The Open Innovation Paradigm in Developing Economies: Evidence from Chinese Firms

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ABSTRACT

Despite a growing trend towards the axiomatic acceptance of 'open innovation's' benefits, the generalizability of this new operational paradigm to developing economies has yet to be fully explored. This study provides empirical evidence and analysis regarding the relationship between open innovation-based strategies and innovation performance among Chinese firms. Our findings indicate that Chinese firms face certain barriers to the adoption of open innovation strategies relating to inadequate internal research expertise and limited absorptive capacity. These weaknesses make it difficult for them to benefit from the key external sources of openness (e.g. inter-firm networks, university linkages and research institute relations). While the positive role of absorptive capacity in facilitating open innovation outcomes has been supported in this study, we find this role is limited to large firms generally. These findings imply that developing economies like China will garner the benefits available from open innovation when they develop the capabilities required to identify, assimilate and commercialise knowledge and technologies from external sources.

Keywords: Open innovation, developing economies, Chinese firms, sources of openness, absorptive capacity.

INTRODUCTORY BACKGROUND

The 'open innovation' paradigm, first popularised by Chesbrough (2003a, 2003b, 2006) as a contrast to the traditional 'closed innovation[1]' approach, has aroused growing research interest in recent times. It challenges the traditional and fundamental assumptions regarding the manner in which firms conduct innovation and commercialize innovation outputs. According to both Chesbrough and also other scholars contributing to the empirical literature on open innovation, this new paradigm demonstrates three essential characteristics, namely: the importance of the permeability of firms' transactional and knowledge boundaries (Laursen and Salter, 2006; Gassmann and Enkel, 2004); the strong and effective interactions between the firm and its environment (Lichtenthaler, 2008； Pisano, 1990; McGee et al., 1995); and the adoption of open search strategies spanning a wide range of external actors and sources (West and Gallagher, 2006; Christensen, 2006).

Open innovation's proponents have asserted that it is a potential source of distinctive technological competency and hence a driver of long-term competitive advantage (Chesbrough et al, 2006; Christensen, 2006). Clearly, however, open innovation can only act as a facilitator of innovation and cannot overcome fundamental deficiencies or ineffective systems elsewhere in the organisation. Further, the ubiquitous applicability of the open

[1] Closed innovation might be characterised as a system where primary R&D, product development and commercialisation are undertaken within the focal firm, with limited involvement of external firms, agents or other parties.

innovation model as a means to improve innovation performance has yet to be proven. The majority of previous studies have largely been undertaken at a conceptual level or were based on single case studies (Dodgson et al., 2006). Thus the generalizability and validity of this new paradigm requires extensive empirical testing. Where empirical work has been undertaken, the results have been ambiguous and difficult to generalise, driven in part by two main oversights in the extant open innovation literature.

First, the majority of extant research is drawn from firms operating primarily in North America and the European Union. These jurisdictions tend to have elaborate knowledge diffusion systems (for example, strong government agencies and universities closely co-located with firms). It is thus perhaps important to assess if the situation might be different outside these highly developed regions, especially in developing countries, such as China.

China presents an interesting arena to explore the wider applicability of the open innovation approach to emerging economies. With the economic reform processes driving organizational change from central planning toward a more market-driven economy, and the implementation of an open door policy over the past 30 years, China has experienced substantial changes in virtually every aspect of its society and economy, including within its national innovation system (Li, 2009; Tan, 2001; Motohashi and Yun, 2007).

During this latter stage of China's economic transitional phase, its innovation system has exhibited some features that are typically expected in open innovation systems, including an advanced degree of information fluidity and knowledge transfer between firms and other economic agents (government, research labs, foreign partners). Some evidence has been found including enhanced porosity of organizational boundaries (Liu and White, 2001); increased science and technology (S&T) outsourcing activities with concomitant industry and science linkages (Motohashi and Yun, 2007); more buy-in of technologies or contracting-out of R&D activities (Liu and White, 2001) and enhanced commercialization of new technologies, especially in the form of spin-offs from either universities or other public research institutes (Chang and Shih, 2004).

Alternatively, it has been noted that many of China's firms actively maintain strict privacy of operational and strategic information, driven partially by unfavorable social cultural norms and a policy orientation that tends not to be well developed in terms of IP protection (Huang et al., 2004). There is also limited access to qualified and experienced technical personnel and information (Gao and Fu, 1996). These limitations in the current innovation system tend to hinder its process towards openness. Moreover, many of China's firms with sufficient scale still place major emphasis on the establishment of, and investment in, 'in-house' R&D capacity, a practice in accordance with closed innovation processes (Li, 2009; Liu and White,

2001). Vertically integrated arrangements between R&D and production are also features that are inherited from the traditionally centrally planned economic system of China's recent past (Dobson and Safarian, 2008).

These specific contextual barriers may raise questions regarding the ability for open innovation strategies to be applied in the Chinese environment. While there is a growing trend to acknowledge the benefits of an open innovation approach, it has been shown to have limited, rather than universal, applicability in various industrial and national contexts (Gassmann, 2006; Chesbrough and Crowther, 2006).

Second, Chesbrough (2003c) tended to focus his analysis on large multinational corporate entities, like Xerox and IBM. In many important respects relevant to open innovation, these large firms differ from smaller and medium sized firms. Large organisations may have excess resources and capabilities in the management of internal and external knowledge flows that are not available for smaller firms. They also have more urgent needs for outsourcing due to the higher degree of technology and knowledge diversity (Edler et al., 2002; Granstrand and Oskarsson, 1994). It is thus important to consider whether the open innovation model can be applied in the small and medium enterprise (SME) context as well as in larger organisations. It is also worth considering the non-uniform patterns of openness between large firms and SMEs as smaller firms might adopt open strategies in a

very different way from larger ones (Lichtenthaler, 2008).

During the period of China's economic and industrial reforms, larger firms have been responsible for a disproportionately high share of S&T-related industrial expenditures and activities in the manufacturing sector. Some leading industrial corporations such as Haier, Lenovo and Huawei have also played a crucial role in enhancing indigenous innovation performance (Bin, 2008; Motohashi and Yun, 2007). Meanwhile, SMEs in China have developed alongside these industrial conglomerates as important suppliers, albeit with a lower focus on primary and applied R&D, and are beginning to play a significant role in driving sectoral cooperation and innovation (Chen, 2006).

Therefore, in this study we seek to partially address these gaps existing in current empirical literature by assessing the broader applicability of open innovation in developing economies, taking China as an example. Moreover, this study also aims to explore the differentiated impacts of open strategies on the innovation performance of Chinese firms, taking into account the mediating factor of firm size.

THEORETICAL FRAMEWORK & HYPOTHESES

Open innovation seeks to be a comprehensive paradigm, embracing various components of knowledge, information and learning with complex relationships among them. Therefore, a clear conceptual model is required to measure the 'openness' of a firm's innovation strategy.

By definition, open innovation entails "the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand markets for external use of innovation, respectively." (Chesbrough, Vanhaeverbake & West, 2006, p. 1) In essence, there are two critical components of the open model evident in the relevant literature.

First is the wide ranging use of external knowledge sourcing, including through the use of inter-firm linkages (with suppliers, customers and potentially competitors) and with external knowledge generating agencies (research institutes, universities and the like) (Laursen and Salter, 2006; Katila and Ahuja, 2002). The other important theme relates to those internal organizational systems that facilitate the firm's processes of identification, assimilation and exploitation of that accrued knowledge (West and Gallagher, 2006).

These two dimensions of open innovation will be integrated and utilised in this study to form a basic theoretical framework for hypothesis development. Thus, we focus on the respective effects of external knowledge sourcing, and internal knowledge absorption capabilities of the

focal firms to explicate the impact of open innovation on their innovation performance in different firm size contexts.

External Knowledge Sources and Open Innovation Performance

The open innovation model suggests that firms without an introspective focus on their R&D are still able to successfully innovate by drawing on knowledge, information and expertise from a variety of external sources and actors (Laursen and Salter, 2006). However, different external sources play different roles in producing knowledge spillovers that in turn shape innovation performance. This paper continues by exploring the effects of multiple external sources and institutional actors on innovation performance, through a specific focus on *inter-firm networking (involving customer, supplier and competitor linkages)*, *universities and research institutes*, and *the use of the Internet*.

Inter-firm networking Open innovation, to a great extent, is characterised by the establishment of various ties across the boundaries of firms. These ties involve linkages with other parties such as customers, suppliers and competitors to establish a value network for firms (Vanhaverbeke and Cloodt, 2006; Vanhaverbeke, 2006). Such network arrangements can assist firms in capturing knowledge during the early stages of technology development, while also facilitating an active role for suppliers, customers and other external agents in

creating value towards the commercialization of innovation outputs (Chesbrough and Rosenbloom, 2002).

This open innovation research has extended and contributed to wider research that has claimed that inter-organizational networks and collaborations play a significant role in advancing the capacity of firms to improve innovation (e.g. Monsted, 1994; Chaston, 2000; Porter and Ketels, 2003; Faems, et al, 2005; Nieto and Santamaria, 2007). Overall, a consensus has developed that the exclusion of participation in such networks acts as a limiting factor in terms of enhancing their knowledge base (Shaw, 1998). Networking mitigates resource and capability absences by harnessing knowledge within factor markets (Cooke, 1996; Powell et al., 1996; Ahuja, 2000; Vanhaverbeke, 2006); by the synergistic sharing of potentially complementary skills and resources (Hagedoorn and Duysters, 2002); by the formation of shared risk arrangements and real options on future technologies (Grandori, 1997); and by the enhancement of market power of participant firms, especially in nascent technologies (Human and Provan, 1996).

In the specific Chinese context examined in this paper, such inter-organizational relationships could be interpreted within the frame of an indigenous concept embedded in Chinese society with a long history – 'Guanxi'. The practice of Guanxi, defined as the presence of direct, particularistic ties between individuals or organizations (Tsui and Farh,

1997), has profound influences on firms in China (Luo and Chen, 1996; Tsang, 1998; Xin and Pearce, 1996; Park and Luo, 2001; Tsui and Farh, 1997).

Recent studies have found that the implication of Guanxi in the context of open innovation is much stronger for Chinese small and medium enterprises than for their larger peers. In China, many large state-owned enterprises (SOEs) are descendants, in some form, of former state-owned enterprises and agencies of the old centrally planned economy. Many of these organisations are unwilling or unmotivated to develop Guanxi-based inter-firm networks due to the government protection they enjoy, as well as the limited commercial pressures or competition they face (Dobson and Safarian, 2008). Furthermore, their bureaucratic rigidities make them sluggish in cooperating with others (Xin and Pearce, 1996; Park and Luo, 2001). These inherent features tend to inhibit their effective use of technology transfers, which has tended to emerge as a barrier to their technological innovation and success (Chang and Shih, 2004).

SMEs, on the other hand, face a dynamic, and in many ways unpredictable, economic environment in China. Their need for survival and their innate entrepreneurial spirit drive SME's managers to make the best use of Guanxi-based networks to overcome their disadvantages in size, resources and market relating to innovation. Furthermore, their smaller size also allows them to be more flexible and faster to engage in inter-firm networking.

It has been reported that small privately-owned enterprises, as major drivers of China's private sector (Hu et al., 2005), are becoming relatively more active in cooperation and regional innovation initiatives than their larger counterparts. This is especially true for those firms that are clustered in technologically advanced regions such as east and southern China (Chang and Shih, 2004; Tan, 2001; Lai et al., 2005). Based on this prior work, we propose that in China, small and medium firms are more likely to utilize inter-firm ties and networking to support their innovation performance than larger firms. This overall proposition has been operationalised via the following hypotheses:

H1: – Inter-firm networking (involving customer, supplier and competitor linkages), as a key knowledge source of open innovation, will have a significant effect on innovation performance of Chinese firms.

H1a: – The effect of inter-firm networking on innovation performance of SMEs will be greater than that of large firms in China.

Universities & Research Institutes Universities and research institutes (URIs) are often discussed as important sources of knowledge and ideas that facilitate open innovation outcomes. The close cooperation with universities can help firms to keep up with the latest technological developments while concurrently exploring the commercial potential of these technologies (Vanhaverbeke, 2006). Research institutes and technological consultants are

recognized as another potentially useful source of external knowledge (Creplet et al., 2001; McKenna, 2000) by supporting both formal information exchange and also flows of tacit knowledge and shared know-how across and within industries (Bierly and Daly, 2007).

While URIs would seem to provide, a priori, important knowledge and information to benefit innovation, the practicalities of URI-firm engagement as a source of innovation present some significant challenges. In China, firms generally have few incentives to build collaborations with URIs to facilitate such knowledge transfer (Gu, 1999). This, combined with the more rudimentary status of Chinese URI capacity, ensures that the level of URI-firm linkages is lower in China than in most developed countries (Motohashi and Yun, 2007).

Furthermore, universities and research institutes tend to focus on theoretical or fundamental research domains where the created knowledge may not be directly applicable to industries (Simard and West, 2006) or specific firm problems (Quintas et al., 1992). Thus for many Chinese firms, the inadequacies of national innovation capabilities at a tertiary level, resulting from the era of a centrally planned economy (Motohashi and Yun, 2007; Guan et al., 2005) may lead to the limited absorption. A lack of sufficient absorptive capacity and efficient communication channels within firms may create an effective barrier to the identification and integration of valuable technological and scientific knowledge.

Christensen et al (2005) also point out the high potential search and transaction costs associated with open innovation. In addition to the costs of knowledge search and transactions associated with external sourcing, the cost of assimilating exogenous knowledge and integrating this knowledge into the firm, including the cost of investing in building internal absorptive capacity, may be high (Quintas et al., 1992; Fabrizio, 2006). Under such circumstances, the benefits provided by open innovation strategies might not justify the costs resulting from this openness in the absence of a sufficient contemporaneous investment in internal absorptive capacity.

This argument can be stated in the following hypothesis:

H2: – Universities and research institutes, as important external sources of scientific knowledge, tend to have little positive effects on innovation performance of Chinese firms.

The Internet The advantages of the Internet have been widely recognized in terms of enhancing information access and improving communications for virtually all types of firms. Internet access is especially beneficial for firms in the open innovation context in terms of the rapidity and immediacy of internet-driven innovation and internet-related innovation communities (Tuomi, 2000). Diverse applications of the Internet such as websites, networked databases and e-commerce applications, may improve the effectiveness of open

innovation by broadening the potential scope of a firm's transactional and knowledge exchange boundaries. Zwass (2003) has proposed that e-commerce applications related to collaboration, communication and interconnections will facilitate specific innovation opportunities. Dodgson, Gann and Salter (2006) further suggest that information and communication technologies would enable the exchange of distributed sources of information, facilitating open innovation processes.

Over recent years, the Internet has developed at a rapid rate in China (Du, 1999; Zhu and He, 2002). The Internet not only benefits China's innovation and learning systems with its general advantages, it can also help to provide cheaper and faster linkages between domestic and international collaborators, hence promoting the opening up processes of innovation. This is imperative for developing countries like China in enhancing the innovation capabilities of its domestic firms (Zheng and Sheng, 2006). Based on this, we hypothesize that:

H3: – The use of the Internet, as an important knowledge source of open innovation, will positively affect innovation performance of Chinese firms.

Absorptive Capacity and Open Innovation Performance

Independent effect In addition to the utilization of external knowledge sources, another element of the open innovation model exists, relating to the firm's internal ability to

enhance its own operational and strategic position through the integration of externally acquired knowledge. Akin to Cohen and Levinthal's (1990) 'absorptive capacity' notion – this capability allows the firm to effectively internalise, transform and commercialise the knowledge acquired into performance outcomes.

Absorptive capacity is a key component of open innovation because only through its presence can the knowledge acquired from outside be leveraged and utilized by firms to generate economic value. Absorptive capacity's mediating significance in transforming openness into measurable performance has been the focus of much empirical work (e.g.; DeSanctis et al., 2002; Tsai, 2001; Huang and Rice, 2009). During the transitional period currently being experienced by China's innovation system, the role of absorptive capacity in S&T outsourcing has been highlighted (Motohashi & Yun, 2007). Liu and White (1997) also believe that in the developing economies such as China, innovation performance is best driven by the synergy between investment in absorptive capacity and investment in the sources of new knowledge.

H4: – Investment in absorptive capacity is positively related to innovation performance of Chinese firms.

Interaction effects Other than the direct and individual effect of absorptive capacity, its combined effects with the usage of external sources of open innovation is of great interest

to the current study. In fact, the positive role of absorptive capacity in optimizing advantages provided by external knowledge sources can be inferred by both theoretical and empirical studies on related issues.

It has been suggested that the processes relating to the effective scanning for external sources may be facilitated by greater absorptive capacity capabilities (West & Gallagher, 2006). According to Fabrizio (2006), the lack of the absorptive competencies required to identify and exploit exogenous knowledge is one of the main conditions that might restrict effective knowledge transfer among firms. Even if external knowledge can be fully identified and accessed, it does not necessarily follow that firms can harness it into their existing innovation system to create real benefits. Absorptive capacity is required to leverage that knowledge externally acquired. In that sense, absorptive capacity is of vital importance in the facilitation of innovation effectiveness.

Furthermore, absorptive capacity might create search capabilities that neutralise some potential threats associated with outsourcing activities. The creation of contractual or long-standing relationships with other firms, universities and research institutes may create high up-front search and transactional costs of the firms involved. These costs, once accrued, generally decrease after adequate knowledge accumulation has occurred (Teece et al., 1997; Zander & Kogut, 1995; Zott, 2003). This implies that the benefits provided by absorptive

capacity tend to outweigh the costs associated with external sourcing, especially over the longer term (Chesbrough, 2003c).

However, this positive mediating effect of absorptive capacity on the relationship between external knowledge sources and innovation performance might be partially contingent on firm size. Generally, SMEs rate lower in terms of absorptive capacity capabilities when compared to larger firms in the same industry. SMEs, by definition, have relatively fewer resources such as skilled labour and embedded knowledge stocks which are critical forms of absorptive capacity for innovation activities (Alvarez and Barney, 2002; Lundin et al., 2006). The lack of these resources and expertise in R&D function or in downstream areas (e.g. production, marketing and distribution) might cause specific problems for SMEs in establishing complementary assets that are required antecedents to absorptive capacity effectiveness (Oakey et al., 2001). This leads to the phenomena that small firms are generally less able to incorporate the acquired technologies and capabilities from outside, thus often failing to commercialize the potential innovation benefits.

In China, previous research has also suggested that larger corporations have more regulatory and financial incentives to invest in absorption-related capabilities and the adoption of exogenous technologies than their smaller competitors (Bin, 2008).

The arguments above can be summarized in the following hypothesis:

H4a: – The co-occurrence of external knowledge sourcing with strong internal absorptive capacity will improve the innovation performance of large firms in China.

METHODS

Sample

The data for our study are drawn from the *World Bank Investment Climate Survey 2003*. This survey collected data from 14 key manufacturing and service sectors involving 2400 firms from cities in 15 provinces of mainland China. These cities are distributed across the five main economic regions of China, namely the North-eastern (e.g. Changchun, Benxi, Haerbin, Dalian), the Eastern (e.g. Hangzhou, Wenzhou), the Southern (e.g. Shenzhen, Jiangmen), the Western (e.g. Chongqing, Lanzhou, Kunming, Xi'an, Guiyang, Nanning) and Middle China (Changsha, Wuhan, Nanchang). The survey was designed to focus on identifying the level of growth and performance of average Chinese firms. It thus excluded observations from the most advanced cities in China (e.g. Shanghai, Beijing, Guangzhou) as well as cities in the relatively less developed provinces (e.g. Xizang, Qinghai, Xinjiang).

Our research is conducted on the basis of a sample drawn from the original survey data. We used SPSS's EM (expectation and maximization) method to analyse and replace missing data within the sample. After undertaking this process, we divided the sample into two

sub-groups, namely large firms and SMEs, according to firm size (proxied by employee numbers). As in many jurisdictions in China, there are no consistently used criteria for the definition of SMEs (Jefferson et al., 2003). Hence we utilised an employment size of less than 200 to define small and medium-sized enterprises. After this process, we were left with our subsample consisting of 874 larger firms and 1500 SMEs.

Measures

Dependent Variable The dependent variable — Innovation Performance (Innov2002) is measured by calculating the proportion of sales derived from new products (services) and/or the value of exports of new products (services) over total sales in the year 2002. This measure is consistent with Negassi (2004) and Laursen and Salter (2006), and is a strong measure of the innovation performance of firms. Compared with various other measures that are employed in the innovation literature, (for example, R&D expenditure as a proxy for innovation, which is a measure of inputs rather than outcomes), it is a relatively direct measure of the success of the commercialization of firms' innovative efforts.

Independent Variables Our measures for independent variables are as follows — As a measure of external information sourcing, the use of Inter-firm Networking (*Interfirm*) is constructed by responses in the survey relating to whether or not the firm had engaged in any contractual or long-standing relationship with other firms in the year 2002. This is reported

as a dummy variable taking the value of 1 when the business indicated that it had used inter-firm networking and 0 otherwise (after recoding the original survey responses). Firms were also asked whether they had any contractual or long-standing relationship with local universities or with research institutions in the year 2002. The answers to these two questions form the constructs of variable Universities (*Uni*) and Research Institutes (*RI)*. Both of them are binary variables taking the value of 1 for the response yes and 0 for no, after our recoding of the original responses. Another important source of external knowledge, the Internet (*Internet*) is measured by the percentage of the total value of the firm's sales that were ordered over the internet or by email in 2002. We find that this is a useful proxy for the integration of internet technology in Chinese businesses (Tan and Ouyang, 2004). It is a continuous variable ranging from 0 to a maximum value of 1.

Investment in Absorptive Capacity (*ACAP*) — Because of the difficulty in directly measuring absorptive capacity, in this study we used a proxy measure for it. Although R&D intensity is the most commonly used proxy in the prior research, this measure has been frequently criticized as it "treats absorptive capacity as a static resource and not as a process or capability" (Lane, et al., 2006, p. 838) and does not take into account the quality of R&D work undertaken within the firm (Schmidt, 2009). Thus another proxy is usually used to operationalize this construct — R&D human capital (e.g. Liu and While, 1997; Gao, et al., 2008; Veugelers, 1997). The validity of this measure can be linked to Cohen and Levinthal's (1990) argument that the absorptive capacity of a firm depends on the individual absorptive capacity of its members. In essence, absorptive capacity as a kind of knowledge management

capacity (Lichtenthaler and Lichtenthaler, 2009), needs to be facilitated by humans rather than tools, machines and other tangible assets of a firm's R&D department. Such capability is especially important when some hidden knowledge and tacit experience need to be transferred between external sources and the firm's internal knowledge base (Bessant and Rush, 1993). Therefore, the size of R&D personnel (in the natural logarithm) has been employed as a proxy for ACAP of the focal firm.

Control Variables In addition to these independent variables, we control for the effects of market concentration, firm age, foreign partnerships, industry, and previous innovation performance of the firms in each sub-sample.

Market Concentration (*Market*) is determined according to an ordinal variable measuring the extent of major market dominance for the firm's main product within: (a) the city the firm is located within; (b) the firm's province; (c) within China; and (d) overseas. The initial survey responses have been recoded to provide an ordinal measure of market dominance with values of 0 (low dominance) to 4 (high dominance).

Firm Age (*Age*) is calculated by the difference between the survey year 2003 and the year the firm was established. Membership of Foreign Partnerships (*Foreign partner*) is measured by a binary variable with 1 if the firm has a foreign partner and 0 otherwise, after we recoded the original answers. An Industry Dummy (*Industry*) is measured with the value of 1 if the

business is in the manufacturing industry and 0 otherwise, after recoding the original responses of 14 different industry types. This is to compensate for the higher propensity to openness within the manufacturing sector.

We included the Previous Year Innovation Performance (*Innov2001*) as well (calculated similarly to our dependent variable) to account for the consideration that innovation is a continuous behaviour and prior innovative activities and investments might be highly correlated to and influence current innovation performance (Boer et al., 2001).

RESULTS

Descriptive statistics and correlations for all variables are presented in Table 1. Table 2 displays our findings with regard to previously-stated hypotheses. Model 1 & Model 2a present the basic regression results of the two sub-samples respectively - 1500 SMEs and 874 large firms. The adjusted R^2 for the omnibus models are 63.9% and 54.9% respectively, indicating a strong goodness of fit for both models.

<< Insert Table 1 about here >>

<< Insert Table 2 about here >>

With regard to the first hypothesis, which states that knowledge sources derived from inter-firm networking will improve firms' innovation performance, the variable *Interfirm* positively and (highly) significantly co-varies with our DV for SMEs, but is insignificant for the large firms subsample. Therefore, H1 is partially supported, with H1a hypothesizing that the use of inter-firm networking will have greater impact on innovation performance for SMEs than their large counterparts in China fully supported.

H2 argues that universities and research institutes will have little positive impact in terms of driving the innovation performance of Chinese firm. This hypothesis is largely supported in our sample, as the coefficient of variable *Uni* is negative for large firms, and insignificant for SMEs. The coefficients of the variable *RI* are not significant for observations from both sub-sample groups.

The coefficients for the variable *Internet* are positive with strong significance for both of the subsample groups, supporting our assertion in H3 that the use of knowledge sources from the Internet is a positive antecedent to innovation performance for both large firms and SMEs in China. Moreover, the magnitudes of the use of the Internet's effects between different size types of firms are broadly similar.

Regarding the independent role of absorptive capacity, H4 is partially supported as ACAP has little impact on firms in SME sub-samples, despite its positive and significant effect on large firms.

Of our control variables, the market concentration (*Market*) variable seems to co-vary with innovation performance for large firms (both positive and significant) but not significant for SMEs, and the membership of partnerships with foreign firms (*Foreign partner*) also exhibits significant covariance with our dependent variable – with its directionality dependent on firm size (negatively for SMEs and positively for larger firms). Firm age (*Age*) does not present significantly for any of the subsamples in our study. Additionally, the previous innovation performance (*Innov2001*) positively affect current ones with high significance for both subsamples, and manufacturing firms (the value of *Industry* = 1) in both size types generally exhibit higher innovation outputs than their counterparts in service sector.

In order to further test H4a, we extend the employment of hierarchical models for the large firms sub-sample (Model 2b). Those external knowledge sources which have weak or little impacts on innovation performance, i.e. *Inter-firm networking (involving customer, supplier and competitor linkages)*, *Universities* and *Research Institutes* are combined (interacted) with *ACAP* to examine whether the interactive effects will present more significantly than

their individual effects alone. For Model 2b, when the three interactive variables (*ACAP * Interfirm*, *ACAP * Uni* and *ACAP * RI*) are introduced, the adjusted R^2 increases to 55.7% and both *ACAP * Uni*, *ACAP * RI* are shown as anticipating significant and positive mediating effects on our DV. With the introduction of *ACAP*, the negative value of universities is reduced, and the coefficient of research institutes turns significantly positive, although there is no improvement in the impact of the use of inter-firm networking. On the basis of these findings, H4a is partially supported.

The results of hypotheses testing are summarized in Table 3.

<< Insert Table 3 about here >>

DISCUSSION AND CONCLUSION

In this study, we have aimed to empirically investigate whether open innovation strategies can provide competitive strengths for developing economies (e.g. China) as has been shown in developed economies. The research model of our study has integrated both external and internal perspectives, the two critical components of open innovation framework. Our main findings are illustrated in the Figure 1 and Figure 2 as below.

<< Insert Figure 1 about here >>

<< Insert Figure 2 about here >>

The majority of Chinese firms are still undergoing the process of emergence from imitation to innovation (Dobson and Safarian, 2008). Some have begun to pursue internally supported, and relatively closed approaches to innovation with the establishment of internal R&D efforts, in an attempt to scientifically research and innovate themselves, rather than simply following the technological outputs discovered by other countries (Bin, 2008). This indicates that, at present, China is still at the very preliminary stage of its innovation system emergence, and is in aggregate exploring the most efficient innovation mode to develop from its current situation.

It is not necessary that China should mimic the emergence path from closed to open innovation followed by western countries and advanced Asian countries. If it should, however, the inadequate indigenous research expertise and the lack of absorptive capacity within firms might act as a barrier to the accrual of the potential benefits shown to flow from open innovation strategies elsewhere. This might provide some level of explanation for the results in our study – why these key external sources that are so prevalent in studies of open innovation in developed nations have little evident effect on the innovation performance of Chinese firms, without their interaction with absorptive capacity investments.

This finding is consistent with the related western theories (Christensen, 2006; Lichtenthaler, 2008; Laursen and Salter, 2006) that have emphasised that research externalization is critical for successful innovation, but limited by the absence of effective investments in internal absorptive capacity. These investments have been shown to be requirements for the effective management of the transfer of externally acquired knowledge and technologies into the organisation.

As expected, for large firms in China, the crucial knowledge sources for open innovation, such as universities and research institutes, combined with the role of absorptive capacity, do indeed antecede higher innovation performance. The insignificant effect of research institutes turns significantly positive when ACAP is present. Moreover, ACAP plays an effective role in lessening the negative effect of universities. This indicates that the advantages of absorptive capacity are expected to outweigh the search and transactional costs associated with contractual or long-standing relationships with universities. In that sense, innovation performance improvement may simply not eventuate in the absence of appropriate absorptive capacity investment – even if key knowledge sources have been identified and valuable technologies and know-how have been obtained from these exogenous sources.

While the positive mediating role of absorptive capacity has been supported, we find this role is generally limited to large firms. This finding is consistent with Christensen's argument (2006) that even when seeking to adopt open innovation principles, firms in

practice adopt differing forms of openness. It is indicated in this study that the variation of absorptive capacity's effect exists over different firm size categories.

Nevertheless, the interaction between absorptive capacity and inter-firm networking for large firms is not as evident as the interaction effects (for universities and research institutes) discussed earlier. This might be an artefact of the measure of absorptive capacity used in our study. Using R&D capacity as the proxy for ACAP might only capture part of this capability phenomenon. Investments in traditional R&D resources tend to bridge the formal and explicit knowledge nexus between universities and research institutes more effectively than the more applied knowledge that flows directly between firms collaborating with one another, where the knowledge exchanged is often informal, tacit and un-codified, and usually with more of learning-by-doing processes (Quintas et al., 1992). This kind of know-how is more effectively assimilated through knowledge management skills embedded in the overall knowledge base of the whole focal firm than in elaborate R&D departments alone.

In addition to this limitation of ACAP measure, there are another two main limitations of this study. First, some crucial external sources are not explicitly investigated, such as customers, suppliers and competitors (Laursen and Salter, 2006). Although these firms will invariably be included in the measures of general inter-firm relationships, their separate effects can not be examined in our study due to the aggregated information in the database

we used. This will be an area for future research. Second, the sampling frame for this study purposefully focused on certain regions, excluding firms from the most technologically advanced regions of China (such as Shanghai, Beijing, the Yangtze River delta region, and the Pearl River delta region). More in-depth qualitative studies in these areas will be considered as a supplement to this quantitative research to provide comprehensive empirical evidence regarding the use of open innovation in China.

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TABLE 1.

Means, Standard Deviations, and Correlations

Variable	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11
1. *Innov2002*	.41	.29											
2. *Interfirm*	.53	1.06	.08**										
3. *Uni*	.48	1.00	.01	.27**									
4. *RI*	.39	.93	.08**	.35**	.47**								
5. *Internet*	3.90	12.52	.20**	.08**	.10**	.09**							
6. *ACAP*	2.90	1.30	.01**	.27**	.24**	.22**	-.05*	.11**					
7. *Market*	2.54	.93	.23**	.09**	.15**	.20**	.18**	.11**	.10**				
8. *Foreign partner*	.15	.36	.15**	.12**	.08**	.12**	.11**	.07**	.12**	.29**			
9. *Age*	21.80	14.94	-.09**	-.07**	-.03	-.01	-.12**	-.03	.09**	-.05*	-.09**		
10. *Innov2001*	.40	.25	.80**	.01	-.03	.04	.11**	.05*	.01	.19**	.14**	-.04	
11. *Industry*	.52	.50	.18**	.08**	.15**	.20**	.08**	.13**	-.11**	.40**	.26**	-.01	.07**

** Correlation is significant at the 0.01 level (one-tailed)

* Correlation is significant at the 0.05 level (one-tailed)

TABLE 2.

Results of Regression Analysis for Innovation Performance

Dependent Variable →	**Innovation Performance (*Innov2002*)**		
Independent Variables & Control Variables ↓	**SMEs**	**Large firms**	
	Model 1	**Model 2a**	**Model 2b**
(Constant)	.033	-.091 *	-.067
Inter-firm Networking (*Interfirm*)	.016 **	.005	-.012
Universities (*Uni*)	.002	-.036 ***	.036
Research Institutions (*RI*)	.000	.007	-.075
Internet (*Internet*)	.002 ***	.003 ***	.003 **
Absorptive Capacity (*ACAP*)	-.008	.014 +	.010
Market Concentration (*Market*)	.008	.039 **	.039 **
Foreign Partner (*Foreign partner*)	-.065 **	.052 *	.048 *
Age (*Age*)	-.001	.000	.000
Previous Performance (*Innov2001*)	.90 ***	1.11 ***	1.09 ***
(Manufacturing) Dummy (*Industry*)	.053 ***	.047 *	.050 *
*ACAP * Interfirm*			.004
*ACAP * Uni*			-.019 *
*ACAP * RI*			.022 **
n	1500	874	874
Adjusted R^2	63.9%	54.9%	55.7%

+ $p < .10$

* $p < .05$

** $p < .01$

*** $p < .001$

TABLE 3.

Results of Hypotheses Testing

	Hypotheses	Sub-samples		Overall Results
		SMEs	**Large**	
Key Knowledge Sources	H1: Inter-firm networking (involving customer, supplier and competitor linkages) will have a significant effect on innovation performance of Chinese firms.	Supported	Not Supported	Partially Supported
	H1a: The effect of inter-firm networking on innovation performance of SMEs will be greater than that of large firms in China.	—	—	Supported
	H2: Universities and research institutes tend to have little positive effects on innovation performance of Chinese firms.	Supported	Supported	Supported
	H3: The use of the Internet will positively affect innovation performance of Chinese firms.	Supported	Supported	Supported
Absorptive Capacity	H4: Investment in absorptive capacity is positively related to innovative performance of Chinese firms.	Not Supported	Supported	Partially Supported
	H4a: – The co-occurrence of external knowledge sourcing with strong internal absorptive capacity will improve the innovation performance of large firms in China.	—	Partially Supported	Partially Supported

FIGURE 1.

Knowledge Sources Shown to Contribute to the Innovation Performance of Chinese SME's

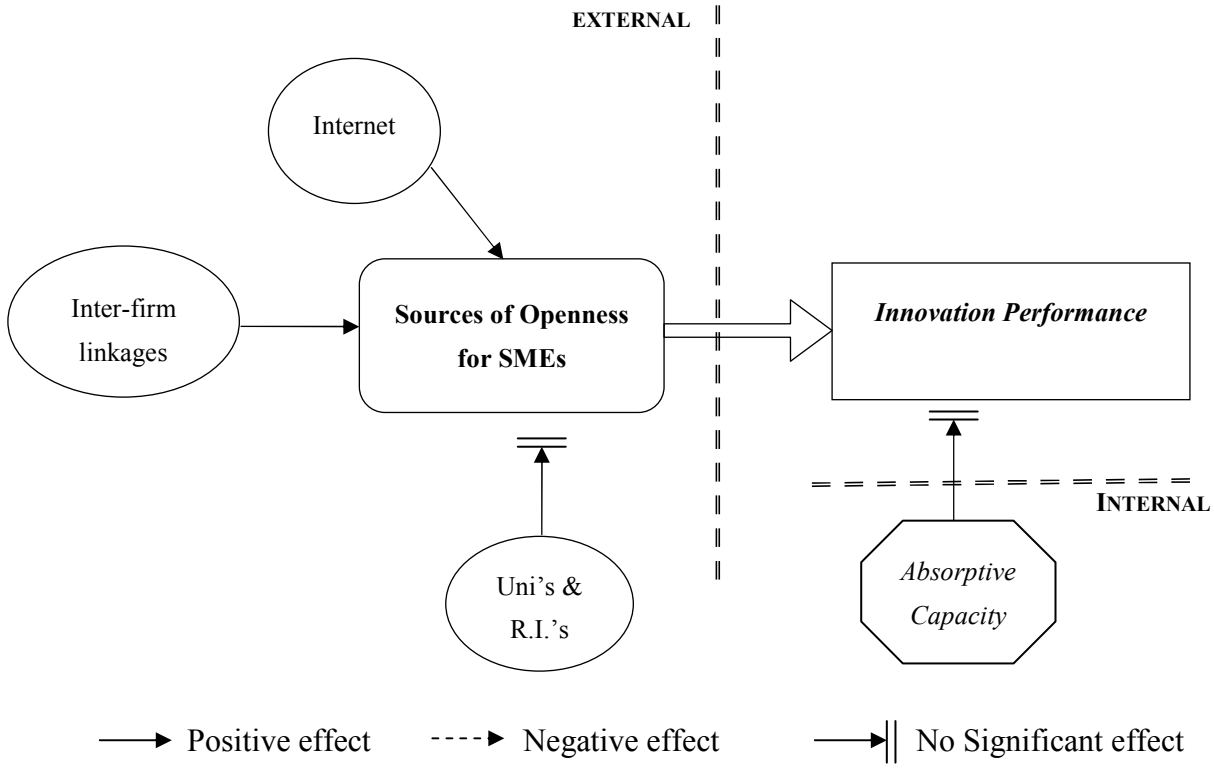

FIGURE 2.

Knowledge Sources Shown to Contribute to the Innovation Performance of Large Chinese Firms