Academic collaborations and firm innovation performance in China:

The role of region-specific institutions

Abstract

Although prior research has highlighted the importance of academic collaborations in enhancing firms' innovation performance, it has largely focused on developed countries. As a result, how academic collaborations influence innovation in emerging countries, which differ fundamentally from developed countries in their institutional environment, remains unclear. We contribute to this literature by examining how collaborations with universities and research institutes influence the ability of Chinese emerging market enterprises (EMEs) to develop innovations. Our analysis challenges the assumption of institutional homogeneity within a given country, showing that institutions evolve in different ways across sub-national Chinese regions. This uneven institutional evolution affects the enforcement of intellectual property rights (IPRs), the level of international openness, the quality of universities and research institutes across regions and thus the degree to which Chinese EMEs benefit from academic collaborations. Our findings reveal that sub-national institutional variations have a profound impact on the relationship between academic collaborations and firms' innovation performance, illustrate that some established assumptions are not valid in emerging countries, such as China, and offer insights into how EMEs can enhance their innovation performance.

Keywords: Academic collaborations; performance; institutions; regions; China; emerging countries.

1. Introduction

Firms that collaborate with universities and research institutes (URIs hereafter) source scientific and technological knowledge that can enhance their innovation performance (Mindruta, 2013; Ponds et al., 2010). Prior studies have provided valuable insights indicating that such collaborations improve a firm's patenting success, entry to new technological fields and new product development (George et al., 2002; Perkmann et al., 2011; Zucker et al., 1998). Nevertheless, the findings and assumptions that have informed the theory on this subject are largely based on studies in developed (Western) countries. These countries are characterized by mature institutions (which are largely homogeneous within a given economy), well-established innovation systems, world-class universities and strong indigenous research and development (R&D) capabilities. The significant ways in which emerging markets differ from developed economies limit scholarly understanding of the role of academic collaborations in enhancing the innovation performance of emerging market enterprises (EMEs) (Eom and Lee, 2010; Eun et al., 2006). We address this important phenomenon by focusing on one of the largest, most diverse and most innovative emerging countries, China.

Chinese firms, such as Lenovo and Huawei, have improved their innovativeness and ability to compete against their foreign counterparts (Eun et al., 2006; Mu and Lee, 2005). However, although the theory for developed countries considers internal R&D to be the most valuable component of a firm's innovation strategy (Teece, 1986; Zhou and Wu, 2010), many Chinese firms do not possess and cannot rapidly develop strong R&D capabilities (Motohashi and Yun, 2007; Perks et al., 2009). One means by which Chinese firms can compensate for their limited internal R&D capabilities is to pursue an innovation strategy that relies heavily on academic collaborations. In fact, whereas firms in developed countries rank universities as their least frequent source of information (BIS, 2012; Perkmann et al., 2011), between one-third and half of all external R&D of Chinese EMEs focuses on academic collaborations (OECD, 2008; 2009). The Chinese innovation model differs from those for developed countries in not only its reliance on URIs but also the context in which it originates. Because university-industry theory is not universally valid (Howells et al., 2012), one challenge here is to identify how the Chinese innovation context differs from what theory about Western countries assumes and predicts and to understand how such differences influence the effectiveness of academic collaborations in enhancing the innovation performance of EMEs.

One key explanation for such variations is the importance of institutions, defined as the rules of the game (North, 1990). Institutions may facilitate or constrain collaboration by influencing transaction costs and the set of rules, supportive structures and resources (Phillips et al., 2000; Wang et al., 2012). Nevertheless, despite the centrality of this premise, the current theory for developed countries rests upon the assumption that institutions are homogeneous across different sub-national locations within a given country (Nelson and Rosenberg, 1993; Edquist, 1997), thus overlooking the role of cross-regional institutional idiosyncrasies (Liebeskind et al., 1996; Hong, 2008).[1] Indeed, although prior research recognizes that innovation is fundamentally a location-specific process (Asheim and Coenen, 2005), there has been little research about the role of subnational region-specific institutions in facilitating or constraining the interactions and collaborations between various organizations (Doloreux and Parto, 2005).

In this study, we argue that institutions vary significantly *within* emerging countries, such as China (Meyer and Nguyen, 2005), and propose that such institutional variations determine the enforcement of intellectual property rights (IPRs), the level of international openness across regions, the research quality of URIs and thus the effectiveness of academic collaborations in enhancing the innovativeness of Chinese EMEs. Cross-regional institutional idiosyncrasies in IPR enforcement, international openness and the quality of academic talent in URIs influence the benefits and costs of academic collaborations as well as the search, transaction and transformation costs associated with identifying and using external knowledge (Whitley, 2000). Thus, such idiosyncrasies are key discriminating factors of the effects of academic collaboration on EMEs' innovation performance.

Using a sample of 375 innovative Chinese firms, we empirically confirm this premise, illustrating that the uneven institutional development across subnational regions within China influences IPR enforcement, international openness and the quality of academic talent in URIs

[1] A notable exception is Chan et al. (2010).

and, consequently, affects the performance of academic collaboration. Whereas URIs and firms in Western countries take for granted an abundance of well-developed institutions (e.g., countrywide consistent and enforceable IPR laws and contractual agreements), China's political and economic reform gives regional governments a large degree of authority over policy-making and control of legal development and enforcement (Chan et al., 2010). We demonstrate that the resulting within-country differences can enhance or undermine the value of URI-firm R&D collaborations. We also show that the relationship between academic collaborations and EMEs' innovation performance is not linear and monotonic. This finding has implications for current thinking about the trade-offs between the development of internal innovative capabilities and the reliance on external academic collaborations.

Our analysis contributes to the literature by identifying how location-specific institutional idiosyncrasies moderate the role of academic collaboration in enhancing EMEs' innovation. By explaining why academic collaborations are likely to be more beneficial in some regions than in others, we establish a conceptual link between two important research strands (namely, academic collaboration and regional innovation systems), which have only been studied in isolation in previous studies. The analysis of subnational institutional idiosyncrasies is important because it extends prior theoretical predictions by explaining why academic collaborations with similar characteristics can lead to different innovation outcomes and yield different returns. By describing the critical role of academic collaborations, our analysis reveals an innovation business model of EMEs that differs considerably from that of developed country firms, which largely focuses on the development of internal R&D capabilities and relies only slightly on academic collaborations. Although our analysis in the remainder of the paper focuses mainly on China, a number of the predictions of our framework could be adapted to other emerging economies.

2. Benefits and costs of academic collaborations

One of the key characteristics of Chinese EMEs, as opposed to firms in developed countries, is that they only rarely possess internal R&D capabilities, and they cannot develop such capabilities rapidly due to time compression diseconomies (Motohashi and Yun, 2007; Perks et al., 2009). Hence, these firms rely significantly on university collaborations (Wang and Lin, 2013). URIs enhance firm innovation through various mechanisms. First, they provide a pool of specialized labor that constitutes a crucial element of intellectual human capital (Zucker et al., 1998). Academic collaboration enables the firm to lower its search costs, acquire scientific talent and knowledge, and conduct joint research with universities (Cohen et al., 2002; Jaffe, 1989; Prahbu, 1999) that would not be possible otherwise (Romijin and Albaladejo, 2002).

Second, URIs may enhance firms' problem-solving abilities and facilitate the integration of external knowledge into the firm's own processes (Fabrizio, 2006). They conduct basic and exploratory research that is typically expensive for firms to undertake and help firms to transform knowledge into commercially successful products (George et al., 2002; Zucker et al., 1998). Furthermore, academic collaboration enables firms to develop innovative capabilities through interactive learning (Cohen et al., 2002). Because firms need to renew their capabilities on a continual basis, access to external inputs enables them to keep abreast of the latest technological advances and to develop new technologies (Prahbu, 1999). There are strong complementarities between academic research and firms' R&D that enhance entrepreneurial orientation and innovation performance (George et al., 2002).

Nevertheless, identifying, assimilating, and utilizing external knowledge comes at a cost. First, academic collaborations may involve coordination and monitoring problems (Mindruta, 2013; George et al., 2002) as well as problems that arise due to the reluctance of URIs to become involved in business (Hershberg et al., 2007). Such problems may occur because of the differences in administrative systems between firms and academic institutes in terms of employment and funding (Bruneel et al., 2010). The sunk cost of such investments is particularly high in cases where the firm's partners turn out to be unsuitable. Furthermore, differences in the objectives, incentives, values and cultures between URIs and firms may make partnerships less productive. For instance, the intellectual property rules that universities adopt often conflict with firms' knowledge acquisition and protection objectives, thus creating transaction-related problems (Bruneel et al., 2010). Whereas academics are oriented toward recognition and reputation and wish to publish their discoveries, firms focus on protecting valuable knowledge (Fabrizio, 2006).

Furthermore, the cognitive distance between firms and URIs may weaken the value of academic collaborations. For instance, firms often cannot objectively rate universities as a source of information because of the differences in evaluations concerning the optimal quality of an invention (Howells et al., 2012). This cognitive distance can be particularly large when managers are trained to think "internally" (Grönlund et al., 2010) and have not developed an open culture. These costs may hamper the way in which knowledge from URIs can be combined with the firm's own knowledge and therefore reduce the usefulness of academic collaborations.

As academic collaborations come with a set of both benefits and costs, it is imperative to use a contingency approach to capture heterogeneity across regions and understand when and under what conditions academic collaborations are more beneficial for the firm. In the next section, we explain how the uneven institutional change across Chinese regions influences IPR enforcement, international openness and the research quality of URIs, and we address how these factors in turn affect the value of academic collaboration.

3. Theoretical Framework and Hypotheses

3.1. Institutional variations across regions

It has long been established that institutions set the rules that form a country's incentive structures and economic specialization (North, 1990). Institutions can have a profound effect on a country's innovation system by determining infrastructure, the quality of human capital and the resources available for innovation (Bosker and Garretsen, 2009; Roper et al., 2004). Whereas firms and URIs in Western economies operate in institutional environments that are stable and largely homogeneous within the country, subnational institutional variations in emerging countries such as China influence how markets function in different regions (Chang and Wu, 2013; Khanna and Palepu, 1997). The simultaneous operation of market and state-controlled governance mechanisms creates a multi-layered institutional system that is moving in different directions across regions (Peck and Zhang, 2013).

China's open-door policy unraveled in three administrative decentralization phases, with each successive stage further empowering the regional government. The three phases (namely, delegation of responsibility for economic performance, tax contributions to the central government and delegation of control for state-owned enterprises and organizations) led to a significant institutional and economic fragmentation of the country (Boisot and Meyer, 2008). It also created an institutional and administrative structure characterized by local protectionism, with each regional government controlling and protecting its own enterprises and organizations.

Because institutions, which are part of the dynamics of innovation (Crescenzi et al., 2013), vary significantly across Chinese regions, they can influence the effectiveness of a firm's academic collaborations. Governments in different regions have distinct motives, objectives and preferences (Wang et al., 2012) and thus generate different institutional pressures that can affect the value of academic collaborations. We argue that these institutions, which are idiosyncratic to each region, may influence the effects of academic collaboration on EMEs' innovativeness by affecting the strength of IPR enforcement, the degree of international openness (in terms of inward foreign direct investment, FDI), and the research quality of URIs in each region. The next sections discuss how administrative decentralization and the uneven development of institutions may lead to cross-regional variations in these three aspects and how these variations in turn affect the value of academic collaborations for EMEs.

3.2. Cross-regional variations in IPR enforcement

Appropriability regimes refer to factors that influence the ability of an organization to protect and capture the economic value of its innovations. A key dimension of an appropriability regime is the effectiveness of legal mechanisms to protect IPRs (Teece, 1986). IPR laws are typically underdeveloped or under-enforced in emerging economies, providing organizations with little protection from imitators and opportunistic behavior (Bradley et al., 2012; Keupp et al., 2012). More importantly, whereas IPR laws in Western economies are equally suitable for all organizations within a given country, IPR enforcement differs significantly across regions in China due to uneven regional development in institutions and markets. Administrative decentralization has led regional authorities and provincial governments to have substantial judicial independence and frequently influence courts' judgments (Peck and Zhang, 2013). Such institutional differences also lead to significant cross-regional variations in the frequency of infringements, the effectiveness of courts, the enforcement of contracts and the rules for innovation subsidies (Li and Qian, 2013; Li, 2012). This view is supported by evidence that indicates that IPR enforcement varies significantly across Chinese regions (Ang et al.,, 2014). In the next section, we discuss how such sub-national differences in the strength of IPR enforcement influence the effects of academic collaborations on EMEs' innovation performance.

3.2.1 Effects of IPR enforcement on academic collaborations

It is theoretically accepted that the effective protection of IPRs depends on both the existence of IP laws and their enforcement (Ang et al., 2014). However, in practice, although many emerging countries have IPR laws, their enforcement is problematic. We hypothesize that a region's strength of IPR enforcement moderates the effects of academic collaborations on an EME's innovation performance. Weak IPR enforcement increases transaction costs and the difficulty of writing and executing contracts. The regional fragmentation of China makes transactions among geographically scattered firms and URIs even more costly and impedes the potential to identify new opportunities for collaborations (Boisot and Meyer, 2008). Conversely, a strong IPR regime that enforces the law provides a protective framework for contractual agreements and R&D collaborations by increasing stability, improving partner commitment, and discouraging opportunistic behavior (Carson and John, 2013; Jean et al., 2014). Therefore, a higher level of IPR enforcement increases the willingness of URIs and firms to share resources and knowledge in R&D collaborations, which may in turn lead to better innovation outcomes for the firm.

Moreover, because URIs are moving away from the "open science" model that views knowledge as a public good and are increasingly focusing on the exploitation of internal knowledge and collaborative research partnerships with industry, they are placing a greater emphasis on protecting and capturing value from their IP (Hewitt-Dundas, 2012; 2013). Strong IPR enforcement allows URIs to commercially exploit ideas and IP generated from internal and collaborative research projects. For example, in 1999, the Chinese Ministry of Education issued legislations that allowed universities to protect and commercialize their IP. Since then, universities in regions that incorporated such legislations into their policies became more enthused about collaborating with businesses (Hong, 2008), which may in turn lead to better innovation outcomes for the firm.

Furthermore, R&D partners contribute different resources and knowledge. Therefore, it is critical to know each partner's IP and rents from the potential innovation ex ante (Carson and John, 2013). A stronger IPR regime specifies each party's rights, obligations and responsibilities, thus creating formal collaboration procedures (Jean et al., 2014). Nevertheless, as the collaboration evolves and the partners increase their investments and commitment, they become vulnerable and economically exposed in the case of opportunistic behavior. URIs are better protected from potentially opportunistic firms in regions with strong IPR mechanisms, which allows firms to devote new resources to collaboration because they feel that their IPRs are protected (Li, 2012). Similarly, firms are more willing to share knowledge with URIs when they know that they can prevent academic staff from opportunistically disseminating such information or using it in scientific publications. This increased willingness in turn enhances the efficiency of academic collaborations and can lead to improved innovation outcomes (Carson and John, 2013; Jean et al., 2014).

Conversely, firms and academic institutions in regions with weak IPR enforcement might be reluctant to engage and invest in URI-firm collaborations, fearing that the opportunistic behavior of their partners will increase transaction costs and lower economic returns. Greater uncertainty in such regions may also result in the renegotiations of contracts in which a firm can bargain opportunistically and therefore make the university less willing to fully commit to R&D collaborations (Carson and John, 2013). Indeed, weak legislation and enforcement constitute a major obstacle that restricts the positive effects of URI-firm R&D collaboration in China (Chang and Shih, 2004). Hence, we expect IPR enforcement in a region to positively moderate the effects of academic collaborations on EMEs' innovation performance:

Hypothesis 1. *The stronger the IPR enforcement is in a given subnational region of an emerging country, the stronger the effects of academic collaborations on an EME's innovation performance will be.*

3.3. Cross-regional variations in international openness

China's recent growth and transformation has relied on its international openness and ability to attract inward FDI. Furthermore, the central government in China has long pursued state rules and policies that support the development of certain regions at the expense of others. Open-door policies prioritized the development of China's eastern coastal regions by encouraging trade and FDI (Liu, 2013). For example, policies in the 1980s established special economic zones in four coastal cities and gradually expanded to another fourteen coastal cities, widening the coast-inland divide in terms of international openness. Furthermore, in 1988, the Beijing Experimental Zone for New Technology and Industrial Development was set up, and 18 preferential policies on taxes, loans, and personnel mobility and recruitment were granted to support its development (Liu *et al*., 2011). The State Council gradually approved 52 similar economic zones across the country. Nevertheless, the largest zones were located in coastal cities, with many of them benefiting from multiple establishments in their locality.

In an attempt to alleviate this increasing inter-regional divide, the Chinese government launched the Western Development Strategy in 1999. This strategy offered policy incentives to encourage openness through international trade and inward and outward FDI in six Western provinces. Despite this initiative, however, the level of international openness, particularly in terms of international trade and FDI, is still considerably higher in the eastern/coastal regions compared to inland regions. These variations have made international openness in China spatially and structurally uneven. For example, Shanghai reported the highest trade-to-GDP and FDI-to-GDP ratios in 2010, whereas Qinghai's ratios were the lowest in the country (National Bureau of Statistics of China, 2011). These cross-regional variations in international openness have also led to the faster growth and development of technology and science parks located in the eastern coastal regions and controlled by 'elite' universities (Hu, 2007).

3.3.1 Effects of international openness on academic collaborations

We expect a region's degree of international openness to moderate the effects of academic collaborations on EMEs' innovation performance. International openness and inward FDI can strengthen a region's economy and accelerate technological catch-up (Todtling and Trippl, 2005). It can also stimulate innovation through spillovers, demonstration effects and competition (García et al., 2013; Kafouros and Buckley, 2008). As multinational enterprises

(MNEs) enter the host market, they create relationships with academic institutions to increase the understanding of the market and reduce transaction costs (Chan et al., 2010).

China's FDI policy has traditionally been based on the 'trading market for technology' incentive, which requires foreign companies to transfer technology to China and collaborate with universities (Mu and Lee, 2005). For example, Tsinghua University in Beijing collaborates with various companies, such as IBM, Siemens and Motorola, forming knowledge networks, collecting and circulating R&D information, and establishing training centers (Liu and Jiang, 2001). In this manner, academic institutions gain access to new knowledge and become repositories of the technology and management practices that MNEs bring with them. Thus, the institutions can transfer knowledge and new technology to local firms through academic collaborations, enhancing EMEs' innovation capabilities.

Furthermore, although foreign investment has focused on the relocation of production in the past, many MNEs have recently offshored R&D activities to emerging economies. For example, over 20% of FDI in the pharmaceutical industry is R&D-related, and large pharmaceutical companies, such as Merck and GlaxoSmithKline, have entered drug-discovery alliances with URIs in emerging countries (Haakonsson et al., 2013). Hence, as innovations that are aimed at the world market are generated in collaboration with universities, EMEs can work with leading scientists in regions with higher international openness and develop new capabilities and innovations.

Prior studies also suggest that international openness establishes global pipelines that link emerging countries to developed economies around the world (Bathelt and Li, 2014). In regions with higher international openness, local academic institutions will act as bridges to the new foreign knowledge and technology that flows through such global pipelines. Therefore, domestic EMEs can work with and benefit from more knowledgeable and globally connected URIs. Because FDI reinforces a well-developed regional innovation system (Crescenzi et al., 2013), the unequal geographic distribution of FDI in China may result in significant differences in the performance outcomes of the firm's academic collaborations. Thus, we expect a region's level of international openness to positively moderate the effects of academic collaborations on an EME's innovation performance. Hence:

Hypothesis 2. *The higher the level of international openness is in a given subnational region of an emerging country, the stronger the effects of academic collaborations on an EME's innovation performance will be.*

3.4. Cross-regional variations in the research quality of URIs

Chinese scientists and academics have in recent years significantly increased their scientific publication rate, propelling China to have the second-highest scientific publication rate in the world (Zhang et al., 2013). Nevertheless, administrative decentralization and institutional variations led to an unequal distribution of strong URIs across regions and to investments selectively targeted at the elite URIs, which are predominantly located in eastern and coastal regions (Zhang et al., 2013). The Chinese government implemented a range of policies to resolve this imbalance and to assist URIs in less developed regions to reach the national average by 2020. For instance, the Ministry of Education issued the Revitalization Initiative of Higher Education for the Central and Western Regions, aimed at the development of 'priority' scientific and social disciplines and the improvement of the research and teaching quality of academic staff in universities located in inland China.

In addition, the Chinese government designed policies to assist URIs in such regions, to retain scientific talent, and to attract new and apply for research grants from the central government. However, the quality gap between coastal and inland URIs remains wide. For example, sub-national variations in the quality of academic talent and institutions in China are reflected in the number of 'elite' universities in each region (Eun et al., 2006; Zhang et al., 2013). The average number of academic papers published in international journals per academic in Beijing, Shanghai and Jiangsu are 0.628, 0.593 and 0.251, respectively. These figures are considerably higher than those for Tibet (0.014), Guizhou (0.039) and Xinjiang (0.014) (China Yearbook of Science & Technology, 2013). Similarly, Beijing, Jiangsu, and Shanghai have 26, 11 and 9 elite universities, respectively, whereas Guangxi and Guizhou each have only one university in the elite group. Similarly, the ratio of university faculties with a professor title is 0.20 in Beijing but only 0.04 in Tibet (National Bureau of Statistics of China, 2011).

Furthermore, geographic constraints in knowledge flows are particularly salient due to regional governments' preference for collaborations between local universities and local firms (Hong and Su, 2013). Whereas knowledge and technologies tended to diffuse from elite academics and institutions to firms or other URIs in distant regions under the former planned system, recent reforms and the development of decentralization have affected this support and left regions with second- and third-tier universities further behind (Hong, 2008). This situation leads to a vicious cycle of development and ultimately limits the role of URI-firm collaboration and technological development in these regions.

3.4.1 Effects of the research quality of URIs on academic collaborations

Because of such subnational variations, we expect the effects of academic collaborations on EMEs' innovation performance to depend on the quality of academic talent in URIs in the region in which the firm operates. High-quality, research-active URIs not only provide firms with access to their own knowledge but also act as boundary spanners, connect firms to a broader community of scientists, and translate tacit knowledge to codified knowledge, thus leading to potential innovations (Hess and Rothaemel, 2011). These localized knowledge flows from top-tier academic institutions to businesses may improve firm performance and innovation (George et al., 2002; Kafouros et al., 2012) and enable firms and URIs to develop novel combinations and products together (Zucker and Darby, 1997).

Furthermore, the research quality of URIs is reflected in their knowledge transfer strategies, activities, and engagement with businesses. Research-intensive URIs and academics undertake a considerably greater amount of technology transfer activities aimed at helping businesses compared with less research-intensive universities (Hewitt-Dundas, 2012). Leading research universities employ highly talented scientists, who devote their time to conducting research in cutting-edge technologies and in turn view URI-firm collaborations as a fertile ground for developing and testing theories, commercializing innovations, training students and generating funds for further research (George et al., 2002). Hence, firms that engage in academic collaborations benefit from access to high-quality URIs in the region and may avoid having to travel to engage with top-tier institutions (Doran et al., 2012; Laursen et al., 2011).

By contrast, less research-intensive universities concentrate on teaching and human capital development through professional courses for the local community (Hewitt-Dundas, 2012). They also receive modest research funding and are thus less likely to possess and offer the research resources and capabilities needed for firm innovation (Laursen et al., 2011). Recent research supports the view that such collaborations in China are region specific, indicating that geographic distance has a negative effect on academic collaborations (Hong and Su, 2013). As a result, firms in regions with high-quality academics and 'elite' URIs benefit more from their geographic proximity, whereas firms in less-favored regions are left behind. These differential effects are strengthened when regional governments encourage firms in their jurisdiction to collaborate with local URIs to ensure that R&D investments and subsidies will stay within their territory (Hong and Su, 2013). This imposed local matching of URIs and firms makes the role of region-specific university quality even more important in influencing firms' innovation performance. Accordingly, we introduce our next hypothesis:

Hypothesis 3. *The higher the research quality of URIs is in a given subnational region of an emerging country, the stronger the effects of academic collaborations on an EME's innovation performance will be.*

The theoretical framework is summarized in Figure 1.

(Insert Figure 1 here)

4. Methods and data

4.1. Empirical setting and data

China is a leading country in the world in terms of patent output and R&D expenditures. This remarkable growth in innovative output was accompanied by profound changes in the political, educational and economic institutions of the country over the last three decades. China is currently considered a mid-range emerging economy (Xu and Meyer, 2013). The transition from a planned economy to a market economy is implemented unevenly across regions, creating sub-national disparities in institutional setups and development (Meyer and Nguyen, 2005). Moreover, China's National Innovation System (NSI) is founded on its academic institutions, and the government's goal is for the country to be among the elite global scientific powers (Zhang, et al., 2013). Thus, China provides an appropriate setting for testing our framework and examining how region-specific idiosyncrasies influence the relationship between academic collaborations and firms' innovation performance.

We draw our data from a unique firm-level dataset entitled the 'Innovation-Oriented Firms Database' (IOFD), which is compiled annually by the Ministry of Science and Technology of China (MSTC). This database is based on a survey of the 400 most innovative Chinese firms, which are selected for the survey based on five aspects of their performance: R&D intensity, the number of granted patents per thousand R&D personnel, the ratio of new product sales to total revenue, their labor productivity, and innovations related to organization and management. These criteria are line with the definition of active and innovative firms in the Oslo Manual (OECD, 2005). The surveyed firms undergo a screening by the MSTC to check that they meet the required criteria, namely, to have a minimum threshold for R&D intensity, have developed patents and have introduced product, process or service innovations in last three calendar years. Successful entrants receive a government subsidy subject to completing the survey each year.

The use of this unique dataset has three important advantages. First, to the best of our knowledge, this is one of the most detailed innovation surveys in China. Second, there is a high reliability among the reported data, as this is not an independent, self-administered survey but is instead administered and managed by the Chinese government. Third, despite the relatively small size of the sample, the surveyed firms are well represented in terms of ownership, industrial and geographic coverage. They consist of both state and non-state owned firms, spanning 22 three-digit industries in medicine, general machinery, electrical appliances and communications and computers and all 31 provinces in China (excluding Hong Kong, Macau and Taiwan). After excluding some outliers, the final sample consists of 375 firms with complete data for the period between 2008 and 2011.

Table 1 shows the demographic characteristics of the sampled firms. Section A shows that the Eastern region accounts for approximately half of the firms, whereas the Central and Western regions each account for slightly less than one quarter of the firms. This pattern is in line with the more rapid economic development and growth of eastern coastal regions compared to inland regions. Furthermore, the sampled firms' ownership structure exhibits comparative symmetry, which shows an equal representation of firms in terms of the share of state assets (those between 50% and 100% and those with lower than 50%). Furthermore, government research institutes are the largest receivers of government funding (in 2006, R&D expenditure for research institutes and universities comprised 49.4% and 15.2% of the total expenditures, respectively) (OECD, 2009). In addition, most non-state controlled businesses fund R&D projects with universities (36.6%) instead of institutes (4.5%) (OECD, 2009). Hence, SOEs in the Western and Central regions tend to collaborate more with government-controlled research institutes. As noted earlier, this trend is also consistent with regional protectionism and local authorities' preference to match local firms to local URIs. Many firms in the Western and Central regions may be SOEs that have substantial in-house R&D capabilities and collaborate with public research institutes rather than universities. In contrast, in the Eastern region, non-state firms dominate and tend to rely more on universities rather than public research institutes. In terms of industry distribution, Section B shows five two-digit industries with the highest number of firms - these together accounted for over 58% of the sampled firms. Therefore, we can control for the industrial effects by concentrating on these five industries.

(Insert Table 1 here)

To test the representativeness of our sampled firms, we collected data from the Annual Report of Industrial Enterprise Statistics (ARIES), obtained from the State Statistical Bureau of China. The ARIES is one of the most comprehensive firm-level dataset ever compiled by the Chinese statistical office, accounting for approximately 90 percent of total output in most industries[2]. It includes manufacturing firms with an annual turnover of over five million Renminbi. Because our sample focuses on innovation-oriented firms only, we derived a further sub-sample from the ARIES (15,943 firms in 2007) containing R&D-intensive firms, and selected firms with above-average R&D intensity (3,817 firms). We used this latter sub-sample to test the representativeness of our study's sample.

More specifically, we conducted t-tests to examine the representativeness of our sample in terms of R&D intensity (in 2008) and innovation performance (in 2009 due to the use of a time lag), which are commonly accepted as the two of the most important indicators of innovative

[2] Different versions of this dataset have been used in previous studies (e.g., Wang et al., 2012; Yi et al., 2009).

firms (Table 2 provides a definition of these variables). The results show that we can reject the null hypothesis; there is no difference between our sample and the population (t ratio=0.681 for R&D intensity and t ratio=1.578 for innovation performance). Therefore, although our sample cannot be regarded as large, it can fairly represent the population of innovation-oriented or R&D-intensive firms in China.

4.2. Measures

4.2.1. Dependent variable

The dependent variable, *innovation performance*, is measured by the share of new product sales, i.e., products new to the firm, new to the domestic market and new to foreign markets, over total sales. Similar measures have been widely used in previous studies (e.g., Berchicci, 2013; Laursen and Salter, 2006; OECD, 2005). Although the number of patents was available to us and has been used in other studies, it fails to capture the broad range of innovations developed by a company. In addition, not all innovations require patenting. Furthermore, as the propensity of patent applications varies considerably across different industries (Griliches, 1990) and can lead to estimation biases, we decided not to use this measure.

4.2.2. Independent variables

Our key independent variable, *academic collaboration,* refers to a firm's degree of collaboration with academic institutions. It is measured as the ratio of the firm's R&D spending on collaborations with URIs to total R&D expenditures. These collaborations consist of cooperated R&D, contracted R&D and other technological consultancy services. Because it is a continuous variable, this operationalization better captures the extent of academic collaboration than merely reporting whether firms collaborate with URIs. Ideally, we would prefer to exclude R&D expenditure used for collaboration with URIs from other regions. However, our dataset does not allow us to create separate measures for intra- and inter-regional collaborations. Nevertheless, prior evidence shows that the vast majority of firm-URI collaborations are in the same region (Hong, 2008) and that when a firm and URI are controlled or owned by the same ministry or the same local government, their probability of collaboration increases by approximately 25% and 64% (Hong and Su, 2013). Because much of the knowledge transferred between URIs and firms is tacit and requires interaction (Polanyi, 1967), there is a consensus in the literature (see Hong, 2008 for a review of the evidence) that firms are more likely to collaborate with URIs that are geographically close.

Indeed, evidence from different countries indicates that geographic distance acts as an important constraint on firm-university collaboration (Anselin et al., 1997; Audrestch and Feldman, 1996; Branstetter, 2000; Jaffe, 1989), which becomes even more difficult in large countries such as China. Indeed, Hong (2008) finds a strong localizing trend in knowledge flows from universities to firms in China. Abramovsky and Simpson (2011) suggest that chemical firms in the UK tend to collaborate with universities that are within a 10 km radius. Similarly, using Chinese patents, Hong and Su (2013) demonstrated that geographic distance impedes firm-university collaborations. Therefore, although our measure may include some inter-regional collaboration in some cases and is not as accurate as distinct measures of intra- and inter-regional collaborations, this aspect is not likely to introduce a serious bias in the results.

Furthermore, because academic collaboration comes with a set of benefits and costs, its effect on firms' innovation performance might not be linear and monotonic. For several reasons, the performance effects of academic collaboration may begin to decline and eventually become negative when the degree of such collaboration goes beyond a certain threshold. Although the number of potential combinations increases with increasing URI-firm collaboration, an excessive degree of university collaboration may significantly increase an EME's governance, coordination and managerial costs (Mindruta, 2013). Because innovation requires managerial time and accurate planning, managers must focus their efforts and energy on a limited number of tasks (Ocasio, 1997). A particularly high degree of URI-firm engagement may also increase the risk of knowledge leakage (McEvily and Zaheer, 1999). Hence, when the degree of academic collaboration is particularly high, the costs of university collaborations may outweigh their benefits, thus leading to an inverse U-shaped relationship.

Three variables may moderate the effects of academic collaborations. Region-specific *IPR enforcement* is measured as the ratio of settled IP infringements to the total number of IP infringements in a region. The data are obtained from the website of the State Intellectual Property Office of China (SIPO). According to the SIPO, IPR violation is defined as the production, use and sale of products using patents of other people and organizations without the legal permission of the IP holder. These include violations of IP rights, other disputes related to IPR and counterfeit products. Because the cases that are referred to government agencies and courts might take more than one year to settle, we used an accumulated measure.

In previous studies, IPR enforcement has typically been measured by either survey-based perception of IPR enforcement (see Lanjouw and Lerner, 1997) or the existence of mechanisms for enforcement (e.g., Park and Ginarte, 1997; Zhao, 2006). The former is subjective and depends on who is surveyed, whereas the latter considers the existence of enforcement laws without considering the effectiveness of these laws (i.e., the outcomes). By contrast, our operationalization focuses on the outcomes of IPR enforcement. Although better enforcement can encourage innovative activities by mitigating the risks of expropriation and information asymmetry, better enforcement could also exert a negative impact on innovation. Stronger IPR enforcement can impede innovation activities by constraining inter-organizational knowledge flows because of limited disclosures of the details of invention in the patent application and the resulting accumulation of sleeping patents (Bessen and Maskin, 2000; Gilbert and Newbery, 1982). Strong IPR protection can also become an obstacle for future innovations that cumulatively build on previous fundamental knowledge and technologies because they can inhibit the exploration and exploitation of alternative applications of the patented invention (Dosi, et al. 2006). For example, Mergers and Nelson (1994) demonstrate how a strong IPR regime significantly slowed the pace of aircraft development in the USA.

Because our hypotheses rely on the outcomes of IPR *enforcement*, it is appropriate to measure this parameter instead of the existence of IPR laws (which tend to be the same across regions). This operationalization is suitable because although China signed major international IP treaties[3], there are discrepancies between the written laws and their enforcement at the local and subnational levels (Ang et al., 2014). Furthermore, unlike in developed countries, IP infringements in China have a 'dual enforcement' system that allows holders of IP rights to use

3 According to prior research (e.g., Park and Ginarte, 1997), the Paris Convention, the Patent Cooperation Treaty (PCT), and International Convention for the Protection of New Varieties of Plants (UPOV)) are the three major international agreements. China has membership in all three agreements.

either civil or administrative mechanisms to resolve IP disputes. Therefore, the degree of region-specific IPR enforcement captures how effectively IP infringements are addressed in each region (despite the fact that IPR laws are set by central governments and are similar for all regions; Ang et al., 2014). Thus, a higher ratio of settled IP infringements to the total number of reported IP infringements in a region leads to a stronger IPR regime in the region.

Region-specific *international openness* is measured by the ratio of inward FDI to GDP in a given region. This value captures both foreign Western capital and investments from Hong Kong, Macao and Taiwan. This operationalization is consistent with prior studies (e.g., Cuadros et al., 2004; Fan et al., 2010). The region-specific *research quality of URIs* is operationalized by the average number of academic papers published in international journals per academic in a given region. This measure is consistent with prior studies that considered URIs in emerging countries (e.g., Zhang et al., 2013). Over 96% of these publications are in the areas of science, technology, engineering and mathematics (STEM) (National Bureau of Statistics of China, 2013). Because the performance of the scientific achievements of university professors is largely reflected in their international research publications, a higher average number of publications in a given region suggests that more ‘star’ academics and higher-quality URIs are present in that region.

4.2.3. Control variables

We control for a number of firm-specific idiosyncrasies. We measure *firm size* using the logarithm of total number of employees. *Firm age* is calculated using the number of years since a firm’s establishment. We control for the R&D resources and capabilities of the firm using three R&D-related variables. First, *R&D intensity* is measured as the ratio of R&D expenditures to the total number of employees. Second, *overseas R&D* is operationalized using a dummy that equals 1 if the company has an R&D center overseas and 0 otherwise. Third, the firm’s *patent stock* can influence the development of new products in the following years. We include this variable, which is measured as the logarithm of the amount of patent stock. As diversification can impact innovation both positively and negatively (Jarrar and Smith, 2011), we also control for the firm’s *diversification* using a dummy that equals 1 if the company is diversified covering at least 2 two-digit industries and 0 otherwise. Furthermore, the *state ownership* of the company influences innovation performance. We control for this variable using a dummy that equals 1 if the share of state-owned assets is greater than 50 percent in a given firm and 0 otherwise. Finally, we control for time and industry effects. We created an industry dummy that is equal to 1 if the company is affiliated with one of the five 2-digit industries and 0 otherwise, as shown in Table 1. Time controls are operationalized by assigning a dummy that is equal to 1 if associated with the corresponding year and 0 otherwise. Table 2 provides a summary of the variables and their definitions.

(Insert Table 2 here)

4.3. Econometric model and estimation method

Because the value of the dependent variable ranges from 0 to 100, it does not satisfy the assumption of an even distribution on number lines without interception. Therefore, a Tobit model is applied (Wooldridge, 2002), which is the established practice in innovation studies that use a similar dependent variable (e.g., Berchicci, 2013; Laursen and Salter, 2006; Tsai, 2009). In addition, the difficulty in fulfilling the requirement for the normality of residuals necessitates the use of a logarithmic transformation for the dependent variable (for details, please see Table 2). We also use lags for all independent variables for one year to account for the fact that innovation takes time to materialize. The adoption of this lag structure also alleviates potential simultaneity between URI-firm collaborations and innovation performance.

Unobserved heterogeneity is a typical problem in panel data analysis. This phenomenon occurs because 'each firm contributes multiple observations that are not independent from each other' (Jensen and Zajac, 2004). This situation increases the possibility that current innovation performance appears to influence firm decisions. We have included a large number of control variables (patent stock in particular) that should alleviate some of these concerns (Blundell *et al.*, 1995). However, there might be other firm-level idiosyncrasies that can still influence the results. A common approach to address this problem is to use either fixed or random effects (Sayrs, 1989), both of which can accommodate unobserved heterogeneity.

We chose random-effects models for two reasons. First, fixed-effects models are less efficient than random-effects models because of the lost degree of freedom (Wooldridge, 2002). Fixed-effects models may lead to biased estimates by producing inflated standard errors for variables that exhibit little variation within units. More importantly, fixed-effects models tend to produce biased results when the time period is short (Chintagunta et al., 1991; Heckman, 1981). As our data cover only 4 years, fixed-effects models are not appropriate. Second, as Tobit is a non-linear function and the likelihood estimator for fixed effects is biased and inconsistent, fixed-effect estimates cannot be realized in the panel Tobit model. By contrast, random effects utilize between-unit variations and allow for different intercepts. Nevertheless, the pooled estimate allows us to use the fixed-effects models (Cameron and Trivedi, 2010) and thus make a comparison with random-effects models. All F tests (in Tables 4 and 4A) reject the fixed-effect option and support the random-effect estimates.

5. Results

Table 3 reports the descriptive statistics for the variables. Most of the correlations are fairly low (except those between firm size and patent stock), and the variance inflation factors range from 1 to 6.75, with a mean of 1.83. These factors are all well below the acceptable level of 10 (Ryan, 1997). Following the typical practice (Aiken and West, 1991), we mean-centered the interaction terms to alleviate potential multicollinearity problems and to increase the interpretability of the findings (Aiken and West, 1991).

(Insert Table 3 here)

Table 4 reports the regression results. Model 1 includes only the control variables and serves as the baseline model. Model 2 includes both the linear and squared terms of academic collaborations. The linear term is positive, but the squared term is negative. The results predict an inverse U-shaped relationship between URI-firm collaborations and firms' innovation performance. The point at which the benefits of academic collaboration begin to decline can be estimated by taking the partial derivative of Model 2 with respect to the academic collaboration variable. This partial derivative represents the slope of the innovation performance curve with respect to academic collaboration. It implies that innovation performance reaches a maximum point (the critical level of academic collaboration) and subsequently declines as the negative effects dominate the positive effects with rising levels of academic collaboration. The turning point was found to be 0.209, or 20.9%. Therefore, in accordance with our previous discussion, there is an optimal level of engagement a firm can have with academic institutions before its innovation performance begins to deteriorate.

Surprisingly, IPR enforcement has a negative direct effect on innovation performance (Models 3 and 6). One possible explanation for this result is that a share of sales of 'new products' in Chinese firms relies on the imitation of existing products and the recombination of existing components that can be found from outside (a practice known as architectural innovation). Indeed, many EMEs possess a good functional understanding of external technologies (Wu et al., 2010), which can be used to develop innovations using inputs available from the market. In such cases, stronger IPR enforcement may be beneficial for companies that generate new technologies themselves but may have adverse effects for companies that rely on external technologies and knowledge spillovers. Furthermore, previous research also suggests that enforcing stronger IPR mechanisms in developing economies that rely on advanced technologies and imitation of products from developed countries will reduce the rate of EMEs' innovation (Lai, 1998).

Models 3-5 present the results for the hypotheses.[4] Model 3 illustrates that the coefficient of the interaction term between academic collaboration and IPR enforcement is statistically significant, providing support for H1. This observation means that stronger IPR enforcement in a region increases the positive effects of academic collaborations on a firm's innovation performance. Furthermore, the interaction term between academic collaboration and international openness in Model 4 is positive and statistically significant. Hence, H2 is also supported. H3 suggests that the innovation performance effects of academic collaboration will be stronger in regions with higher-quality URIs. The relevant interaction term in Model 5 is statistically significant and positive, corroborating H3. To better explain the moderating effects of region-specific institutions, these relationships are presented in Figure 2.

(Insert Table 4 here)

(Insert Figure 2 here)

5.1. Robustness checks

---

[2] Following similar studies (e.g., Grimpe and Kaiser, 2010; Berchicci, 2013), we do not include the interactions between the squared term and moderators.

We performed various analyses to ensure that our findings are robust. One concern arises from the potential correlation between academic collaboration and the error term due to possible simultaneity between academic collaboration and innovation performance. As improvements in innovation performance can lead to increases in academic collaboration, they may result in an upward bias of the estimated effects of academic collaboration. Thus, although our use of random-effects models can alleviate the concern of unobserved heterogeneity, it is important to check whether academic collaboration is endogenous. We use the Dubin-Wu-Hausman method to test for endogeneity. We first identified valid instrumental variables (IVs). A valid instrument should be correlated with the key explanatory variables and also be orthogonal to the error term.

Following Berchicci (2013), we choose *industry-level academic collaboration* and *strategic alliance* as instruments. Industry-level academic collaboration is defined as the average ratio of the firm's R&D spending on collaborations with URIs to the total R&D expenditures in an industry. Strategic alliance is a dummy that equals 1 if the firm is involved in a strategic alliance and 0 otherwise. The industry-level academic collaboration is selected because it may account for an important part of a firm's academic collaboration at the firm level. Similarly, involvement in strategic alliances is also closely related to the level of a firm's academic collaboration. The Hansen tests of over-identification in Table 4 confirm that these instruments are valid and not correlated to the error term. Using these two instruments, the Dubin-Wu-Hausman tests in Table 4 show that the variable of academic collaboration (including the squared term and its interactions) is exogenous except in Model 5.[5] Therefore, our results are not biased by potential endogeneity pertaining to the academic collaboration variable.

Second, to overcome potential heterogeneity and autocorrelation problems that are typical of panel data, we examined the validity of our results using robust standard errors. Due to the unfeasibility of using the traditional White method in the Tobit model, we employed the bootstrap method (Cameron and Trivedi, 2010). The results are presented in Table 4A. The

[5] This finding may explain why the coefficient of the interaction term between academic collaboration and the research quality of universities is significant in Model 5 but not in Model 6 (the full model).

new results are qualitatively similar to those reported in Table 4 except for the interaction term between academic collaboration and the research quality of URIs, which is now insignificant.

Third, because innovation can significantly contribute to productivity (Hall et al., 2009), we use the ratio of new product sales to the number of employees as the dependent variable to re-estimate the models. The results are qualitatively identical to those reported in Table 4. Finally, we have included all variables including interactions in one regression (Model 6 in Tables 4 and 4A). The first two interaction terms remain qualitatively unchanged (supporting H1 and H2), but the interaction term of academic collaboration and the research quality of URIs is now insignificant, thus lending no support for H3.

(Insert Table 4A here)

6. Discussion and Conclusion

6.1. Theoretical Implications

Our study challenges the assumption of institutional homogeneity within a given country. We argue that sub-national institutional variations within China determine IPR enforcement, international openness, the quality of URIs and thus the role of academic collaborations in enhancing the innovativeness of Chinese EMEs. Our findings have several implications for research pertaining to the effects of academic collaborations on a firm's innovation performance and the sources of competitive advantages that enable EMEs to innovate.

First, although research recognizes the role of institutions in shaping the innovation performance of firms from developed economies, little is known about the ways in which institutions influence firms' innovation in emerging countries and how such effects differ from those in developed countries (Xu and Meyer, 2013). Although Western country firms are not completely self-sufficient, they often invest in internal R&D capabilities for several decades and build their innovation models around a set of mature and homogeneous institutions and established innovation systems. By contrast, EMEs are at an early stage of innovation and can only rarely be self-sufficient. Hence, they not only innovate in a different environment but also exhibit greater dependence on their environment. In the Chinese context, the political and institutional transformation gives regional governments a high degree of authority and autonomy (Chan et al., 2010). Our findings reveal that such region-specific institutional idiosyncrasies affect the outcomes of academic collaborations and may explain why EMEs' innovation strategy, which relies heavily on URIs, improves their position in the global race for technological leadership. Because our analysis extends beyond the boundaries of the firm to explain the origins of innovation in emerging countries, it deviates from established innovation theories for developed countries that emphasize the importance of a firm's own innovative capabilities.

Second, we demonstrate how cross-regional institutional variations influence IPR enforcement, international openness and the research quality of URIs and thus the effectiveness of academic collaborations in enhancing a firm's innovation performance. Because our approach explains why academic collaborations are more beneficial in some regions than in others, it helps us establish a conceptual link between two important yet previously isolated bodies of literature, namely, those on academic collaborations and those on regional innovation systems. By showing that the value of academic collaborations depends on the specific combinations of firm-specific factors and location-specific institutions, we complement the research on regional innovation systems (e.g., Edquist, 1997; Kumaresan and Miyazaki, 1999) that has neglected the role of institutions (Doloreux and Parto, 2005). Furthermore, by showing that the effectiveness of academic collaboration depends on the strength of IPRs, the level of international openness and the research quality of URIs in a region, we extend previous research that has neglected subnational differences (e.g., Fabrizio, 2006; George et al, 2002; Roper and Hewitt-Dundas, 2013; Zucker and Darby, 1997). We show that such variations can explain why two collaborative agreements that involve partners with similar characteristics may yield different innovation outcomes in different regions of the same emerging country.

Finally, our findings reveal that collaboration with URIs enhances a firm's innovation performance but only to a certain threshold. The finding of an inverse U-shaped relationship between university collaborations and innovation performance supports the view that the over-utilization of external knowledge and technology may hinder a firm's innovation performance (Berchicci, 2013; Laursen and Salter, 2006; Katila and Ahuja, 2002). This negative marginal effect, which is found when firms over-engage with universities, might be particularly pronounced for emerging market innovators because of their limited absorptive capacity and limited internal R&D capabilities (Motohashi and Yun, 2007; Zahra and George, 2002). Insufficient absorptive capacity makes it difficult for these firms to move away from a set of internal processes and to reconfigure the way in which value is created by managing the external-oriented innovation processes. It also makes it more difficult for them to cope with the challenges that over-search and over-openness create (Grönlund et al., 2010). This finding has implications for the current thinking about the balance between the development of internal innovative (and absorptive) capabilities and reliance on external sources of knowledge.

6.2. Management and Policy Implications

One practical implication concerns the way in which different regions in emerging countries can benefit from collaborations with URIs. Our findings suggest that governments that aim to stimulate innovation in their territories should implement policies in ways that shape the development of region-specific and innovation-supporting institutions. Rather than merely relying on conventional science and technology policies that focus on the supply side of R&D and the individual firm (e.g., the direct provision of R&D subsidies and venture capital), governments should also formulate policies that create institutional conditions that enhance the effects of URI-firm collaborations.

The government can influence three conditions to enhance the effectiveness of such collaborations. First, regional authorities should strengthen IPR enforcement in their jurisdictions and 'allow' for impartial justice in IP infringements. This behavior may have a negative effect on the innovation performance of some firms in the short run but may encourage firms to develop their own technological capabilities. Second, local governments should consider the implementation of international openness policies that facilitate links between their regions and the knowledge bases in developed economies around the world and which further encourage foreign firms to outsource R&D to local universities, thus enhancing the value of URI-firm collaborations. Third, because star scientists act as a bridge between universities and other sources of upstream knowledge (Hess and Rothaermel, 2011), regional governments should improve the research quality of universities by creating an environment that keeps leading academics and enable them to best utilize their talent.

Finally, our analysis suggests that over-engagement with academic institutions can be detrimental to a firm's innovation performance. Hence, it may be advantageous for firms to have fewer but more valuable academic collaborations. Accordingly, managers will have the time to establish shared processes, address initial ambiguities and communication gaps, and create a better fit with academic institutions (Liebeskind et al., 1996; Prahbu, 1999: Rotaermel and Deeds, 2006).

6.3. Limitations and Directions for Future Research

The first limitation of this study concerns the generalizability of the results. The firms in our sample are R&D-intensive firms and may not represent many other Chinese firms that invest little in R&D. Although the firms in our sample span a variety of sectors, they are all based in one emerging economy. Although China is leading the way in terms of innovation, the region-specific institutional idiosyncrasies that form the basis of our framework may differ in other emerging countries. Examining whether and which institutional factors in other emerging countries moderate the effects of academic collaboration on firms' innovation performance is a worthwhile avenue for future research.

Second, due to data constraints, we could not examine the informal contacts between firms and academic institutions. Academic collaborations, despite being common and highly valued, are often informal and thus rarely officially acknowledged (Zucker and Darby, 1997). Such informal links take the form of networking activities and personal relationships between firm members and academics. Although these links can enhance firms' knowledge bases, firms often underestimate their real value because they are not product- or solution-oriented (Feller et al., 2002). Future research can overcome this shortcoming by devising specific survey measures to capture these informal links and their effects on innovation performance.

In summary, we have argued that because innovation, URI-firm collaboration and institutional theories have been created with developed countries in mind, they rest on a set of assumptions that are not always adequate to explain EMEs' innovation models. Because institutions are government-controlled and region-specific, they create a unique innovation milieu that moderates the effectiveness of academic collaborations in improving innovation performance. The firms in our sample compensate for their limited internal R&D capabilities by pursing an innovation strategy that heavily relies on academic collaborations. Depending on the effects of region-specific institutional idiosyncrasies on and the degree of academic collaborations, emerging market firms can increase their innovation performance and thus their ability to become more competitive.

References

Abramovsky, L.; Simpson, H. 2011. Geographic proximity and firm–university innovation linkages: evidence from Great Britain. Journal of Economic Geography, 11, 949–977.

Aiken, L.S., West, S.G., 1991. Multiple Regression: Testing and Interpreting Interactions. Sage Publications, Newbury Park, CA.

Ang, J.S., Wu, C., Cheng, Y. 2014. Does Enforcement of Intellectual Property Rights Matter in China? Evidence from Financing and Investment Choices in the High Tech Industry. *Review of Economics and Statistics*, 96(2), 332-348.

Anselin, L., Varga, A., Acs, Z., 1997. Local geographic spillovers between university research and high technology innovations. Journal of Urban Economics 42, 422‑448.

Asheim, B.T., Coenen, L., 2005. Knowledge bases and regional innovation systems: comparing Nordic clusters. Research Policy 34(8), 1173-1190.

Audretsch, D. B., Feldman, M. P. 1996. R&D spillovers and the geography of innovation and production. American Economic Review 86: 630–640.

Bathelt, H., Li, P.F., 2014. Global cluster networks—foreign direct investment flows from Canada to China. Journal of Economic Geography doi:10.1093/jeg/lbt005.

Berchicci, L., 2013. Towards an open R&D system: internal R&D investment, external knowledge acquisition and innovative performance. Research Policy 42(1), 117-127.

Bessen, J., Maskin, E. 2004, Sequential innovation, patents, and imitation. Working paper 00-01, Department of Economics, MIT, Cambridge.

BIS, 2011. Department for Business Innovation & Skills: First findings from the UK innovation survey 2011.

Blundell, R., Griffith, R., Van Reenen, J. 1995. Dynamic count data models of technological innovation. Economic Journal 105(429), 333-344.

Boisot, M., Meyer, M. W. 2008. Which way through the open door? Reflections on the internationalization of Chinese firms. Management and Organization Review 4(3), 349-365.

Bosker, M., Garretsen, H., 2009. Economic development and the geography of institutions. Journal of Economic Geography 9(3), 295-328.

Bradley, S.W., McMullen, J.S., Artz, K., Simiyu, E.M., 2012. Capital is not enough: Innovation in developing economies. Journal of Management Studies 49(4), 684-717

Branstetter, L., 2000. Measuring the Link Between Academic Science and Industrial Innovation: the Case of California’s Research Universities. NBER Summer Institute.

Bruneel, J., D’Este, P., Salter, A., 2010. Investigating the factors that diminish the barriers to university–industry collaboration. Research Policy 39(7), 858–868.

Cameron, A.C., Trivedi, P.K., 2010. Microeconometrics Using Stata, Revised edition ed. Stata Press, College station.

Carson, S.J., John, G., 2013. A theoretical and empirical investigation of property rights sharing in outsourced research, development, and engineering relationships. Strategic Management Journal 34, 1065-1085.

Chan, C.M., Makino, S., Isobe, T., 2010. Does subnational region matter? foreign affiliate performance in the United States and China. Strategic Management Journal 31(11), 1226-1243.

Chang, P-L., Shih, H.Y., 2004. The innovation systems of Taiwan and China: a comparative analysis. Technovation 24(7), 529-539.

Chang, S-J, Wu, B., 2013. Institutional barriers and industry dynamics. Strategic Management Journal doi: 10.1002/smj.2152

Chintagunta, P.K., Jain, D.C., Vilcassim, N.J. 1991. Investigating heterogeneity in brand proferences in logit models for panel data. Journal of Marketing Research 28(4), 417-428.

Cohen, W.M., Nelson, R.R., Walsh, J.P., 2002. Links and impacts: the influence of public research on industrial R&D. Management Science 48(1), 1-23.

Crescenzi, R., Pietrobelli, C., Rabellotti., R., 2013. Innovation drivers, value chains and the geography of multinational corporations in Europe. Journal of Economic Geography doi:10.1093/jeg/lbt018.

Cuadros, A., Orts, V., Alguacil, M., 2004. Openness and growth: re-examining foreign direct investment, trade and output linkages in Latin America. Journal of Development Studies 40(4), 167-192.

Doloreux, D., Prato, S., 2005. Regional innovation systems: current discourse and unresolved issues. Technology in Society 27(2), 133-153.

Doran, J., Jordan, D., O'Leary, E., 2012. The effects of the frequency of spatially proximate and distant interaction on innovation by Irish SMEs. Entrepreneurship & Regional Development: An International Journal 24(7-8), 705-727.

Dosi, G., Marengo, L., Pasquali, C., 2006. How much should society fuel the greed of innovators? On the relations between appropriability, opportunities and rates of innovation. Research Policy 35, 1110-1121.

Drejer, I., Vinding, A.L., 2007. Searching Near and Far: Determinants of Innovative Firms' Propensity to Collaborate Across Geographical Distance. Industry and Innovation 14(3), 259-275.

Edquist, C., 1997. Systems of innovation approaches—their emergence and characteristics, in: Edquist, C. (Ed), Systems of Innovation. Pinter, London, pp. 1–35.

Eun, J-H., Lee, K., Wu, G., 2006. Explaining the "University-run enterprises" in China: a theoretical framework for university–industry relationship in developing countries and its application to China. Research Policy 35(9), 1329-1346.

Eom, B-Y., Lee, K., 2010. Determinants of industry–academy linkages and, their impact on firm performance: The case of Korea as a latecomer in knowledge industrialization. Research Policy 39(5), 625-639.

Fabrizio, K.R., 2006. The use of university research in firm innovation, in Chesbrough, H., Vanhaverbeke, W., West, J. (Eds), Open Innovation: Researching a New Paradigm. Oxford University Press, Oxford, pp. 134-160.

Fan, G., Wang, X., Zhu, H., 2010. NERI Index of Marketization of China's Provinces 2009 Report. Economic Science Press, Beijing.

Feller, I., Ailes, C.P., Roessner, J.D., 2002. Impacts of research universities on technological innovation in industry: evidence from engineering research centers. Research Policy 31(3), 457-474.

García, F., Jin, B., Salomon, R., 2013. Does inward foreign direct investment improve the innovative performance of local firms? Research Policy 42(1), 231-244.

George, G., Zahra, S.A., Wood, D.R., 2002. The effects of business–university alliances on innovative output and financial performance: a study of publicly traded biotechnology companies. Journal of Business Venturing 17(6), 577-609.

Gilbert, R.J., Newbery, D.M.G. 1982, Preemptive patenting and the persistence of monopoly. American Economic Review 72(3), 514-526.

Griliches, Z., 1990. Patent statistics as economic indicators: a survey. Journal of Economic Literature 28(4), 1661-1707.

Grönlund, J. Rönnberg Sjödin, D., Frishammar, J., 2010. Open innovation and the stage-Gate process: a revised model for new product development. California Management Review 52(3), 106-131.

Grimpe, C., Kaiser, U., 2010. Balancing internal and external knowledge acquisition: the gains and pains from R&D outsourcing. Journal of Management Studies 47(8), 1483-1509.

Haakonsson, S.J., Jensen, P.D.O, Mudambi, S.M., 2013. A co-evolutionary perspective on the drivers of international sourcing of pharmaceutical R&D to India. Journal of Economic Geography doi:10.1093/jeg/lbs018.

Hall, B.H., Lotti, F., Mairesse, J., 2009. Innovation and productivity in SMEs: empirical evidence for Italy. Small Business Economics 33(1), 13-33.

Heckman, J. 1981. Statistical models for discrete panel data. In D. McFadden and C. Manski (eds.), The Econometrics of Panel Data. MIT Press, Cambridge, MA, 114-178.

Hershberg, E., Nabeshima, K., Yusuf, S., 2007. Opening the Ivory Tower to business: university–industry linkages and the development of knowledge-intensive clusters in Asian cities. World Development 35(6), 931-940.

Hess, A.M., Rothaermel, F.T., 2011. Why are assets complementary? Star scientists, strategic alliances, an innovation in the pharmaceutical industry. Strategic Management Journal 32(8), 895-909.

Hewitt-Dundas, N., 2013. The role of proximity in university-business cooperation for innovation. Journal of Technology Transfer 38, 93-115.

Hewitt-Dundas, N., 2012. Research intensity and knowledge transfer activity in UK universities. Research Policy 41(2), 262-275.

Hong, W., 2008. Decline of the center: The decentralizing process of knowledge transfer of Chinese universities from 1985 to 2004. Research Policy 37(4), 580-595.

Hong, W., Su, Y.S., 2013. The effect of institutional proximity in non-local university–industry collaborations: An analysis based on Chinese patent data. Research Policy 42(2), 454-464.

Howells, J., Ramlogan, R., Cheng, S-L., 2012. Innovation and university collaboration: paradox and complexity within the knowledge economy. Cambridge Journal of Economics 36(3), 703-721.

Hu, A.G.Z., 2007. Technology Parks and regional economic growth in China. Research Policy 36(1), 76-87.

Jaffe, A.B., 1989. Real effects of academic research. American Economic Review 79(5), 957-970.

Jean, R.J.B., Sinkovics, R.R, Hiebaum, T.P., 2014. The Effects of Supplier Involvement and Knowledge Protection on Product Innovation in Customer–Supplier Relationships: A

Study of Global Automotive Suppliers in China. Journal of Product Innovation Management 31(1), 98–113

Kafouros, M., Buckley, P.J., 2008. Under what conditions do firms benefit from the research efforts of other organizations? Research Policy 37(2), 225–239.

Kafouros M., Buckley, P.J., Clegg, L.J., 2012. The effects of global knowledge reservoirs on the productivity of multinational enterprises: the role of international depth and breadth. Research Policy 41(5), 848-861.

Katila, R., Ahuja, G., 2002. Something Old, something new: a longitudinal study of search behavior and new product introduction. Academy of Management Journal 45(6), 1183–1194.

Keupp, M.M., Friesike, S., von Zedtwiz, M., 2012. How do foreign firms patent in emerging economies with weak appropriability regimes? Archetypes and motives. Research Policy 41(8), 1422-1439.

Khanna, T., Palepu, K., 1997. Why focused strategies maybe wrong for emerging markets. Harvard Business Review 75(4), 41-51.

Kumaresan, N., Miyazaki, K., 1999. An Integrated Network Approach to Systems of Innovation--the Case of Robotics in Japan. Research Policy 28(6), 563-585.

Lai. E.L.C., 1998. International intellectual property rights protection and the rate of product innovation. Journal of Developmental Economics 55, 133-153.

Lanjouw, J., Lerner. J., 1997. The enforcement of intellectual property rights: A survey of the empirical literature. NBER Working paper W6296.

Laursen, K., Reichstein, T., Salter, A., 2011. Exploring the Effect of Geographical Proximity and University Quality on University–Industry Collaboration in the United Kingdom. Regional Studies 45(4), 507-523.

Laursen, K., Reichstein, T., Salter, A., 2011. Exploring the Effect of Geographical Proximity and University Quality on University–Industry Collaboration in the United Kingdom. Regional Studies 45(4), 507-523.

Laursen, K., Salter, A., 2006. Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms. Strategic Management Journal 27(2), 131-150.

Lee, Y.S., 1996. ‘‘Technology transfer’’ and the research university: a search or the boundaries of university–industry collaboration. Research Policy 25(6), 843–863.

Li, X., 2012. Behind the recent surge of Chinese patenting: An institutional view. Research Policy 41, 236-249.

Li, J., Qian, C., 2013. Principal-principal conflicts under weak institutions: a study of corporate takeovers in China. Strategic Management Journal 34(4), 498-508.

Liebeskind, J.P., Oliver, A.L., Zucker, L.G., Brewer, M.B., 1996. Social networks, learning, and flexibility: sourcing scientific knowledge in new biotechnology firms. Organization Science 7, 428-443Liu, F.C., Simon, D.F., Sun,Y.T., Cao, C., 2011. China’s innovation policies: Evolution, institutional structure, and trajectory. Research Policy 40(7), 917-931.

Liu, H., Jiang, Y., 2001. Technology transfer from higher education institutions to industry in China: nature and implications. Technovation 21(3), 175-188.

Liu, Z., 2013. Human capital externalities in cities: evidence from Chinese manufacturing firms. Journal of Economic Geography doi:10.1093/jeg/lbt024.

Jarrar, N.S., and Smith, M. 2011. Product Diversification: The Need for Innovation and the Role of a Balanced Scorecard. Journal of Applied Management Accounting Research, 9(2), 43-60.

Jensen, M., and Zajac, E. J. 2004. Corporate elites and corporate strategy: how demographic preferences and structural position shape the scope of the firm. Strategic Management Journal 25(6), 507-524.

McEvily, B., Zaheer, A., 1999. Bridging ties: a source of firm heterogeneity in competitive capabilities. Strategic Management Journal 20(12), 1133–1156.

Merges, R., Nelson, R., 1994. On limiting or encouraging rivalry in technical progress: the effects of patent scope decisions. Journal of Economic Behavior and Organization 25, 1–24.

Meyer, K.E., Nguyen, H.V., 2005. Foreign investment strategies and sub-national institutions in emerging markets: Evidence from Vietnam. Journal of Management Studies 42(1), 63-93.

Mindruta, D., 2013. Value creation in university-firm research collaborations: a matching approach. Strategic Management Journal 34, 644-665.

Motohashi, K., Yun, X., 2007. China's innovation system reform and growing industry and science linkages. Research Policy 36(8), 1251-1260.

Mu, Q., Lee, K., 2005. Knowledge diffusion, market segmentation and technological catch-up: The case of the telecommunication industry in China. Research Policy 34(6), 759-783.

National Bureau of Statistics of China, 2011. China Statistic Yearbook 2011. China Statistic Press, Beijing.

Nelson, R., Rosenberg, N., 1993. Technical innovation and national systems, in: Nelson, R. (Ed), National Innovation Systems: A comparative analysis. Oxford University Press, New York.

North, D.C., 1990. Institutions Institutional Change and Economic Performance. Cambridge University Press, Cambridge, MA.

Ocasio, W., 1997. Towards an attention-based view of the firm. Strategic Management Journal 18(S1), 187-206.

OECD 2005. OSLO Manual: Guidelines for Collecting and Interpreting Innovation Data. OECD Publishing, France.

OECD 2008. OECD reviews of innovation policy: China (downloaded on 20 April 2014 from http://www.oecd.org/sti/inno/oecdreviewsofinnovationpolicy.htm)

OECD 2009. Measuring China's innovation system national specificities and international comparisons (downloaded on 20 April 2014 from http://www.oecd.org/sti/sci-tech/42003188.pdf)

Park, W.G., Ginarte, J.C., 1997. Intellectual property rights and economic growth. Contemporary Economic Policy 15(1), 51-61.

Peck, J., Zhang, J., 2013. A variety of capitalism with Chinese characteristics? Journal of Economic Geography doi:10.1093/jeg/lbs058.

Perkmann, M., King, Z., Pavelin, S., 2011. Engaging excellence? Effects of faculty quality on university engagement with industry. Research Policy 40, 539-552.

Perks, H., Kahn, K., Zhang, C., 2009. An empirical evaluation of R&D–Marketing NPD integration in Chinese firms: The guanxi effect. Journal of Product Innovation Management 26(6), 640-651.

Phillips, N., Lawrence, T.B., Hardy, C., 2000. Inter-organizational collaboration and the dynamics of institutional fields. Journal of Management Studies 31(7), 23-43.

Polanyi, M., 1967. The Tacit Dimension. Anchor Books, New York. Ponds, R., van Oort, F., Frenken, K. 2010. Innovation, spillovers and university–industry collaboration: an extended knowledge production function approach. Journal of Economic Geography 10(2), 231-255.

Prahbu, G.N., 1999. Implementing university–industry joint product innovation projects. Technovation 19(8), 495-505.

Romijin, H., Albaladejo, M., 2002. Determinants of innovation capability in small electronics and software firms in southeast England. Research Policy 31(7), 1053-1067.

Roper, S., Hewitt-Dundas, N., Love, J.H., 2004. An ex ante evaluation framework for the regional benefits of publicly supported R&D projects. Research Policy 33(3), 487-509.

Roper, S., Hewitt-Dundas, N., 2013. Catalysing open innovation through publicly-funded R&D: A comparison of university and company-based research centres. International Small Business Journal 31(3), 275-295.

Rotaermel, F.T., Deeds, D.L., 2006. Alliance type, alliance experience and alliance management capability in high-technology ventures. Journal of Business Venturing 21(4), 429-460.

Ryan, T., 1997. Modern Regression Analysis. Wiley, New York.

Sayrs, L. W., 1989. Pooled time series analysis. Sage: Newbury Park, CA.

State Statistical Bureau of China, 2013. China Science and Technology Yearbook. China Statistical Press. Beijing, China.

Teece, D.J. 1986. Profiting from technological innovation: implications for integration collaboration, licensing and public policy. Research Policy 15(6), 285–305.

Tsai, K-H., 2009. Collaborative networks and product innovation performance: toward a contingency perspective. Research Policy 38(5), 765–778.

Todtling, F., Trippl, M., 2005. One size fits all? Towards a differentiated regional innovation policy approach. Research Policy 34(8), 1203-1219.

Wang, C., Hong, J., Kafouros, M., Wright, M., 2012. Exploring the role of government involvement in outward direct investment from emerging economies, Journal of International Business Studies 43(7), 655–676.

Wang, C.C., Lin, G.C.S., 2013. Dynamics of innovation in a globalizing China: regional environment, inter-firm relations and firm attributes, Journal of Economic Geography 13, 397-418.

Whitley, R., 2000. The institutional structuring of innovation strategies: business systems, firm types and patterns of technical change in different market economies. Organization Studies 21(5), 855-886.

Wooldridge, J.M., 2002. Econometric Analysis of Cross Section and Panel Data. The MIT Press, Massachusetts.

Wu, X., Ma, R., Shi, Y. 2010. How do latecomer firms capture value from disruptive technologies? A secondary business-model innovation perspective. IEEE Transactions on Engineering Management, *57*(1), 51-62.

Xu, D., Meyer, K.E., 2013. Linking theory and context: 'strategy research in emerging economies' after Wright et al. (2005), Journal of Management Studies 50(7), 1322-1346.

Yi, J., Wang, C., Kafouros, M., 2013. The Effects of Innovative Capabilities on Exporting: Do Institutional Forces Matter?, International Business Review 22 (2), 392-406.

Zahra, S.A., George, G., 2002. Absorptive capacity: A review, reconceptualization, and extension. Academy of Management Review 27(2), 185-203.

Zhang, H., Patton, D., Kenney, M., 2013. Building global-class universities: Assessing the impact of the 985 Project. Research Policy 42(3), 765-775.

Zhao, M., 2006. Conducting R&D in countries with weak intellectual property rights protection. Management Science 52(8): 1185–1199.

Zhou, K.Z., Wu, F., 2010. Technological capability, strategic flexibility, and product innovation. Strategic Management Journal 31(5), 547-561.

Zhou, K.Z., Wu, F., 2010. Technological capability, strategic flexibility, and product innovation. Strategic Management Journal 31, 547-561.

Zucker, L.G, Darby, M.R., 1997. Present at the biotechnological revolution: transformation of technological identity for a large incumbent pharmaceutical firm. Research Policy 26(4-5), 429-446.

Zucker, L.G., Darby, M.R., Armstrong, J.S., 1998. Geographically localized knowledge: spillovers or markets Economic Inquiry 36(1), 65–86.

Table 1

Firm distribution by provinces, ownership and industry in the sample (N=375)

Section A: Distribution by provinces and ownership					
	Provinces	Number of firms	Ratio (%)	Number of firms according to share of state assets	
				between 50% and 100%	<50%
Eastern region	Beijing	31	8.27	26	5
	Tianjin	11	2.93	8	3
	Zhejiang	28	7.47	4	24
	Shandong	22	5.87	8	14
	Guangdong	22	5.87	8	14
	Fujian	19	5.07	10	9
	Liaoning	16	4.27	6	10
	Jiangsu	15	4.00	4	11
	Shanghai	15	4.00	9	6
	Hebei	9	2.40	5	4
	Hainan	8	2.13	0	8
Sub-total		**196**	**52.30**	**88 (45%)**	**108 (55%)**
Central region	Anhui	15	4.00	8	7
	Henan	13	3.47	5	8
	Heilongjiang	12	3.20	8	4
	Hunan	11	2.93	7	4
	Jilin	10	2.67	5	5
	Hubei	9	2.40	6	3
	Jiangxi	9	2.40	4	5
	Shanxi(Taiyuan)	8	2.13	6	2
Sub-total		**87**	**23.20**	**49 (56%)**	**38 (44%)**
Western region	Neimenggu	7	1.87	2	5
	Sichuan	13	3.47	6	7
	Chongqing	12	3.2	8	4
	Shanxi (Xi'an)	9	2.40	7	2
	Guizhou	7	1.87	3	4
	Gansu	7	1.87	6	1
	Yuannan	6	1.60	4	2
	Ningxia	6	1.60	3	3
	Guangxi	5	1.33	5	0
	Qinghai	5	1.33	3	2
	Xinjiang	11	2.93	5	6
	Xizang	4	1.07	1	3
Sub-total		**92**	**24.50**	**53 (58%)**	**39 (42%)**
Total (all provinces)		**375**	**100%**	**190 (51%)**	**185 (49%)**

Section B: Distribution by industry

	Number of firms	Percentage (%)
Medicine	54	14.40
General machinery	36	9.60
Specialised machinery	46	12.20
Electrical appliances	34	9.10
Communication and computers	48	12.80

Table 2
Definitions of variables

	Definition
Dependent variable	
Innovation performance	Log (1+ ratio of new product sales to total sales x 100)
Independent variable	
Academic collaboration	Ratio of expenditure on collaboration with universities and institutes to total R&D expenditure
Moderators	
IPR enforcement	Ratio of accumulated ratio of closed IPR cases to the total number of legal IPR cases entertained
International openness	Ratio of amount of foreign direct investment to GDP in a given region calculated by Fan et al.(2010)
Research quality of URIs	Average number of academic papers published in international journals per academic in a given region
Control variables	
Firm size	Log (number of employees)
Firm age	Number of years since establishment or restructuring
R&D intensity	Ratio of R&D expenditure to number of employees in total
Overseas R&D	Dummy, equals to 1 if the company builds R&D center overseas
Patent stock	Log (1+ number of stock patents)
Diversification	Dummy, equals to 1 if the company operates in at least 2 two-digital industries
State ownership	Dummy, equals to 1 if share of state-owned assets is more than 50 percent
Industry dummies	Five dummies, equal to 1 if affiliated at the 5 two-digit industries (for details see Table 1)
Year dummies	Three Dummies, equal to 1 if associated with the corresponding year

Table 3

Descriptive statistics and correlations

Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11
1. Innovation performance	3.585	1.006	1.000										
2. Academic collaboration	0.110	0.156	-0.057	1.000									
3. IPR enforcement	0.890	0.070	-0.151	-0.013	1.000								
4. International openness	3.720	2.347	0.037	-0.071	0.105	1.000							
5. Research quality of URIs	0.169	0.149	-0.023	-0.066	0.279	0.376	1.000						
6. Firm size	7.847	1.651	-0.009	-0.184	0.087	-0.008	0.217	1.000					
7. Firm age	14.048	9.319	0.007	-0.110	-0.023	0.078	0.077	0.303	1.000				
8. R&D intensity	4.377	7.909	0.031	-0.056	0.015	0.043	0.040	0.007	-0.030	1.000			
9. Overseas R&D	0.107	0.309	0.054	-0.081	0.022	-0.010	0.033	0.194	0.110	-0.001	1.000		
10. Patent stock	4.410	1.657	0.127	-0.181	0.087	0.112	0.300	0.676	0.275	0.025	0.188	1.000	
11. Diversification	0.196	0.397	-0.084	-0.049	0.012	0.109	0.035	0.211	0.097	0.039	0.033	0.094	1.000
12. State ownership	0.506	0.500	-0.091	-0.079	0.032	-0.073	0.157	0.320	-0.007	-0.005	-0.051	0.211	-0.056

Table 4

Regression Results (Random effects)

Dependent variables	Innovation performance					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Control variables						
Firm size	-0.025	-0.032	-0.033	-0.031	-0.031	-0.030
	(0.036)	(0.036)	(0.035)	(0.036)	(0.036)	(0.036)
Firm age	2.57E10-4	-2.35E10-5	-8.68E10-4	1.19E10-5	1.65E10-4	-0.001
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
R&D intensity	0.003	0.003	0.003	0.002	0.003	0.002
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Overseas R&D	0.107	0.097	0.101	0.094	0.091	0.100
	(0.129)	(0.127)	(0.126)	(0.127)	(0.127)	(0.125)
Patent stock	0.079^{**}	0.081^{**}	0.095^{***}	0.081^{**}	0.092^{***}	0.097^{***}
	(0.034)	(0.033)	(0.033)	(0.034)	(0.034)	(0.034)
Diversification	-0.205^{**}	-0.217^{**}	-0.209^{**}	-0.218^{**}	-0.222^{**}	-0.211^{**}
	(0.092)	(0.091)	(0.089)	(0.091)	(0.091)	(0.090)
State ownership	-0.289^{***}	-0.280^{***}	-0.277^{***}	-0.281^{***}	-0.271^{***}	-0.267^{***}
	(0.093)	(0.094)	(0.091)	(0.092)	(0.092)	(0.092)
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes
Independent variables						
Academic collaboration		1.373^{***}	0.548^{*}	0.593^{*}	0.622^{**}	0.516^{*}
		(0.426)	(0.299)	(0.302)	(0.302)	(0.299)
Academic collaboration squared		-3.273^{***}	-2.905^{***}	-2.901^{***}	-3.070^{***}	-2.651^{***}
		(0.649)	(0.647)	(0.660)	(0.657)	(0.657)
IPR enforcement			-1.879^{***}			-1.814^{**}
			(0.564)			(0.582)
International openness				0.010		0.020
				(0.017)		(0.018)
Research quality of URIs					-0.367	-0.278
					(0.296)	(0.320)
Interactions						
Academic collaboration x IPR enforcement			10.986^{***}			10.584^{***}
			(2.247)			(2.336)
Academic collaboration x International Openness				0.191^{***}		0.168^{**}
				(0.067)		(0.073)
Academic collaboration x Research quality of URIs					2.178^{***}	-0.585
					(1.167)	(1.311)
Cons	3.418^{***}	3.424^{***}	3.506^{***}	3.538^{***}	3.486^{***}	3.478^{***}
	(0.229)	(0.242)	(0.226)	(0.228)	(0.231)	(0.228)
Observations	1125	1125	1125	1125	1125	1125
Wald chi2 test	66.09^{***}	102.78^{***}	138.84^{***}	111.83^{***}	108.64^{***}	146.65^{***}
Log likelihood function	-1470	-1452	-1436	-1448	-1450	-1432
Left or right censored	59	59	59	59	59	59
F test w.r.t. pooled Tobit	246.84^{***}	257.47^{***}	257.88^{***}	260.62^{***}	258.16^{***}	259.66^{***}
Rho	0.500	0.511	0.511	0.514	0.512	0.514
Hansen J test	to be filled	3.413	4.496	4.314	3.576	8.700
Dubin-Wu-Hausman	to be filled	2.437	6.093	5.139	7.789*	8.055

Standard errors in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4A

Regression results (Bootstrap method)

Dependent variables	Innovation performance				
	Model 2	Model 3	Model 4	Model 5	Model 6
Independent variables					
Academic collaboration	1.373**	0.548	0.593*	0.622*	0.516*
	(0.638)	(0.352)	(0.318)	(0.358)	(0.304)
Academic collaboration squared	-3.273**	-2.905***	-2.901***	-3.070***	-2.651***
	(1.268)	(1.120)	(1.005)	(1.101)	(0.998)
IPR protection		-1.879***			-1.814**
		(0.639)			(0.736)
International openness			0.010		0.020
			(0.015)		(0.018)
Research quality of universities				-0.367	-0.278
				(0.313)	(0.332)
Interactions					
Academic collaboration x IPR enforcement		10.986***			10.584***
		(3.885)			(4.028)
Academic collaboration x International Openness			0.191*		0.168*
			(0.099)		(0.096)
Academic collaboration x Research quality of URIs				2.178	-0.585
				(1.486)	(1.605)
Cons	3.424***	3.506***	3.538***	3.486***	3.478***
	(0.237)	(0.284)	(0.254)	(0.232)	(0.265)
Observations	1125	1125	1125	1125	1125
Wald chi2 test	80.10***	85.12***	84.80***	82.38***	93.43***
Log likelihood function	-1452	-1436	-1448	-1450	-1432
Left or right censored	59	59	59	59	59
F test w.r.t. pooled Tobit	257.47***	257.88***	260.62***	258.16***	259.66***
Rho	0.511	0.511	0.514	0.512	0.514
Hansen J test for over-identification	3.413				
Dubin-Wu-Hausman test of endogeneity	2.437	6.093	5.139	7.789*	8.055

Bootstrap standard errors in parentheses. All control variables are included but not reported here for terseness. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.