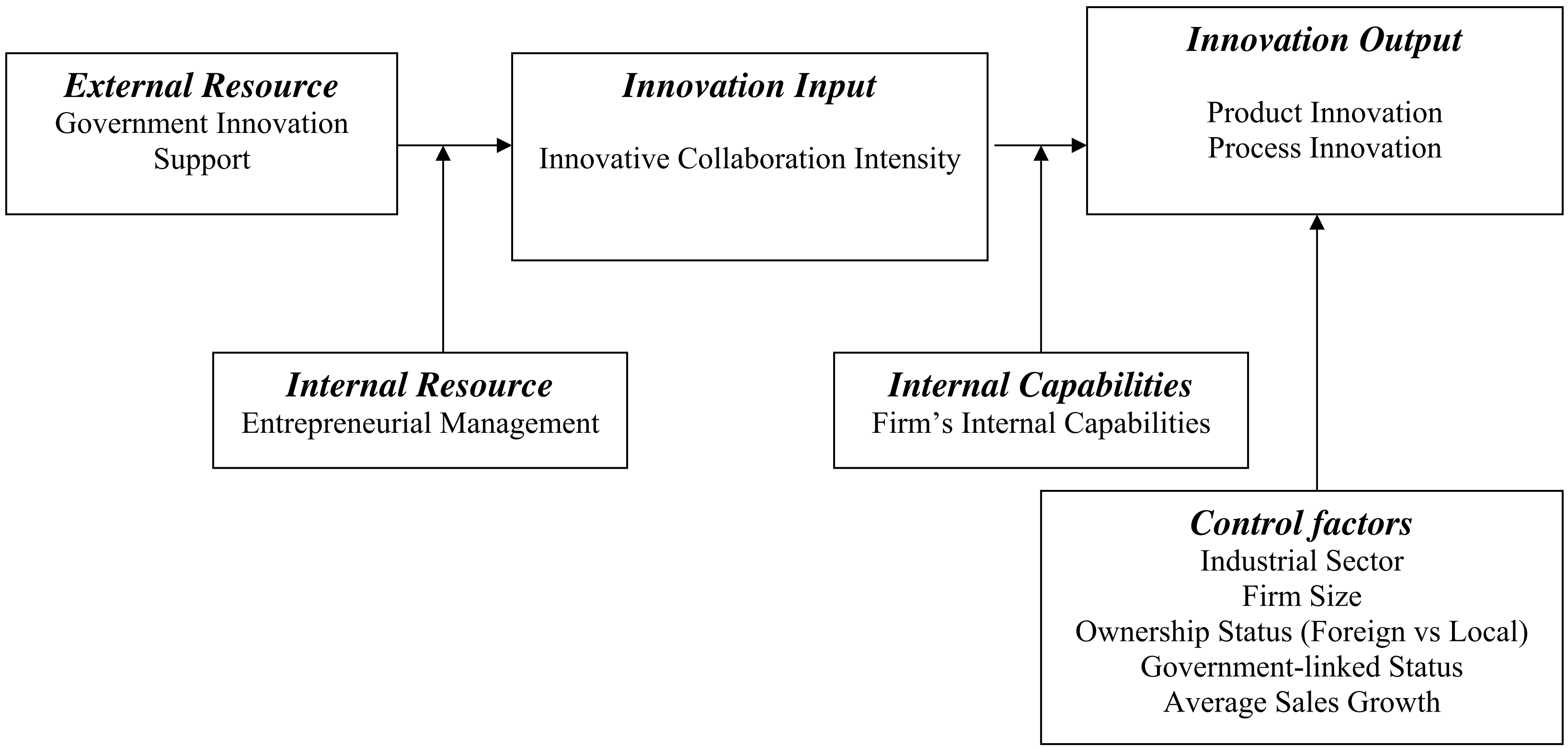

Table 1. Descriptive Statistics and Correlations (N = 314)[a]

Dependent Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Product innovation	1.00														
2. Process innovation	0.08	1.00													
Independent Variable															
3. Government innovation support	0.13†	0.16†	1.00												
Mediating Variable															
4. Innovative Collaboration	0.22*	0.21*	0.15*	1.00											
Moderating Variables															
5. Entrepreneurial management	0.02	0.03	0.03	0.03	1.00										
6. Organizational capabilities	0.01	0.02	0.02	0.04	0.01	1.00									
Control Variables															
7. Chemicals industry	0.03	0.02	0.01	0.04	0.04	0.05	1.00								
8. Precision engineering industry	0.08†	0.10†	0.05	0.05	0.05	0.04	0.04	1.00							
9. General manufacturing industry	0.02	0.04	0.01	0.06	0.06	0.03	0.06	0.05	1.00						
10. Others[b]	0.01	0.03	0.01	0.03	0.02	0.02	0.05	0.06	0.03	1.00					
11. Ownership (foreign-owned = 1)	0.02	0.05	0.04	0.05	0.01	0.01	0.02	0.05	0.04	0.03	1.00				
12. Government-linked (GLC = 1)[c]	0.04	0.02	0.02	0.05	0.03	0.02	0.03	0.02	0.02	0.04	0.01	1.00			
13. Average sales growth	0.06	0.07	0.01	0.06	0.04	0.01	0.04	0.01	0.01	0.02	0.02	0.04	1.00		
14. Firm size (log of total employment)	0.05	0.01	0.03	0.04	0.05	0.04	0.05	0.03	0.01	0.03	0.01	0.03	0.02	1.00	
15. Innovation environment	0.09†	0.02	0.04	0.03	0.02	0.02	0.03	0.04	0.02	0.01	0.02	0.03	0.03	0.05	1.00
Mean	2.65	2.95	3.22	3.43	4.88	4.15	0.04	0.40	0.46	0.10	0.08	0.06	17.14	2.71	3.56
Standard deviation	1.23	1.19	0.70	0.76	1.34	0.98	0.42	0.48	0.51	0.52	0.50	0.48	11.10	0.75	0.82
Minimum	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	-20.00	1.39	1.00
Maximum	5.00	5.00	5.00	5.00	10.00	7.00	1.00	1.00	1.00	1.00	1.00	1.00	80.00	5.39	5.00
Variance Inflation Factor (VIF)	1.02	1.11	1.26	1.24	1.20	1.01	1.05	1.16	1.28	1.07	1.10	1.21	1.20	1.08	1.16

* $p < .05$; † $p < .10$

a. Total responses from third phase of survey;
b. Others include Electronics, Transport engineering, and Biomedical Sciences industries
c. GLC – Government-linked company

Table 2. Regression Results Examining the Mediating Impact of Innovative Collaboration on Product Innovation (N=314)[a]

	Dependent variable - Innovation Collaboration			Dependent variable - Product Innovation				
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Constant	0.062(0.043)	0.068(0.045)	0.073(0.053)	0.026(0.020)	0.028(0.025)	0.069(0.040)	0.057(0.047)	0.072(0.044)
Controls								
Chemical industry	0.046(0.052)	0.043(0.048)	0.049(0.055)	0.070(0.056)	0.073(0.051)	0.048(0.046)	0.049(0.051)	0.061(0.054)
Precision engineering industry	0.105†(0.067)	0.109†(0.068)	0.102†(0.065)	0.092†(0.073)	0.082†(0.075)	0.100†(0.053)	0.108†(0.069)	0.115†(0.064)
General manufacturing industry	0.163†(0.053)	0.168†(0.058)	0.171†(0.062)	0.110†(0.238)	0.109†(0.237)	0.154†(0.04)	0.160†(0.055)	0.175†(0.057)
Others[b]	0.191†(0.064)	0.196†(0.062)	0.185†(0.051)	0.125†(0.219)	0.126†(0.227)	0.187†(0.066)	0.192†(0.068)	0.195†(0.060)
Ownership (foreign-owned =1)	0.035(0.032)	0.030(0.029)	0.034(0.028)	0.060(0.053)	0.059(0.051)	0.034(0.033)	0.038(0.029)	0.041(0.031)
Government-linked company (GLC)[c]	0.041(0.036)	0.044(0.038)	0.046(0.040)	0.048(0.029)	0.050(0.030)	0.040(0.040)	0.043(0.041)	0.046(0.038)
Average sales growth	0.053(0.041)	0.049(0.043)	0.051(0.045)	0.061(0.052)	0.060(0.051)	0.050(0.049)	0.056(0.045)	0.058(0.043)
Firm size (log of total employment)	0.034(0.041)	0.032(0.042)	0.036(0.044)	0.077(0.063)	0.070(0.066)	0.038(0.038)	0.041(0.032)	0.044(0.038)
Innovation environment	0.233*(0.091)	0.235*(0.088)	0.244*(0.095)	0.205*(0.494)	0.214*(0.500)	0.240*(0.081)	0.243*(0.080)	0.248*(0.086)
Main effects								
Government innovation support		0.481*(0.223)	0.492*(0.310)	0.264*(0.483)	0.228*(0.403)			0.083(0.063)
Entrepreneurial management		0.172†(0.052)	0.184†(0.063)	0.157†(0.045)	0.124†(0.039)			0.051(0.045)
Interactive effects								
Govt. support X entrep.management			0.818**(0.424)		0.312*(0.473)			0.098(0.071)
Main effects								
Innovation collaboration intensity						0.426*(0.302)	0.448*(0.366)	0.459*(0.372)
Organization capabilities						0.113†(0.057)	0.104†(0.062)	0.165†(0.072)
Interactive effects								
Innov. collaboration X org. capabilities							0.599**(0.505)	0.601**(0.623)
Log likelihood	-278.38	-305.32	-343.00	-205.66	-218.94	-272.69	-289.59	-309.63
Pseudo R-Square	0.15	0.24	0.33	0.08	0.10	0.13	0.24	0.29
Probability	0.028	0.000	0.000	0.021	0.027	0.000	0.000	0.000

a - Total responses from third phase of survey; b - Others include Electronics, Transport engineering, and Biomedical Sciences industries; c - GLC = Government-linked company. Notes: Numbers are standardized regression coefficients. Numbers in parentheses are standard errors. † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$

Table 3. Regression Results Examining the Mediating Impact of Innovative Collaboration on Process Innovation (N=314)[a]

	Dependent variable - Innovation Collaboration			Dependent variable - Process Innovation				
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Constant	0.062(0.043)	0.068(0.045)	0.073(0.053)	0.022(0.020)	0.025(0.024)	0.028(0.019)	0.030(0.017)	0.032(0.021)
Controls								
Chemical industry	0.046(0.052)	0.043(0.048)	0.049(0.055)	0.007(0.012)	0.009(0.014)	0.017(0.015)	0.019(0.017)	0.023(0.022)
Precision engineering industry	0.105†(0.067)	0.109†(0.068)	0.102†(0.065)	0.024(0.018)	0.027(0.019)	0.052(0.025)	0.056(0.026)	0.058(0.031)
General manufacturing industry	0.163†(0.053)	0.168†(0.058)	0.171†(0.062)	0.093(0.020)	0.094(0.021)	0.129†(0.068)	0.134†(0.071)	0.138†(0.073)
Others[b]	0.191†(0.064)	0.196†(0.062)	0.185†(0.051)	0.063(0.013)	0.065(0.014)	0.187†(0.083)	0.134†(0.071)	0.132†(0.090)
Ownership (foreign-owned =1)	0.035(0.032)	0.030(0.029)	0.034(0.028)	0.019(0.011)	0.017(0.013)	0.019(0.014)	0.025(0.016)	0.029(0.076)
Government-linked company (GLC)[c]	0.041(0.036)	0.044(0.038)	0.046(0.040)	0.008(0.009)	0.009(0.008)	0.027(0.013)	0.029(0.015)	0.030(0.020)
Average sales growth	0.053(0.041)	0.049(0.043)	0.051(0.045)	0.033(0.016)	0.035(0.017)	0.038(0.029)	0.039(0.031)	0.041(0.034)
Firm size (log of total employment)	0.034(0.041)	0.032(0.042)	0.036(0.044)	0.016(0.011)	0.025(0.013)	0.025(0.010)	0.027(0.024)	0.029(0.031)
Innovation environment	0.233*(0.091)	0.235*(0.088)	0.244*(0.095)	0.119*(0.020)	0.122*(0.079)	1.255*(0.083)	1.301*(0.093)	1.341*(0.099)
Main effects								
Government innovation support		0.481*(0.223)	0.492*(0.310)	0.101*(0.025)	0.188*(0.026)			0.108(0.061)
Entrepreneurial management		0.172†(0.052)	0.184†(0.063)	0.091*(0.019)	0.047*(0.020)			0.057(0.028)
Interactive effects								
Govt. support X entrep.management			0.818**(0.424)		0.195*(0.021)			0.893(0.069)
Main effects								
Innovation collaboration intensity						0.252*(0.090)	0.250*(0.366)	0.267*(0.085)
Organization capabilities						0.106†(0.037)	0.109†(0.042)	0.117†(0.066)
Interactive effects								
Innov. collaboration X org. capabilities							0.385**(0.172)	0.390**(0.144)
Log likelihood	-278.38	-305.32	-343.00	-202.83	-215.88	-216.55	-224.49	-250.10
Pseudo R-Square	0.15	0.24	0.33	0.07	0.09	0.21	0.25	0.28
Probability	0.028	0.000	0.000	0.025	0.029	0.016	0.000	0.000

a - Total responses from third phase of survey; b - Others include Electronics, Transport engineering, and Biomedical Sciences industries; c - GLC = Government-linked company. Notes: Numbers are standardized regression coefficients. Numbers in parentheses are standard errors. † $p < 0.10$; * $p < 0.05$; ** $p < 0.01$