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Does open innovation apply to China? Exploring the contingent role of external knowledge sources and internal absorptive capacity in Chinese large firms and SMEs

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Abstract

While 'open innovation' is often considered to be an organisational strategy with universal application, its generalisability and applicability to organisations operating within emerging economies has yet to be fully explored. This study provides empirical evidence of its importance within a substantial sample of Chinese large firms and small and medium enterprises. Using Tobit regression analysis, our findings indicate that external knowledge sources from inter-firm networking are more important in creating the benefits of open innovation for Chinese small and medium enterprises than their larger peers. Linkages to university and research institutes generally have few direct effects on the innovation performance of both large and small firms in China. However, the role of universities and research institutes is shown to be important among our large firm sample when combined with evident internal absorptive capacity. This interaction is generally limited to our large firm sample, and is not as evident among small firms.

Our study indicates that the barriers to the adoption of open innovation by Chinese firms might be largely related to the comparatively weak domestic research expertise and limited organisational absorptive capabilities, with this most particularly evident for small and medium enterprises.

These findings suggest that, based on this evidence, there is no need for emerging economies like China to mimic the emergence path from closed to open innovation followed by developed countries. Chinese firms will be more likely to garner the benefits available from openness when they develop the capabilities required to identify, assimilate and commercialise knowledge and technologies obtained from external sources.

Keywords: open innovation, China, knowledge sources, absorptive capacity, large firms, SMEs

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INTRODUCTION

The 'open innovation' paradigm, first popularised by Chesbrough (2003a, 2003b, 2006) as a contrast to the traditional 'closed innovation' approach, has aroused growing research interest in

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recent times. As an approach to organisational design, it challenges the traditional and fundamental assumptions regarding the manner in which firms conduct innovation and commercialise innovation outputs (Liao, Rice & Lu, 2014). According to Chesbrough and other scholars, this new paradigm demonstrates some essential characteristics, such as the strong and effective interaction between a firm and its environment through permeable firm boundaries (Laursen & Salter, 2006; Volberda, Foss, & Lyles, 2010; Huizingh, 2011) and the adoption of open search strategies spanning a wide range of external actors and sources (West & Gallagher, 2006; Leiponen & Helfat, 2010).

Open innovation's proponents have asserted that it is a potential source of distinctive technological competence and hence a driver of long-term competitive advantages (Chesbrough, 2006). However, open innovation strategies can act only as a facilitator of innovation and cannot overcome fundamental deficiencies or ineffective systems and capability configurations elsewhere in the organisation (Rice, Liao, Martin, & Galvin, 2012). Further, the ubiquitous applicability of the open innovation model as a means to improve innovation performance has yet to be proven and thus the generalisability and validity of this new paradigm requires further empirical testing. Indeed, where empirical work has been undertaken, the results have been ambiguous and difficult to generalise. We see two main limitations in the extant literature that we hope to address, namely the inadequate empirical evidence of open innovation's application in the context of emerging economies and of its differential impacts on different sized organisations.

First, the majority of extant research on open innovation is drawn from firms operating in North America and Europe (Chaston & Scott, 2012). These jurisdictions tend to have elaborate knowledge diffusion systems (e.g., strong government research 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 emerging countries, such as China.

China presents an interesting, and highly topical, context to explore the wider applicability of the open innovation approach. With the economic reform processes driving the centrally planned economy towards more market-driven arrangements, and the implementation of an 'opening-up' policy over the past 35 years, China has experienced substantial changes in virtually every aspect of its society and economy, including within its national innovation and technology system (Tan, 2001; Motohashi & Yun, 2007; Li, 2009). Its National Innovation System has experimented a series of reform initiatives driving it from a plan-based system towards a market-based open system of innovation (Liu & Lundin, 2008). These initiatives include establishing special economic zones across China to support the development of high-technology enterprises, top-down systemic reforms, and bottom-up initiatives supporting the development of enterprise-centred innovation activities (Liu & Lundin, 2008; Savitskaya, Salmi, & Torkkeli, 2010).

During more recent stages of China's economic transitional phase, its National Innovation System has exhibited some open innovation features in terms of innovation practices adopted by pioneering domestic corporations such as Lenovo, Huawei, Little Swan, Haier (Liu & Lundin, 2008; Fu & Xiong, 2011). Among these indigenous open innovators, an increased degree of information fluidity and knowledge transfer between focal firms and external knowledge sources (i.e., users, suppliers, government, public and private research institutes, and foreign partners) has been observed. This has been mainly realised through external knowledge sourcing, collaborative innovation, and open innovation networks (Fu & Xiong, 2011).

Other evidence of the emerging trend towards openness in China is appearing, including enhanced porosity of organisational boundaries (Liu & White, 2001; McAdam, Moffett, & Peng, 2012); increased science and technology and research and development (R&D) outsourcing activities (Liu & Lundin, 2008); increased in-sourcing of advanced foreign technologies (Liu & White, 2001; Fu & Xiong, 2011); globalisation of R&D by acquisition of foreign research centres and setting up R&D units globally (Liu & Lundin, 2008); growing industry–science linkages through establishing science

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and technology industrial parks, university science parks and technology business incubators (Motohashi & Yun, 2007; Savitskaya, Salmi, & Torkkeli, 2010); and more effective commercialisation of new technologies, especially in the form of spin-offs from universities and public research institutes, licensing, and intellectual property selling (Chang & Shih, 2004; Fu & Xiong, 2011).

Alternatively, it has been noted that while China's National Innovation System has exhibited some features that are typically expected in open innovation systems, a large proportion of domestic firms still heavily rely on their in-house resources, capabilities and internal channels for sourcing innovation (Fu & Xiong, 2011).

In addition, many of domestic firms still maintain strict privacy of operational and strategic information, driven partially by unfavourable social cultural norms, a weak intellectual property protection environment, and a complex intellectual property rights legislation system (Savitskaya, Salmi, & Torkkeli, 2010). The underdeveloped state of markets for technology transactions also presents a barrier to outbound open innovation practices (Savitskaya, Salmi, & Torkkeli, 2010). These limitations in China's current innovation system tend to hinder its progress towards openness.

Moreover, many of Chinese firms, that may have sufficient scale, still place major emphasis on the establishment of, and investment in 'in-house' R&D capacity in order to gradually move beyond the traditional imitation and manufacturing mode with few R&D activities or formal R&D centres (Liu & White, 2001; Li, 2009). This is essentially a practice in accordance with closed innovation processes. The vertically integrated arrangement between R&D and production is also a feature that is inherited from the traditionally centrally planned economic system in China's recent past (Dobson & Safarian, 2008).

These specific contextual barriers may raise questions concerning whether open innovation strategies can be applied in the context of China. While there has been growing acknowledgement of the benefits of an open innovation approach, very little empirical evidence has been presented regarding its applicability in emerging countries, most especially China (Fu & Xiong, 2011; Kafouros & Forsans, 2012). This leads to our main research motivation for studying open innovation under the specific Chinese context. China provides an interesting setting to examine whether open innovation is also applicable in the contexts where the domestic innovation system is rudimentary and the indigenous innovation capacity has not been well built.

The second limitation in the existing open innovation literature relates to the issue that while the importance of external sources, and the related instrument absorptive capacity (ACAP), have been widely investigated by recent open innovation studies, their contingent roles within different sized organisations have not been thoroughly explored. Large organisations may have adequate resources and capabilities that are not available for smaller firms in the management of internal and external knowledge flows. They also have more urgent needs than smaller counterparts for outsourcing due to the higher degree of diversity of their technology and knowledge (Granstrand & Oskarsson, 1994; Edler, Meyer-Krahmer, & Reger, 2002). On the other hand, small firms are expected to benefit a lot from open innovation because their limited resources and market reach always make it impossible to do R&D independently (Huizingh, 2011). However, they have difficulties in building and maintaining collaborative networks and managing intellectual property rights also due to their resources limitations (Huizingh, 2011).

It is thus important to examine whether the open innovation model is also needed in the small and medium enterprise (SME) context. More specifically, it is worth considering the non-uniform patterns of and mechanisms underlying open innovation between large firms and SMEs (van de Vrande, Vanhaverbeke, & Gassmann, 2010). Although some recent studies have begun to explore this issue (e.g., van de Vrande, de Jong, Vanhaverbeke, & de Rochemont, 2009; Lee, Park, Yoon, & Park, 2010), the use of open innovation by SMEs around the globe has not been thoroughly examined (van de Vrande, Vanhaverbeke, & Gassmann, 2010). The applicability of open innovation paradigm

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to smaller firms in the settings of emerging economies such as China will be further investigated in our research.

During the period of China's economic and industrial reforms, larger firms have been responsible for a disproportionately large share of science and technology-related industrial expenditures and activities. Some leading industrial corporations such as Haier, Lenovo, and Huawei have played a crucial role in enhancing indigenous innovation performance (Motohashi & Yun, 2007; Bin, 2008).

Meanwhile, private SMEs in China, driven by competition and entrepreneurship, have developed symbiotically alongside these larger industrial conglomerates, albeit with a generally lower focus on R&D globalisation (Liu & Lundin, 2008). They are, however, beginning to play a significant role in driving sectoral cooperation and innovation, and initiating outbound open innovation practices such as out-licensing and spin-offs to facilitate the commercialisation of new technologies developed in house (Chen, 2006; Fu & Xiong, 2011).

Based on the discussion above, our study seeks to address these two gaps existing in the current empirical literature by focusing on the research problem: does open innovation apply to emerging economies (taking China as an example)? Our study aims to explore the research problem by specially assessing the question: what are the impacts of open innovation strategies in terms of the effects of external knowledge sources and ACAP on the innovation performance of Chinese firms (including both large firms and SMEs)?

THEORETICAL BACKGROUND AND HYPOTHESES

Open innovation seeks to be a comprehensive operational and strategic paradigm, embracing various components of knowledge, information, and learning processes. 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, 2006: 1). Chesbrough's definition essentially implies that there are two dimensions of open innovation activities – inbound open innovation and outbound open innovation (Chesbrough & Crowther, 2006). Inbound open innovation refers to the *ex ante* processes of actively in-sourcing and absorbing knowledge from external environment to supplement a firm's internal R&D, while outbound open innovation represents the *ex post* and purposeful activities to facilitate external commercialisation paths for creative ideas and knowledge generated in house (Chesbrough, 2006; Spithoven, Clarysse, & Knockaert, 2011). The focus of this paper is on inbound open innovation activities and there are primarily two critical dimensions evident in the relevant literature relating to the inbound open innovation model.

First is the wide range 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 (universities, research institutes, and the like) (Katila & Ahuja, 2002; Laursen & Salter, 2006). This dimension is also emphasised by van de Vrande, Vanhaverbeke, and Gassmann (2010) as an urgent need to integrate open innovation in the existing literature about technology transaction and cooperation/alliances with innovation partners. The other important theme relates to the internal organisational capabilities that facilitate a firm's processes of identification, assimilation, and exploitation of that externally obtained knowledge, such as ACAP (Cohen & Levinthal, 1990; West & Gallagher, 2006). van de Vrande, Vanhaverbeke, and Gassmann (2010) also believed this is a concept with a strong potential to connect to the insights related to open innovation, thus an essential dimension of an organisation's inbound open innovation model.

These two dimensions will be integrated and utilised in this study to form a basic theoretical framework for hypothesis development. This study focuses on not only the respective effects of external

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knowledge sourcing and internal knowledge absorption capabilities of the focal firms, but also their interactive effects on open innovation performance in the contexts of different sized Chinese firms.

EXTERNAL KNOWLEDGE SOURCES AND INNOVATION PERFORMANCE OF CHINESE FIRMS

The open innovation model suggests that firms without an introspective focus on their own R&D are still able to successfully innovate by drawing on knowledge, information, and expertise from a variety of external sources and actors (Laursen & Salter, 2006). Different external sources play different roles in producing knowledge spillovers and in turn shaping innovation performance. This study continues by exploring the roles of multiple external sources and actors, from different external institutions that organisations collaborate with, in driving their open innovation effectiveness. Firms generally collaborate with two types of institutions, partner firms (involving business customers, suppliers and sometimes even competitor linkages), and universities (research institutes). Research suggests that firms collaborate differently with various external partners and not all types of potential partners make valuable contributions to the innovation performance of firms (Wagner, 2013).

Inter-firm networking

Open innovation, to a great extent, is characterised by the establishment of various ties across firm boundaries. A large portion of value created in new products/services is created outside a particular firm's boundary (Tushman, 2004). These ties involve linkages with other parties to establish an integrative and collaborative value network (Vanhaverbeke, 2006; Vanhaverbeke & Cloodt, 2006; Bucic & Ngo, 2012). Such network arrangements can assist firms in capturing key knowledge during the early stages of technology development, while also facilitating the active roles of suppliers, customers and other external agents in generating value towards the commercialisation of innovation outputs (Chesbrough & Rosenbloom, 2002).

Open innovation research has been extended and contributed to the wider research on the role of inter-organisational networks and collaborations in advancing the capacity of firms to promote innovation (e.g., Porter & Ketels, 2003; Faems, Van Looy, & Debackere, 2005; Nieto & Santamaria, 2007). Overall, a consensus has been developed that suggests that the exclusion of participation in such networks becomes a limiting factor for enhancing a firm's knowledge base (Shaw, 1998). Networking mitigates resource and capability absences by the harnessing of knowledge within factor markets (Ahuja, 2000; Vanhaverbeke, 2006); by the synergistic sharing of potentially complementary skills and resources (Hagedoorn & Duysters, 2002); by the sharing of risks and costs associated with developing new technologies (Grandori, 1997); and by the enhancement of market power of participant organisations, especially with nascent technologies (Human & Provan, 1996).

On the basis of this discussion, we hypothesise:

> Hypothesis 1a: Inter-firm networking (involving customer, supplier and competitor linkages), as a key knowledge source of open innovation, will have a positive effect on innovation performance of both large firms and SMEs in China.

In the specific Chinese context examined in this study, such inter-organisational relationships could be interpreted within the frame of an indigenous concept embedded in the Chinese society with a long history – 'Guanxi'. The practice of Guanxi, defined as the presence of direct, particularistic ties between individuals or organisations (Tsui & Farh, 1997), has a profound influence on firms operating in China (Xin & Pearce, 1996; Tsui & Farh, 1997; Park & Luo, 2001).

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In the Chinese context, an organisation's interaction with other firms and government agencies through the Guanxi networks is essentially a reciprocal process of information diffusion, and resources and capabilities accumulation (Park & Luo, 2001; Huang & Rice, 2012). Guanxi network plays an effectively role in establishing strong relationships with suppliers, customers and other stakeholders based on trust and mutual benefits, continuously exchanging knowledge, information, technology and other forms of favours, and enabling technical learning and building innovative capabilities of cooperative organisations in the network (Park & Luo, 2001; Chen, Lin, & Chang, 2009).

Recent studies have found that the implication of Guanxi in the context of innovation and knowledge management is stronger for small and medium Chinese entrepreneurial organisations than for their larger peers (Fu, Tsui, & Dess, 2006; Phan, Zhou, & Abrahamson, 2010). For many larger organisations, bureaucratic rigidities reduce cooperation with others (Xin & Pearce, 1996; Park & Luo, 2001). Many large Chinese firms are descendants, in some form, of current and former state-governed enterprises and agencies in the old centrally planned economy. Some 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 less commercial pressures or competition they face (Dobson & Safarian, 2008). These inherent features tend to inhibit their effective use of knowledge transfers, which has tended to emerge as a barrier to their technological innovation and success (Chang & Shih, 2004).

SMEs, on the other hand, face a more dynamic, and in many ways unpredictable, economic environment in China. Their need for survival and their innate entrepreneurial spirit drive them to make the best use of Guanxi-based networks to overcome their disadvantages in size, resources, and market relating to innovation (Fu, Tsui, & Dess, 2006). Furthermore, their smaller size also allows them to be more flexible and faster to engage in inter-firm networking to establish essential organisational connections with external sources from key stakeholders (Park & Luo, 2001).

It has been reported that small privately owned enterprises, as a major driver of China's private sector (Hu, Jefferson, & Qian, 2005), are becoming relatively more active in cooperation and regional innovation initiatives than their larger counterparts (Park & Luo, 2001; Fu & Xiong, 2011). This is especially true for those firms that are clustered in technologically advanced regions such as in eastern and southern China (Tan, 2001; Chang & Shih, 2004; Lai, Chiu, & Leu, 2005). Based on this argument, we propose that in China, small and medium firms are more likely to utilise inter-firm ties and networking to support their innovation than larger firms. This overall proposition can be operationalised via the following hypothesis:

> Hypothesis 1b: The effect of inter-firm networking on innovation performance will be greater for SMEs than for large firms in China.

Universities and research institutes (URIs)

Universities are often discussed as an important source of knowledge that facilitates 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 recognised as another potentially useful source of external knowledge (McKenna, 2000; Creplet, Dupouet, Kern, Mehmanpazir, & Munier, 2001) by supporting both formal information exchange, and flows of tacit knowledge and shared know-how across and within industries (Bierly & Daly, 2007). In the context of open and networked innovation, the relationship between public research organisations and industry is considered to be an important driver of innovation processes (Perkmann & Walsh, 2007).

While URIs would seem to provide important knowledge and information to benefit innovation, empirical research on this assumption revealed contradictory results. While Un, Cuervo-Cazurra, and

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Asakawa (2008) found R&D collaborations with universities have a positive impact on product innovation, Wagner (2013) did not find the effect of universities and consultants as sources of openness on innovation performance. It implies that the practicalities of URI-firm engagement as a source of open innovation present some significant challenges, particularly in China where firms generally have fewer incentives to build collaborations with URIs to facilitate such knowledge transfer (Gu, 1999). This, combined with the comparatively more rudimentary status of Chinese URI capability, results in the lower level of URI-firm linkages in China than in most developed countries (Motohashi & Yun, 2007; Brehm & Lundin, 2012).

Universities and research institutes tend to focus on theoretical or fundamental research domains where the created knowledge may not be directly applicable to fit with the industry know-how (Simard & West, 2006) or specific organisational problems (Quintas, Wield, & Massey, 1992). Thus for Chinese firms, the inadequacy of national innovation capabilities at a tertiary level, resulting from the era of a centrally planned economy, may lead to the limited absorption (Guan, Yam, & Mok, 2005; Motohashi & Yun, 2007). The lack of sufficient ACAP and efficient communication channels may create a strong barrier to the identification and utilisation of valuable technological and scientific knowledge generated from URIs (Liu & Lundin, 2008).

Lower contact frequency, weaker intensity of connection, and less intensive communication between firms and university researchers compared with the collaborations between partner organisations (such as customers, suppliers and competitors) might also lead to the ineffective and inefficient knowledge transfer between organisations and URIs (Wagner, 2013). Christensen, Olesen, and Kjær (2005) also pointed to the high potential search and transaction costs associated with open innovation. In addition to the costs of search and transactions associated with external knowledge sourcing, the cost of assimilating exogenous knowledge and integrating this knowledge into the focal firm, including the cost of investing in building internal ACAP, may be also high (Quintas, Wield, & Massey, 1992; Fabrizio, 2006).

Under such circumstances, for Chinese firms the benefits provided by open innovation practices in terms of collaborating with universities (and research institutes) might not justify the costs resulting from openness. This argument can be stated in the following hypothesis:

> Hypothesis 2: Universities and research institutes, as important knowledge sources of open innovation, will have little positive effects on innovation performance of firms in China.

ACAP AND INNOVATION PERFORMANCE OF CHINESE FIRMS

Independent effects

In addition to the utilisation 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 & Levinthal's (1990) 'ACAP' notion, this capability allows firms to effectively transform and commercialise external knowledge to their performance outcomes.

ACAP is a key pre-condition of organising inbound open innovation when organisations are screening their environment to search for valuable external knowledge sources, because only through its presence can the knowledge acquired from outside be internalised, leveraged, and utilised by firms to generate economic value (Spithoven, Clarysse, & Knockaert, 2011). ACAP's significance in transforming openness into measurable performance has been the focus of much empirical work (e.g., Tsai, 2001; DeSanctis, Glass, & Ensing, 2002; Huang & Rice, 2009). During the transitional period currently being experienced by China's innovation systems, the role of ACAP in science and technology outsourcing has been highlighted (Motohashi & Yun, 2007). Liu and White (1997) also

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believe that in the emerging economies such as China, innovation performance is best driven by the synergy between investment in ACAP and investment in the sources of new knowledge.

Hypothesis 3a: Investment in ACAP is positively related to innovation performance of both large firms and SMEs in China.

Interaction effects

Other than the direct and individual effect of ACAP, its combined effects with the usage of external sources of open innovation is of great interest to the current research. Salge, Bohné, Farchi, and Piening (2012) argued a firms' internal ACAP routines play a key moderating role in harnessing the value of open innovation and explaining the inter-firm differences in their returns from openness. In fact, the positive role of ACAP in optimising advantages provided by external knowledge sources can be inferred by both theoretical and empirical studies.

It has been suggested that the processes relating to the effective scanning for external sources could be facilitated by greater ACAP capabilities (West & Gallagher, 2006). Additionally, according to Fabrizio (2006), the lack of the absorptive competencies required to identify and explore 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 integrate it into their existing innovation system to create real benefits. ACAP is required to leverage that externally acquired knowledge.

Furthermore, empirical research suggests that ACAP can act as a leverage of inbound open innovation performance through its positive and significant effect on collaborative learning among the collaborative innovation partners in the networking (Bucic & Ngo, 2012). In that sense, ACAP is of vital importance in the facilitation of open innovation effectiveness.

Furthermore, ACAP might create capabilities that neutralise some potential threats associated with outsourcing activities. The creation of contractual or long-standing relationships with partner firms, universities and research institutes may create high up-front search and transactional costs for the firms involved. These costs, once accrued, generally decrease after adequate knowledge accumulation has occurred (Zander & Kogut, 1995; Teece, Pisano, & Shuen, 1997; Zott, 2003). This implies that the benefits provided by ACAP tend to outweigh the costs associated with external knowledge sourcing, especially over the longer term (Chesbrough, 2003a). In the Chinese context, it has been also observed that the strength of the effect of foreign technology and knowledge on innovation capacity depends on the level of ACAP of receiving firms in the region (Fu, 2008).

However, this positive moderating effect of ACAP on the relationship between external knowledge sources and innovation performance might be partially contingent on firm size. While for R&D intensive large firms, the role of ACAP in leveraging open innovation advantages is relatively well understood, little attention has been paid to SMEs who generally rate lower in terms of the effectiveness of their knowledge absorption capabilities when compared with larger firms in the same industry (Spithoven, Clarysse, & Knockaert, 2011). SMEs, by definition, have relatively fewer resources such as skilled labour and embedded knowledge stocks which are critical forms antecedent to the ACAP for innovation activities (Alvarez & Barney, 2002; Lundin, Sjöholm, & Qian, 2006). The general 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 Chinese SMEs in establishing complementary assets which are the basis of ACAP effectiveness (Oakey, During, & Kauser, 2001). Previous research has also suggested that China's larger corporations have more regulatory and financial incentives to invest in absorption-related capabilities and assimilate exogenous technologies than their smaller competitors (Bin, 2008). This leads to the phenomenon that small firms in China are

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comparatively less able to exploit the full potential of ACAP to leverage and optimise open innovation benefits derived from external knowledge sources.

The arguments above can be summarised in the following hypothesis:

Hypothesis 3b: The moderating effect of internal ACAP on the relationship between external knowledge sourcing and innovation performance will be greater for large firms than for SMEs in China.

METHODS

Sub-samples

The data for this study is drawn from the *World Bank Investment Climate Survey 2003*. The series of World Bank Investment Climate Surveys collected a wide range of qualitative and quantitative firm-level information on the investment climate in 53 developing countries (Smith & Hallward-Driemeier, 2005). The Investment Climate Survey was first conducted in China in 2002 among 1,500 respondent firms in five largest cities (i.e., Beijing, Guangzhou, Shanghai, Chengdu, & Tianjin) (Smith & Hallward-Driemeier, 2005).

This study is on the basis of a sample of 2,400 Chinese firms in a follow-up survey conducted in 2003 (The World Bank, 2006). Respondent firms were from 18 cities in mainland China. These cities are distributed across five major 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, Nanning), the Western (e.g., Chongqing, Lanzhou, Kunming, Xi'an, Guiyang), and the Middle regions (e.g., Changsha, Wuhan, Nanchang, Zhengzhou).

This data set is used in this study because it involves a wider industrial (involving firms from 14 manufacturing and service sectors) and geographical coverage (these two survey data cannot be incorporated due to the differences in their survey questions). The survey respondent was senior manager of each firm (and the firm's accountant for accounting and finance information or personnel manager for information relating to human resources).

SPSS's expectation and maximisation method was used to analyse and replace missing data within the sample drawn from the survey. 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, Hu, Guan, & Yu, 2003), we utilised an employment size of less than 200 to define small and medium-sized enterprises. This definition is consistent with the World Bank's report which suggests the SME sector cut-off could range between 200 and 300 employees for APEC countries (Ayyagari, Beck, & Demirguc-Kunt, 2007). After this process, sub-samples consisting of 874 large firms and 1,500 SMEs remained.

Measures

Dependent variable

The dependent variable – Innovation performance (*Innov2002*) is measured by calculating the proportion of sales derived from new products (services) and/or value of exports of new products (services) to the total sales in the year 2002. This measure is consistent with Negassi (2004) and Laursen and Salter (2006), and is a continuous measure of the innovation performance of firms. Compared with other measures of innovation performance that were employed in innovation studies (e.g., R&D expenditure, which is actually a measure of inputs rather than outcomes), it is a relatively direct measure of the success in the commercialisation of firms' innovative efforts.

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However, the secondary data set we used aggregated different types of innovation (e.g., radical and incremental), therefore we could not differentiate the degrees of novelty of innovation. This has been recognised as a limitation in this measure.

Independent variables

The measures of independent variables are as follows – The use of Inter-firm Networking (*Interfirm)* is constructed by responses to the survey question regarding 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 with 1 for yes and 2 for no). Firms were also asked whether they had participated in any contractual or long-standing relationship with local universities or with research institutes in the year 2002. The answers to these two questions form the constructs of variable Universities (*Uni*) and Research Institutes (*RI*). Both of these are binary variables taking the value of 1 for the response yes and 0 for no. Although the depth of external knowledge sourcing has not been explored by this construct, this variable provides a useful insight into the focal firm's actual state of connectedness with key external knowledge sources from the market (involving suppliers, customers, partners and potential competitors) and institutions (involving university and research centres) based on the year 2002.

Investment in ACAP – because of the difficulty in directly measuring ACAP, a proxy measure is used in this study. Although R&D intensity is the most commonly used proxy in the prior research, this measure has been frequently criticised as it 'treats absorptive capacity as a static resource and not as a process or capability' (Lane, Koka, & Pathak, 2006: 838) and it does not take into account the quality of R&D work undertaken within the firm (Schmidt, 2009). Thus another proxy is used to operationalise this construct – R&D human capital (e.g., Liu & While, 1997; Veugelers, 1997; Gao, Xu, & Yang, 2008). The validity of this measure can be linked to Cohen and Levinthal's (1990) argument that the ACAP of a firm depends on the individual ACAP of its members. In essence, ACAP as a type of knowledge management capacity needs to be more effectively facilitated by human knowledge than tools, machines and other tangible assets of a firm's R&D department (Lichtenthaler & Lichtenthaler, 2009). Therefore, the size of total R&D personnel (in the natural logarithm) is considered to be a more suitable proxy for ACAP of the focal firm.

It has been noted in our study that some SME employees play multiple roles in the organisation, the actual contribution to ACAP by these employees throughout the whole organisation may not be completely measured by the scale of formal R&D personnel. Based on this consideration, we utilised the survey question regarding the size of personnel engaged in the focal organisation's research and development *activities* rather than merely in the formal R&D department/function in both the large and SME contexts.

Control variables

In addition to these independent variables, this study controls for the effects of market, firm age, foreign partnership, industry, IT infrastructure, and previous innovation performance of firms in each sub-sample.

Market dominance (*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. These initial response categories were then coded 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 when the firm was established. Foreign partnership (*Foreign partner*) is measured by a binary variable with 1 if

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the firm had a foreign partner and 0 otherwise. An Industry Dummy (*Industry*) is measured with the value of 1 if the business was in the manufacturing industry and 0 otherwise, after coding the original qualitative responses with the 14 industry categories. This measure is to take into account the differences in the propensity to openness between firms in manufacturing sectors and non-manufacturing sectors.

IT infrastructure is especially beneficial for firms in the open innovation context by broadening the potential scope of a firm's transactional and knowledge exchange boundaries, and providing cheaper and faster linkages between domestic and international collaborators. This enhanced scope is imperative for emerging countries like China in promoting the opening up processes of innovation (Dodgson, Gann, & Salter, 2006; Zheng & Sheng, 2006). IT infrastructure 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 (*Internet*). This is a useful proxy for the integration of internet technology in Chinese businesses (Tan & Ouyang, 2004). It is a continuous variable ranging from 0 to a maximum value of 1. The Previous Year Innovation Performance (*Innov2001*) is included as a control variable as well (calculated similarly to the dependent variable) to take account of 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 the findings with regard to previously stated hypotheses. It has been noted that the dependent variable is double censored because it is a percentage which, by definition, ranges between 0 and 100 excluding values <0 and >1, therefore Tobit regression model is employed to address this feature of dependent variable. This statistical method is in accordance with Laursen and Salter's (2006) research.

Model 1a and Model 2a, respectively, present the basic Tobit regression results of the two sub-samples – 1,500 SMEs and 874 large firms. 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 significantly affects the dependent variable for SMEs, but is insignificant for the large firms sub-sample. Therefore, Hypothesis 1a is not supported, with Hypothesis 1b hypothesising that the use of inter-firm networking will have greater impact on innovation performance of SMEs than that of their large counterparts in China fully supported.

Hypothesis 2 suggests that universities and research institutes will have little positive effect in terms of driving the innovation performance of Chinese firm. This hypothesis is largely supported in samples, 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.

Regarding the independent role of ACAP, Hypothesis 3a is not supported as ACAP has insignificant impact on firms in SME sub-sample, despite its positive and significant effect on large firms.

In order to further test Hypothesis 3b, the hierarchical models are employed for the large firms and SME sub-samples (Model 1b and Model 2b). Those external knowledge sources which have weak or little effects on innovation performance that is *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, both *ACAP* × *Uni* and *ACAP* × *RI* are shown as anticipating significant and positive moderating effects on the dependent variable. With the introduction of *ACAP*, the negative value of *Uni* is reduced, and the coefficient of *RI* turns significantly positive, although there is no improvement in the effect of the use of inter-firm networking. On the basis of these findings,

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Table 1. Means, standard deviations and correlations

Variable	*Mean*	*SD*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
1. *Innov2002*	0.41	0.29										
2. *Interfirm*	0.53	1.06	0.08[a]									
3. *Uni*	0.48	1.00	0.01	0.27[a]								
4. *RI*	0.39	0.93	0.08[a]	0.35[a]	0.47[a]							
5. *ACAP*	2.90	1.30	0.01[a]	0.27[a]	0.24[a]	0.22[a]						
6. *Market*	2.54	0.93	0.23[a]	0.09[a]	0.15[a]	0.20[a]	0.11[a]					
7. *Foreign partner*	0.15	0.36	0.15[a]	0.12[a]	0.08[a]	0.12[a]	0.07[a]	0.12[a]				
8. *Age*	21.80	14.94	−0.09[a]	−0.07[a]	−0.03	−0.01	−0.03	0.09[a]	−0.05[b]			
9. *Internet*	3.90	12.52	0.20[a]	0.08[a]	0.10[a]	0.09[a]	−0.05[b]	0.18[a]	0.11[a]	−0.12[a]		
10. *Innov2001*	0.40	0.25	0.80[a]	0.01	−0.03	0.04	0.05[b]	0.01	0.19[a]	0.14[a]	0.11[a]	
11. *Industry*	0.52	0.50	0.18[a]	0.08[a]	0.15[a]	0.20[a]	0.13[a]	−0.11[a]	0.40[a]	0.26[a]	0.08[a]	−0.01

[a]Correlation is significant at the 0.01 level (one-tailed)
[b]Correlation is significant at the 0.05 level (one-tailed)

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TABLE 2. RESULTS OF TOBIT REGRESSION ANALYSIS FOR INNOVATION PERFORMANCE

	Dependent variable			
	Innovation performance (Innov2002)			
	SMEs		*Large firms*	
Independent variables and control variables	*Model 1a*	*Model 1b*	*Model 2a*	*Model 2b*
(Constant)	0.032	0.045	−0.087*	−0.063
Inter-firm networking (*Interfirm*)	0.016*	0.018	0.005	−0.013
Universities (*Uni*)	0.001	−0.018	−0.036***	0.037
Research institutions (*RI*)	0.000	−0.021	0.007	−0.075**
Absorptive capacity (*ACAP*)	−0.007	−0.011^{+}	0.015*	0.011
Market dominance (*Market*)	0.007	0.007	0.040***	0.040***
Foreign partner (*Foreign partner*)	−0.065**	−0.067**	0.052*	0.048*
Age (*Age*)	−0.001	−0.001	0.000	0.000
IT infrastructure (*Internet*)	0.002***	0.003***	0.003**	0.003**
Previous performance (*Innov2001*)	0.89***	0.88***	1.09***	1.08***
(Manufacturing) dummy (*Industry*)	0.054***	0.058***	0.046*	0.048*
ACAP × *Interfirm*		−0.001		0.004
ACAP × *Uni*		0.006		−0.020**
ACAP × *RI*		0.006		0.022**
n	1,500	1,500	874	874
LR χ^2	834.07***	837.75***	450.23***	463.11***
Log likelihood	327.41	329.24	75.087	81.526

$^{+}p < .10$; *$p < .05$; **$p < .01$; ***$p < .001$

Hypothesis 3b is partially supported. On the other hand, for Model 1b, none of the interaction variables is significant. This is consistent with the statement of Hypothesis 3b that the positive moderating effect of ACAP on the relationship between external knowledge sources and innovation performance tends to affect large firms more significantly than SMEs in China.

Of the control variables, the market dominance (*Market*) variable seems to co-vary with innovation performance for large firms (both positive and significant) but not significantly for SMEs. The partnership with foreign firms (*Foreign partner*) exhibits significant covariance with the 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 sub-samples in the study. IT infrastructure (proxied by *Internet*) is positive with strong significance for both of the sub-sample groups. Additionally, firms' previous innovation performance (*Innov2001*) positively affects current innovation performance, with high significance for both sub-samples. Manufacturing firms (the value of *Industry* = 1) in both size types generally exhibit higher innovation outputs than their counterparts in non-manufacturing sectors.

DISCUSSION AND CONCLUSION

This study seeks to empirically investigate whether open innovation can improve innovation performance and provide competitive strengths for different sized organisations in China as has been shown in developed economies. The research framework of our study has integrated both external and internal perspectives involving external knowledge sourcing and internal ACAP as the core components of an inbound open innovation model. The main findings with respect to these two types of critical

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components and their relationships to open innovation in Chinese SMEs and large firms are presented in Figures 1 and 2, respectively.

Figure 1 illustrates the positive sources of external knowledge for SMEs in China and those that have no significant effects on innovative performance. In addition, the absence of a significant effect of ACAP is shown as well as its insignificant moderating effect on the relationships between external knowledge sources and innovation performance.

Figure 2 illustrates the external knowledge sources which have positive and negative effects on innovative performance of large firms as well as the effect of ACAP to leveraging that knowledge towards innovative performance. The results indicate positive moderating effects of ACAP on the relationship between external knowledge sources (i.e., universities and research institutes) and innovation performance.

At present, actually the majority of Chinese firms are still undergoing the process of emergence from imitation to innovation (Dobson & Safarian, 2008). Some have just 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, China is still

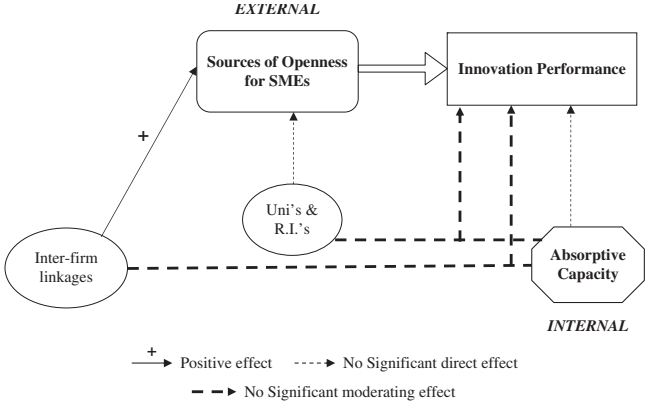

FIGURE 1. KNOWLEDGE SOURCES SHOWN TO CONTRIBUTE TO THE INNOVATION PERFORMANCE OF CHINESE SMES

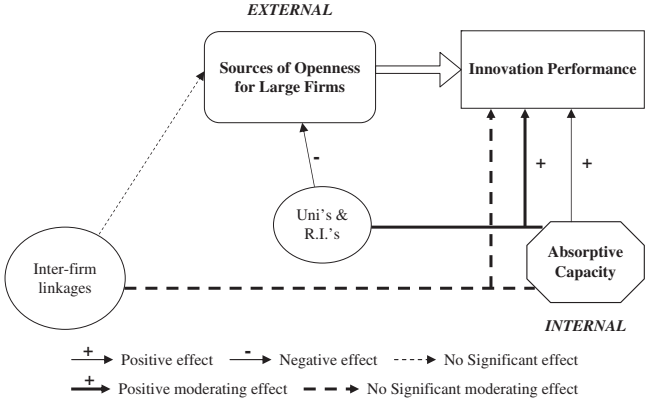

FIGURE 2. KNOWLEDGE SOURCES SHOWN TO CONTRIBUTE TO THE INNOVATION PERFORMANCE OF CHINESE LARGE FIRMS

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at the very preliminary stage of its innovation system's development, and is exploring the most efficient innovation mode based on its current situation.

Based on our findings, we believe it is not necessary that China should mimic the emergence path from closed to open innovation followed by western countries and other advanced Asian countries. If it should, however, inadequate indigenous research expertise and the lack of ACAP within firms might act as a barrier to the accrual of 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 direct effect on the innovation performance of Chinese firms.

This finding is consistent with the related western theories and evidence which have emphasised that research externalisation is critical for successful innovation, but limited by the absence of effective investments in the internal ACAP (Christensen, 2006; Laursen & Salter, 2006). These investments have been shown to be requirements for the effective management of transferring externally acquired knowledge 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 ACAP, do antecede improved 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 ACAP are expected to outweigh the search and transactional costs associated with contractual or long-standing relationships with universities and research institutes. In that sense, innovation performance improvement may be leveraged in the presence of appropriate ACAP investment. While the positive moderating role of ACAP has been supported, we find this role is generally limited to large firms. This finding is consistent with Christensen's (2006) argument that even when seeking to adopt open innovation principles, firms in practice perform differently. It is indicated in this study that the variation in ACAP's effect exists among firms with different sizes.

We believe that the limited direct and moderating effects of ACAP for Chinese SMEs may possibly be an artefact of the measure used in this study. Although we have already partly addressed the limitations in ACAP measures in previous studies such as R&D intensity, using R&D active personnel (namely the size of personnel engaged in the focal organisation's research and development *activities*) as the proxy for ACAP might still just partly capture this phenomenon by only focusing on the formal knowledge absorption capacity.

Investments in traditional R&D resources and activities tend to facilitate the transfer of formal and explicit knowledge. Such knowledge is more easily communicated, transferred and stored with the normal R&D routines. Where the knowledge exchanged is informal, tacit and un-codified, and usually based more on learning-by-doing processes which are particularly utilised by SMEs (Harris, 2009; Ngah & Jusoff, 2009), knowledge is more effectively assimilated through the broader and more comprehensive knowledge management and knowledge absorption skills embedded in employees' daily work rather than in the organisation's normal R&D activities alone.

This measure could also largely explain the research result that the ACAP's interactive effect with inter-firm networking is not as evident as its interaction with universities (research institutes) for large firms in China. This is mainly due to the characteristics of knowledge flows from universities (research institutes) which are more tangible, explicit, and easily able to be leveraged by ACAP compared with the more applied knowledge and tacit know-how that flow directly between firms collaborating with one another (Quintas, Wield, & Massey, 1992). Therefore, seeking the most appropriate measure to capture the construct of ACAP in different research contexts will be an interesting and potentially fruitful area for future studies.

Although the secondary data set employed in our study is a little outdated, our research still largely represents the current situation of open innovation in China. This has been evidenced by the

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consistency between our findings and the macro statistics released by a recent national innovation survey in China. This survey conducted in 2008 by the National Bureau of Statistics of China and the Tsinghua University Technological Innovation Research Centre also indicated that despite a certain degree of open innovation adoption in China, the most prevailing innovation modes of domestic firms are still closed and independent (Fu & Xiong, 2011). Furthermore, institutional information sources (mainly from universities and research institutes) are not regarded as key external knowledge sources in driving innovation performance in the eyes of most Chinese firms (Fu & Xiong, 2011).

Our research findings are also consistent with recent empirical findings provided by other Chinese researchers (Fu, 2008; Fu & Xiong, 2011) who generally argued that the weakness in ACAP and the limited indigenous innovation capability to truly benefit from valuable external knowledge/technology sources and spillovers would further hinder the upgrading of China's innovation system to a more value-added open mode.

In sum, this study reveals that there are many reasons for the differences in the form and effectiveness of open innovation activities between established and emerging economies. We have found that for the effective adoption of open innovation in emerging economies such as China, the contingent effects of constructive external knowledge sources and internal ACAP are essential considerations.

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