Who Can Cultivate University Ties More in China? A Local Firm or a Foreign Firm?

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***Abstract*—University ties are an important innovation resource for both foreign direct investment (FDI) firms and local firms. Since these university connections involve local personal ties, which are established through long-term efforts that require social and cultural embeddedness, it is probably more difficult for FDI firms to establish such ties than it is for local firms. However, FDI firms, which have two advantages, size and R&D capacity, can possibly compensate for that disadvantage. This paper contributes to the current innovation and international business literature by comparing the effect of university ties on innovation between local firms and FDI firms due to their heterogeneous resources and capabilities. Specifically, this paper examines the joint influence of university ties, R&D capacity, and firm size in both FDI firms and local firms in China. The results show that R&D capacity and firm size have different moderating effects on FDI firms and local firms, suggesting that internal capability and external personal relationship with universities are substitutes in local firms but complementary in FDI firms. Our results are relevant for practicing managers because they show that acquiring the knowledge in universities is contingent on firm characteristics as well as ownership types.**

***Index Terms*—Foreign direct investment (FDI), firm size, innovation, R&D capacity, university ties.**

I. Introduction

THE CONTRIBUTION made to nations and industries by university R&D has drawn much attention in previous empirical works at the macrolevel [1]–[3]. Most of these studies find a positive relationship between the level of scientific knowledge in universities and the development of a country or industry [3], [4]. However, most of these studies suggest that university–industry relationships take place spontaneously, rather than depending on individual intervention [5]. This stream of thought not only underestimates the contribution of personal efforts, such as relationships among firms' top managers, university professors, scientists and engineers, but also downplays the interactive exchange between knowledge creation and exploitation by which a firm adopts scientific innovation [6], [7].

Particularly, managerial ties, which are defined as the boundary-spanning ties and interpersonal connections of top managers [8], [9], are very important mechanisms for a firm to acquire scientific knowledge. Although there are many prior studies focusing on managerial ties with suppliers, customers, competitors, government [10], [11], relatively few studies discuss the university ties. Based on the concept of managerial ties, our research defines university tie as a specific type of managerial ties, which mainly investigate the interpersonal relationships between top managers in firms and professors, scientists and engineers in universities. In this study, we incorporate ideas from the social capital theory into university–firm cooperation studies, an approach that may support an increased contribution of universities' R&D to a firm's innovation. Based on Peng and Luo's concept of managerial ties [10], which are defined as managers' social ties, contacts, and networks affecting a firm's strategic choices and performance, our study focuses on the managers' social relationships with professors, scientists, and engineers in universities, so-called university ties defined as the personal relationships between members in a firm and members in an university.

Furthermore, previous studies, which examine the extent of university–firm cooperation on managerial actions either by using the case study method [12], [13] or using the quantitative method [14], [15], have implicitly assumed that firms are homogeneous. However, this assumption is not appropriate, since firms are heterogeneous in terms of resources and capabilities [16], [17]. Thus, we take the heterogeneous nature of firms into consideration in examining how the university ties together with firm characteristics affect firm innovation. For example, a firm with higher R&D capacity can effectively transform the knowledge derived from university ties to innovation. Moreover, larger firms possess more resources to retain university ties and to improve innovation whereas smaller firms are eager to establish ties with universities in order to gain competitive advantages and legitimacy and accordingly to extricate the liability of smallness [10], [18]. Hence, in this study, we would like to investigate how a firm's R&D capacity and size explain the relationship between a firm's university ties building and its innovation.

Finally, with the trend of globalization, an increasing number of FDI firms not only invest in their home countries but also conduct their R&D activities worldwide [19], [20]. However, the R&D activities conducted by FDI firms are very different from those conducted by local firms. Although previous

Manuscript received May 27, 2009 revised November 14, 2009 and March 7, 2010; accepted April 21, 2010. Date of publication June 7, 2010; date of current version April 20, 2011. This work was supported by the Program for National Natural Science Foundation of China under Grant 70772111, by the Research Fund for the Doctoral Program of Higher Education form the Ministry of Education under Grant 20060698031, and by the Key Project of Chinese Education Ministry under Grant 09JZD0030. Review of this manuscript was arranged by Department Editor E. McDonough.

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Digital Object Identifier 10.1109/TEM.2010.2049849

studies have typically assumed that the knowledge possessed by foreign firms is generally transferred from their home countries [21], [22], an increasing number of studies suggest that R&D activities in host countries can play an important role in FDI firms' own knowledge-creating activities, rather than relying only on their R&D activities in home countries if local environment in host countries can offer qualified R&D human capital at lower costs [23]. Under this circumstance, university's science and technologies in host countries are regarded as one of the important source for knowledge acquisition and knowledge creation for FDI firms because of available human capital [24]. In addition to FDI firms, local firms are also suggested to access this advanced knowledge from universities easily because of their social embeddedness in the same geographic region [19].

Nevertheless, do FDI firms have the same social-embedded advantage as local firms have on university ties in a host country? Will local firms or FDI firms better cultivate local university ties for firm innovation? While some previous studies mainly emphasize managerial ties of FDI firms [11] but not university ties, other studies address university ties [25], [26] but not in the international context. The comparison of the effect of university ties between FDI firms and locals firms on innovation has not been fully investigated, and it will extend our understanding on current innovation literature particularly in the increasing trend of globalization. Therefore, a comparison of the effects of university ties on FDI firms and local firms in China will enable us to explore how social-embedded advantage of university ties interacted with firm characteristics influences a firm's innovation in a host country. Our results show that for FDI firms, both R&D capacity and firm size have moderating effects on the relationships between university ties and innovation. More importantly, we also find that internal R&D capacity and external university ties are substitutes for local firms but complementary for FDI firms.

II. Literature Review and Hypothesis Development

Personal relationships have increasingly become a core component of strategy. According to social capital theory, there exists a micro-macro link from managerial connection to social capital and to a firm's performance [27]. More specific, interpersonal relationship is regarded as a main source for knowledge spillover and knowledge creation in innovation literature [28]. Meanwhile, the resource based-view argues that firms cannot greatly improve their performance until they absorb external knowledge and integrate them with internal resources effectively [29], [30]. In this study, we attempt to integrate external knowledge obtained through personal relationship between firms' top managers and universities' professors and engineers with internal firm characteristics, such as ownership, R&D capacity and firm size, to investigate how university ties influence different firms in different ways.

A. University Ties

An increasing importance of external participants in a firm's R&D has been emphasized in current literatures particularly after the Chesbrough's introduction of the concept of "open innovation" [31]. These external participants include suppliers, customers, research institutions, and particularly universities. The primary goals of universities are to conduct research and to deliver teaching. Capitalizing on the generated knowledge is not one of these goals. Universities do, however, often transfer such generated knowledge to their research partners and thereby accelerate technology transfer so as to enable firms to develop new products and improve processes [1], [26], [32]. Basically, universities are vital sources of innovation because they are the producers of both technical personnel and cutting-edge scientific knowledge [33]. Universities, in particular, are key sources of human capital in the form of both star scientists and technical employees [34], [35]. Furthermore, since universities operate largely on the basis of the norms of open science, the research discoveries and techniques from universities are more accessible than those from other organizations [36].

Contacts between individuals at the university and the firm will facilitate knowledge transfer by providing the conduit for knowledge flow. Social capital theory suggests that a firm's external relationships may significantly contribute to its performance [37]. Personal ties—the boundary spanning ties and interpersonal connections of top managers-–have vital influences on a firm's activities [8], [9], [38] and may be a source of both competitive advantage [39] and superior performance [40]. Considering the characteristic of openness of university research, a university tie, the personal relationship between members of the firm and members of the university, may also be such an important connection for the firm. According to Oliver and Liebeskind [41], most exchanges of new scientific knowledge take place through interpersonal relations with individuals at other firms, universities, and government agencies. Thus, firms with broader interpersonal networks with universities have greater opportunities to access the cutting-edge scientific research and rapidly absorb this research into their own research efforts.

Therefore, social contacts between individuals at the university and the firm are recognized as an important vehicle of facilitating the knowledge transfer, especially for local firms [33], [42]. The common culture and social norms facilitate personal contacts that can serve as the conduit for knowledge flow. Since knowledge transferred between universities and firms is usually tacit knowledge [43], the same culture background and social norms could smooth the interpersonal connections, which thus make the process of tacit knowledge transfer more effective. Moreover, local firms with direct interpersonal contacts and well-established social networks are more experienced in terms of absorbing knowledge more efficiently and successfully through personal communication, making the local firm more innovative. Thus, we propose the following hypothesis:

> *Hypothesis 1a:* A local firm with closer university ties is more likely to have better innovation than one with less closer university ties.

Similarly, an increasing number of FDI firms attempt to acquire knowledge and technology from the host country's university knowledge [44]. Based on organizational learning and asset-seeking perspectives, Makino *et al.* argue that firms from newly industrialized countries engaged in FDI activities not only

attempt to acquire firm-specific advantages for asset exploitation, but also to seek technology-based resources and skills in host countries that are not available in their home countries [45]. As the potential impact of personal relationship is well recognized in emerging economies [46], not only it is very important for FDI firms to achieve legitimacy in an environment with different cultures and avoid liability of newness, but also it is helpful for them to obtain science and technologies from local universities in terms of knowledge acquisition. For example, Wright *et al.* emphasize the need to understand the role played by social capital and networks in the strategies of firms operating in emerging economies [47].

Having had the aforementioned discussions, we argue that an increasing number of FDI firms have begun to realize that multinational personal relationships with local university professors play a very vital role in accessing local university science and technology, especially in emerging economies such as China, the Middle East, and Latin America which have the characteristics of the void of formal institutions and rules [10], [48]. In such cases, personal connections between top managers and professors, scientists and engineers are beneficial to smooth the knowledge transfer with the lack of formal law protection. In their study on the biotechnology sector, Mattos *et al.* suggest that personal connections in the scientific arena are essential for technical development as well as for innovation productivity for FDI firms in emerging economies [49]. Thus, we propose the following hypothesis:

> *Hypothesis 1b:* An FDI firm with closer university ties in a host country is more likely to have better innovation than one with less closer university ties.

B. R&D Capacity

Internal capability and external personal relationships have been shown in previous studies to be complements [50], [52]. For instance, firms can obtain external complementary resources through their social capital, such as ties with professors, scientists, and engineers in universities, to develop their internal R&D capacity [53]. Moreover, some studies indicate that higher levels of internal R&D capacity, such as R&D spending and technological sophistication, could facilitate the knowledge exploitation and transformation which resulted from personal communication between firms and universities since there is less knowledge gap between these two entities [54], [55].

More importantly, by defining "absorptive capacity" as a firm's ability "to recognize the value of new, external knowledge, assimilate it, and apply it to commercial ends," Cohen and Levinthal find that a higher level of technological competence can create higher absorptive capacity including the capability of identifying opportunities from external sources, which in turn leads to a higher level of innovation by integrating external knowledge with internal knowledge [29]. Moreover, a top manager in a firm with strong research and product development platforms possess valuable resources and technological knowledge to offer potential knowledge exchanges with their counterparts, and therefore, are more likely to be presented with greater opportunities to absorb a wide range knowledge from employees in universities, including professors, scientists, and engineers [52], [56]. Particularly, a top manager in a local firm with the abundant knowledge resources (internal R&D capacity) is more alert to the promising knowledge and could evaluate the external knowledge from the universities more precisely which derived from a wide range of external personal connections for accessing the required technologies or knowledge, which in turn improve its innovation. Based on the above discussions, a local firm's internal R&D capacity has a moderating effect on the relation between university ties and innovation. Thus, we propose the following hypothesis:

> *Hypothesis 2a:* A local firm with closer university ties is more strongly correlated to firm innovation when it possesses higher R&D capacity.

In emerging countries, FDI firms are used to be more innovative than local firms due to their higher R&D capacity, such as skilled and extensive training of employees, more machinery and equipment per worker, greater technical efficiency, and superior technological knowledge [57]. Therefore, when a top manager of FDI firm conducts knowledge-seeking activities via university ties in some developing countries, the firm's superior internal R&D capacity seems to be an important factor in acquiring and exploiting the university knowledge [58]. Moreover, the FDI firms' advantage of higher innovation expenditure and more advanced technology capabilities make their top managers more likely to build personal connections with professors, scientists, and engineers in local universities in a host country. Thus, we propose the following hypothesis:

> *Hypothesis 2b:* A FDI firm with closer university ties in a host country is more strongly correlated to firm innovation when it possesses higher R&D capacity.

C. Firm Size

Recent empirical studies suggest that firm size plays an important role in university–industry relationships since size can influence the effect of a firm's interpersonal connections with university employees on a firm's innovation [29], [59]. Typically, larger firms have a higher probability of benefiting from communications with academic research due to economies of scale of R&D activities. For example, in their German study, Czarnitzki and Rammer find that small firms (less than 500 employees) rely less on knowledge transfer from universities and research institutions than large firms do [60]. Particularly in the manufacturing sector, only 11% of small firms, compared to 24% of large firms, acquire knowledge from publicly funded research institutes. The rationale underlying the role of firm size in affecting the progress of knowledge acquisition is that top managers in large firms have more resources to help them establish multiple relationships with professors, scientist, and engineers in universities, and these complementary knowledge from different universities or different professors could be combined and lead to radical innovation [61]. On the contrary, top managers in small firms have relatively limited resources for developing multiple relationships simultaneously; therefore, the limited resources will hinder knowledge exploration and

TABLE I
SAMPLE DESCRIPTION

Classification		The number of firms（N=226）	Percentage
Main Industry	Electronic And Other Electrical Equipment And Components(SIC 36)	48	22%
	Fabricated metal products (SIC 34)	47	21%
	Computer equipment (SIC 35)	27	12%
	others	102	45%
	Subtotal		**100%**
Firm size (According to department of Chinese industry classification)	Large-scale firms	20	8.8%
	Big firms	47	20.8%
	Median size firms	74	32.7%
	Small firms	85	37.7%
Ownership	FDI firms	115	50.9%
	Local firms	111	49.1%
Distribution	Beijing, Shanghai, Guangzhou, Shannxi, Henan, Zhejiang, Ningxia, Shandong, Jiangsu, Liaoning, Shanxi, and Hunan		

exploitation [61]. As a result, larger firms are more likely to build personal connection with employees in universities not only by acquiring knowledge directly, but also by combining the complementary knowledge in their network. Therefore, a university–industry research ties for generating, receiving, applying, and commercializing knowledge is more accessible for large firms. Furthermore, universities mainly focus on fundamental and basic research projects with extended duration of the development projects that are less likely to lead to immediate economic appropriations. The basic science insights achieved through these relationships are more likely to have significant positive effects on innovative performance in a long run. Therefore, only large firms with abundant capital or resources are capable of harvesting the investment on university ties for a long period of time, and then they can benefit continually knowledge transfers from university ties to improve the innovation. Thus, we derive the following hypothesis:

Hypothesis 3a: A local firm with closer university ties is more strongly correlated to firm innovation when the firm size is larger.

Similarly, Narula and Dunning provide three reasons explaining why a larger FDI firm has an advantage in improving innovation activities by exploiting university ties [58]. First, acquiring technological know-how through university ties is more difficult when it takes place in a different country, and thus, only larger FDI firms can afford the time-consuming and costly process as the same rationale of local firms. Second, the top managers in larger FDI firms are more likely to have the experience of operating in multiple countries, which is important to build personal connections in different countries. These tangible and intangible assets are very helpful to establish the trust and identification between two persons with different culture background. As a result, such larger FDI firms can further improve their innovation by possessing closer university ties. Therefore, we propose the following hypothesis:

Hypothesis 3b: An FDI firm with closer university ties is more strongly correlated to firm innovation when the firm size is larger.

III. RESEARCH METHOD

A. Sample

Our investigation regarding R&D collaboration and firm innovation mainly focuses on manufacturing sectors in China. Table I shows the characteristics of our sample. As can be seen, our sample firms showed the representative for this research in terms of firm size, types of ownership, and location distribution.

B. Pilot Test

First of all, we developed a questionnaire based on previous studies. We translated the English questionnaire into Chinese and back-translated it independently into English to assure consistency and accuracy [62]. Then, we conducted a pilot test with three firms located in Xi'an, Shannxi Province, China.

There were two purposes for the pilot test in this study. First, it enabled us to improve our questionnaire by making it more comprehensive and accurate in asking questions toward our sample firms. Second, it overcame some shortcomings of the questionnaire survey, such as difficulties of obtaining an in-depth understanding regarding firms' perspectives. Based on the results of these pilot tests, our questionnaire was revised.

C. Survey

The survey was carried out during the period between February 2004 and August 2004 by professors and graduate students from a university located in Northwestern China. The survey was conducted by face-to-face interviews. The questionnaire was answered by the top managers of the sample firms since top managers play an important bridging role in the knowledge transfer. In order to obtain new knowledge from professors in universities, top managers need to spend considerable

costs (such as gifts and banquets) to building and sustaining the ties [10]. The interviewers recorded the answers to the questions and took notes on any question, which was omitted or not answered completely.

Out of 350 sample firms, 226 firms accepted our invitation for the face-to-face interview and completed their answer by the end of 2004, making a response rate of 64.6%. This response rate was acceptable since it was higher than 20% [63].

D. Variables Measurement

Except for firm size (log number of employees) and R&D capacity (number of employees in the R&D department/number of employees), we measured remaining variables with multiple items on a seven-point Likert scale ranging from 1 = "disagree very strongly" to 7 = "agree very strongly," or from 1 = "very bad" to 7 = "very good."

1) Dependent Variable: Prior studies suggest innovation can be measured by input-based measurement such as R&D expenditure or other output-based measurement such as new product development, number of scientific publications, or number of patents. We used the number of granted patents, including invention patents, utility patents, and design patents, as our measure for innovation for the following reasons. First, although multiple indicators, such as R&D input, patent counts, patent citations, or new product announcements, allow us to measure a firm's innovation, the statistical overlap between these indicators is strong [64]. Particularly, input-based indicators show how much a firm's efforts are committed to innovation development but do not show the outcome of such efforts [65]. Thus, we did not use input-based indicators such as R&D expenditure as our measure for innovation in order to avoid multicollinearity. Second, we used number of patents instead of new product development as our output-based indicator of innovation mainly because while new product development refers to the commercialization of innovation, patents are more fundamentally related to innovation performance itself, which is a better explanatory indicator for our research. Moreover, if we use patent number and new product development together, it may occur multicollinearity problem since patents include both product innovation and process innovation, which may have an overlap with new product development. Moreover, the number of patents has been widely used as a measure for innovation by prior studies, including Beneito [66] and Alfranca *et al.* [67]. Finally, although scientific publication is another possible measure for innovation, it is relatively less popularly adopted by firms compared to patents. Based on the aforementioned discussions, we decided to use number of patents as our measure for innovation in this research.

Previous studies suggest that a scaling method is more effective than exact figures of innovation performance, as the measures are asked via the questionnaire [68], [69]. Moreover, since the time lag between patent application and patent grant is very different from one to one, it is not appropriate to use the patent number in one year for measuring one firm's innovation. Thus, we used three scaled items for measuring a firm's innovation by patents granted. The following three questions was asked in the questionnaire: "Please indicate the change in the number of granted invention patents/utility patents/design patents as compared with last 5 years" (1 = "declining rapidly," 7 = "increasing rapidly"). The Cronbach's alpha was 0.95.

2) Explanatory Variables: a) University ties: We employed two seven-point scale questions for measuring university ties based on previous studies [10], [11], [70], which measure managerial ties. The following two questions appear in our questionnaire: "I (top manager) have established close personal relationships with professors, scientist, and engineers at local universities in China" and "I (top manager) have personally connected with professors, scientist, and engineers at local universities in China frequently." On a seven-point Likert scale, the manager was asked to select from "disagree very strongly" to "agree very strongly." The Cronbach's alpha was 0.95.

b) Firm size: Firm size is widely accepted as a predictor of competitive behavior [71] and also is consequential in industry–university communications [29], [59]. Thus, we were interested in how firm size affects the building of university–firm personal relationships. We measured firm size by using the natural logarithm of the number of employees in 2004 [72], which was collected via the questionnaire during our survey.

c) R&D capacity: Following Fontana *et al.*'s [25] suggestion, we used a firm's R&D intensity (the number of employees in the R&D department/total employees) in 2004 to measure a firm's R&D capacity. The number of employees in the R&D department was collected via the questionnaire during our survey.

3) Control Variable: a) Firm Size and R&D capacity: Negassi points out that larger firms are more likely to spend on R&D activities because they have superior marketing and financing capability [73]. Therefore, while testing one explanatory variable, we regarded the other as a control variable. For instance, we controlled for R&D capacity effect while testing the firm size effect, and *vice versa*.

b) Industry type: The industry classification is also related to a firm's innovation outcome, since competitive intensity and extent of knowledge acquisition from external sources may vary across industries [74]. In our study, industry classification was measured by the two-digit primary standard industrial classification (SIC) code. The data was available for 124 of the 226 sample firms. A majority of the sample firms were in electronics (SIC 36, 22%), followed by fabricated metal products (SIC 34, 21%), and computer equipment (SIC 35, 12%); firms in other industries made up the remaining 45%. To avoid multilinearity of the dependent variable in regressions, we consolidated the industry classification variable by creating dummies for the three aforementioned industry segments and grouping the remaining industry segments into a nonavailable data category (102 observations) [75].

c) Managerial ties: Our measure of managerial ties is based on Peng and Luo's [10] measures of managerial ties. The following questions appeared in the questionnaire to collect the data: "I (top manager) have established close relationships with 1) top managers at buyer corporations; 2) top managers at supplier corporations; and 3) top managers at competitor corporations". Based on a seven-point Likert scale, the managers were asked to select from "disagree very strongly" to "agree very strongly". The Cronbach's alpha of this variable was 0.90.

TABLE II
CORRELATIONS (LOCAL SAMPLE, $N = 115$)

	Mean	S.D.	1	2	3	4	5	6	7	8	9
1.Industry1	0.04	0.20									
2.Industry2	0.30	0.46	-0.14								
3.Industry3	0.09	0.28	-0.07	-0.20*							
4.Managerial ties	3.09	2.13	0.07	0.15	0.05						
5.Industry competition	3.57	0.99	-0.08	0.05	.07	0.19*					
6.Institutional environment	0.50	0.50	0.04	-0.08	0.12	0.31**	-0.09				
7.Firm Size	648.43	2159.11	0.39**	-0.04	0.06	0.11	0.02	0.16			
8.R&D capacity	0.04	0.08	0.05	-0.06	-0.00	0.12	0.03	-0.03	-0.15		
9.University Ties	3.71	2.54	0.05	-0.08	0.10	0.51**	0.09	0.39**	0.10	0.19*	
10.Innovation	2.34	2.41	-0.04	-0.01	0.06	0.44**	0.06	0.27**	0.23*	0.05	0.45**

* Correlation is significant at the 0.05 level (two-tailed).
** Correlation is significant at the 0.01 level (two-tailed).

TABLE III
CORRELATIONS (FDI SAMPLE, $N = 111$)

	Mean	S.D.	1	2	3	4	5	6	7	8	9
1.Industry1	0.40	0.49									
2.Industry2	0.13	0.33	-0.31**								
3.Industry3	0.15	0.36	-0.35**	-0.16							
4.Managerial ties	3.04	2.00	0.09	-0.18	0.13						
5.Industry competition	3.68	0.84	-0.11	-0.02	0.10	0.04					
6.Institutional environment	0.52	0.50	-0.15	-0.23*	0.26**	0.40**	0.09				
7.Firm Size	2411.46	6160.60	-0.05	-0.11	0.36**	0.18	0.03	0.24*			
8.R&D capacity	0.15	0.24	-0.11	-0.06	-0.01	0.03	0.08	0.06	-0.12		
9.University Ties	3.02	2.26	-0.09	-0.20*	0.19*	0.40**	0.07	0.36**	0.16	-0.06	
10.Innovation	2.84	2.35	0.035	-0.05	0.21*	0.35**	-0.09	0.28**	0.17	0.15	0.36**

* Correlation is significant at the 0.05 level (two-tailed).
** Correlation is significant at the 0.01 level (two-tailed).

d) Competitive intensity: Competitive intensity can affect aggregate innovative activity through its effects on a corporation's organization [76]. To assess the extent of competition in different areas in China, we used the item "Competition is intense in our local environment" (1 = "strongly disagree," 5 = "strongly agree").

e) Institutional policy: We used a dummy variable to measure how institutional environment affects firms' patents application decisions ("What is the most important one considered as the main method to protect technologies from infringement," 1 = "resort to patent law" and 0 = "other methods"). In this way, we ruled out the possible effect of the strength of patent protection on patent application.

IV. RESULTS

A. Descriptive Statistics

Tables II and III show the mean values, standard deviations, and correlations for all the variables in our study. The tables show that the correlations are not high, suggesting that our regression results are free from multilinearity problems. Moreover, we assessed the variance inflation factor (VIF) values and found no significant multicollinearity problem in our research (VIF < 1.75).

B. Reliability and Validity

We collected most of our data using a single survey instrument and a single informant per firm. To address the potential concerns of common method bias and single informant bias, we used several procedural and statistical remedies.

1) Procedural Remedies: We undertook the procedural remedies of reducing item ambiguity, separating scale items for the university ties and innovation measures, and obtaining data from different sources for several control variables.

2) Statistical Remedies: First of all, we included logarithms of part of the survey data in our models such as firm size. Second, we checked Harman's one-factor test [77]. Factor

TABLE IV
RELIABILITY AND VALIDITY

Construct/indicator	Cronbach Alpha	Standardized Loadings	Variance Extracted
Innovation	0.95		0.91
1. Invention patent		0.96	
2.Utility patent		0.95	
2. Design patent		0.96	
University Ties	0.95		0.58
1. Closeness of university ties		0.76	
2. Frequency of university ties		0.76	
Managerial ties	0.90		0.83
1. Competitor ties		0.89	
2. Supplier ties		0.93	
3. Customer ties		0.92	

analysis results show that the measures loaded cleanly on separate factors; all factor loadings were above 0.54, which is a common threshold for acceptance. These analyses indicate that neither a single factor nor a general factor accounted for the majority of the covariance in the measures. Third, because we had multiple respondents from 11 firms, we conducted an analysis of inter-rater agreement [78]. The ICC (1) was larger than 0.84 ($p < 0.000$) and ICC (2) was larger than 0.91 ($p < 0.000$), which suggests homogeneity between pairing respondents. Although the 11 pairings accounted for less than 10% of the sample firms, they provided some confidence as to the reliability of the data [79]. Finally, we collected patent data from Chinese Intellectual Property Office for the 40 firms who applied patents. Considering the questions we asked are the growth number of patents, we analyzed the correlation between our dependent variable (patent) data and the difference of objective patent data between 2003 and 2004. The correlation coefficient was 0.49 ($p < 0.01$). This analysis provides the additional support of the validity of the data. As a result, all the aforementioned analyses suggest that common method bias and single respondent bias are not serious concerns for our study [80].

Furthermore, we analyzed the individual item's reliability and validity. These results are listed in Table IV. The reliability is strongly supported [81]. Each loading for the multi-item variables of innovation, university ties, and managerial ties was significantly related to the appropriate underlying factor. And all standardized item loadings were well above the cutoff of 0.50 [82], supporting reliability.

C. Test of Hypothesis

To gauge the potential impact of different firm attributes between the FDI firms and local firms, we conducted multivariate analysis of variance on the substantive variables in this study (i.e., university ties, firm size, and R&D capacity). We found the significant difference between FDI firms and local firms in terms of university ties ($F = 2.238$, $p = 0.000$), firm size ($F = 3.988$, $p = 0.047$), and the level of R&D capacity ($F = 31.515$, $p = 0.000$). This result supports our contention that there is a significant difference between FDI firms and local firms in their R&D activities, which provides the basic argument of our study.

TABLE V
REGRESSION RESULTS (LOCAL FIRMS)

	Model 1	Model 2	Model 3	Model 4
Industry1	0.012	0.036	0.049	0.033
Industry2	0.118	0.167	0.191*	0.162
Industry3	0.160	0.152	0.140	0.154
Managerial ties	0.250**	0.173	0.190*	0.129
Industry competition	-0.077	-0.101	-0.079	-0.104
Institutional environment	0.097	0.040	0.039	-0.013
R&D capacity	0.328***	0.312***	0.300***	0.466***
Firm Size	0.252**	0.211*	0.204*	0.204*
University Ties		0.309***	0.302***	0.391***
University Ties * R&D capacity			-0.153+	
University Ties * Firm Size				0.255*
R2	0.273	0.340	0.360	0.372
∆ R2		0.067	0.020	0.012
F	2.126*	2.918***	2.112**	2.527**
N	115	115	115	115

$+p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$ (two-tailed test).

Since university ties have different impacts on innovative activities for FDI firms and local firms, we tested these two groups of sample firms separately. We used ordinary least square (OLS) regression and all reported regression coefficients were standardized coefficients in Tables V and VI. Table V shows the effects of university ties, firm size and R&D capacity on a firm's innovation for local firms. Hypothesis 1a, which predicts a direct effect of university ties on firm innovation, is supported as showed in Model 2 ($p < 0.001$). To test the moderating effect, we multiplied university ties, firm size and R&D capacity and entered the multiplicative interaction items into the regression.

TABLE VI
REGRESSION RESULTS (FDI FIRMS)

	Model 5	Model 6	Model 7	Model 8
Industry1	-0.093	-0.066	-0.053	-0.035
Industry2	-0.023	0.030	0.047	0.064
Industry3	-0.035	-0.062	-0.030	-0.104
Managerial ties	0.500	0.367***	0.351**	0.335***
Industry competition	-0.170	0.023	-0.111	0.043
Institutional environment	0.097	-0.025	0.010	-0.041
R &D capacity	0.136	0.077	0.126	0.122
Firm Size	0.294***	0.338***	0.294***	0.292***
University Ties		0.311***	0.353***	0.373***
University Ties × R&D capacity			0.196*	
University Ties × Firm Size				0.352***
R2	0.346	0.376	0.408	0.479
ΔR2		0.030	0.032	0.071
F	2.649**	2.441**	2.322**	3.285***
N	111	111	111	111

$+p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$ (two-tailed test).

Based on Aiken and West's study [83], we mean-centered the variables (transforming the data into deviation score form with means equal to zero) and rerun the regression to minimize any distortion due to high correlations between the interaction term and its component variables. The coefficient of the interaction of university ties and R&D capacity is not significant in Model 3, suggesting that the effect of university ties on firm innovation is not influenced by a firm's R&D capacity. Thus, Hypothesis 2a, which predicts that R&D capacity moderates the relationship between university ties and innovation, is not supported. Third, in Model 4, the coefficient of the interaction of university ties and firm size is significantly positive ($p < 0.05$), indicating that the effect of university ties on firm innovation is affected by firm size. Hence, Hypothesis 3a, which predicts that firm size moderates the relationship between university ties and innovation, is supported.

Table VI shows the results examining the effects of university ties, R&D capacity and firm size on a firm's innovation in FDI firms. Hypothesis 1b, which predicts a direct effect of university ties on innovation, is still supported in Model 6 ($p < 0.001$). Second, the coefficient of interaction of university ties and R&D capacity is positive and significant ($p < 0.05$) in Model 7, indicating that the effect of university ties on innovation depends on a FDI firm's R&D capacity. Therefore, Hypothesis 2b, which predicts that firm size moderates the relationship between university ties and innovation, is supported. Finally, the coefficient of the interaction of university ties and firm size is also positive and significant ($p < 0.001$) in Model 8, showing that the effect of university ties on innovation is also dependent on firm size. Hence, Hypothesis 3b, which predicts that firm size moderates the relationship between university ties and innovation, is also supported.

In order to examine differences between the two samples (local firms and FDI firms) on each direct or moderating effect on firm innovation, we compared the coefficients across regression equations, the technique outlined by Cohen and Cohen [84]. The results show that the relevant *Z*-statistic for the coefficient of university ties is positive but not statistically significant ($Z = 0.05$), suggesting that there is no significant difference between local firms and FDI firms in the use of university ties. However, the relevant Z-statistic for the coefficients of the interaction between university ties and R&D capacity is positive and marginal significant ($Z = 1.84$, $p < 0.10$), indicating that the effect of university ties interacted by R&D capacity on innovation for FDI firms is larger than that for local firms. Furthermore, the relevant *Z*-statistic for the coefficients of the interaction between university ties and firm size is also positive and statistically significant ($Z = 2.94$, $p < 0.01$), suggesting that the effect of university ties interacted by firm size on innovation for FDI firms is larger than that for local firms.

V. DISCUSSION

While some previous studies mainly emphasize managerial ties, instead of university ties, of FDI firms [11], other studies address university ties but not in the international context [25], [26]. This paper contributes to the current innovation and international business literature by comparing the effect of university ties on innovation between local firms and FDI firms due to their heterogeneous resources and capabilities.

This research suggests that a firm's university ties, firm size, and R&D capacity are important determinants for a firm to enhance its innovation. In particular, by possessing university ties, a firm's top management is likely to obtain useful knowledge for its innovation from universities, which supports our Hypotheses 1a and 1b. While this finding is consistent with previous literatures recognizing the importance of university knowledge to a firm's innovation [33], [42], we contribute to the existing literature by further elaborating the interactive role of top managers on university ties. For both local firms and FDI firms, the positive direct relationships between university ties and innovation suggest that both FDI firms and local firms can improve their innovation via closer university ties, which extends current studies by emphasizing that interpersonal connections between top managers and professors, scientists, and engineer in universities could be a viable way to improve knowledge transfer between the two entities. Moreover, for both local firms and FDI firms, we find that firm size has a significant moderating effect between university ties and a firm's innovation, supporting our Hypotheses 3a and 3b. While prior studies suggest that firm size has positive impact on innovation [29], [59], our study finds that the effect of firm size is reflected on the relationship between university ties and innovation. The rationale underlying the role of firm size in affecting the relationship between university ties and innovation output is that large firms possess more resources as well as have more complementary knowledge from different sources, which help top managers in these larger firm transfer the knowledge obtained from personal relationships with universities [25], and further improve their innovation. This finding also implies that larger firms, both FDI firms and local firms, can further strengthen the relationships between top managers at firms and professors, scientists, or experts in universities. The investigation of the contingent effects

of a firm's heterogeneous characteristics can enhance our understanding of the university–industry innovation collaboration.

Who can cultivate university ties more in China? We conduct a comparative study about the relationships among university ties, firm size, R&D capacity, and innovation by comparing two groups of firms, FDI firms and local firms in China to answer the aforementioned question. For FDI firms, R&D capacity shows significantly direct and moderating effects on the relationship between university ties and firm innovation. A firm with higher R&D capacity is expected to more readily recognize and understand a university's knowledge [85], [86] which is derived from personal ties, thereby helping the firm's innovation. Moreover, R&D capacity enables would-be acquirers of technology to understand the extent and significance of what has and what has not been developed by the university. This provides FDI firms valuable information regarding the technology development of local markets, which help FDI firms to formulate their entry strategy. Moreover, such understanding will also affect how the knowledge-seeking firm's top manager perceives its relationships with the professors, scientists, and engineers in universities for the motivation of acquiring the needed knowledge, which in turn improves its own innovative activities [87].

For local firms, on the contrary, R&D capacity is not found a significant effect on a firm's innovation, either directly or as a moderating effect. This result is different from our results in FDI firms as well as from previous research [88]. Previous studies suggest that R&D capacity has a positive effect on a firm's innovation [89]. The main reason for this inconsistent result lies in the characteristics of the local firms in our sample. A majority of the participating local firms are located in a city with more than 50 universities. Developing informal relationships with universities, such as inviting professors as advisors and even as stockholders in exchange for their advanced knowledge or technology, is easier and less costly than establishing an internal R&D department or projects, which need higher R&D expenditures, and will achieve an outcome for a longer period of time. As a result, many local firms are not willing to establish their own R&D capacity since they can easily rely on external R&D outputs through close ties with universities. While university ties have direct impact on a local firm's innovation, R&D capacity does not have a direct or moderating effect on a local firm's innovation. This result implies that internal R&D capacity and external university ties can be substituted for local firms if they can ascertain their technology sources.

In the case of FDI firms, however, our findings suggest that internal R&D capacity may have a complementary impact on the relationship between university ties and firm innovation. The explanation is presumably that it is more costly for an FDI firm to build new relationships in a foreign country than in its home country. In those cases where FDI firms' top managers do attempt to build relationships with professors, scientists, and engineers in local universities, the purpose is to acquire distinctive resources that are not available in their home countries [88]. As a result, these FDI firms find it necessary to invest more, rather than less, in R&D capacity, in order to integrate the desired external boost to firm innovation.

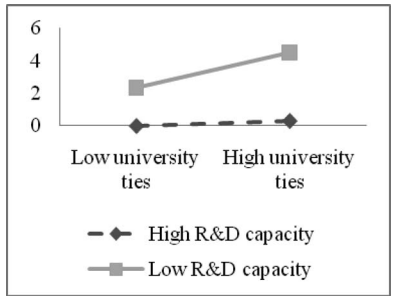

Fig. 1. Interactive effect of university ties and R&D capacity (local firms).

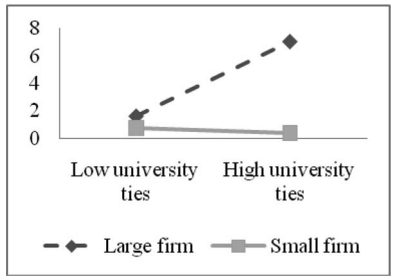

Fig. 2. Interactive effect of university ties and firm size (local firms).

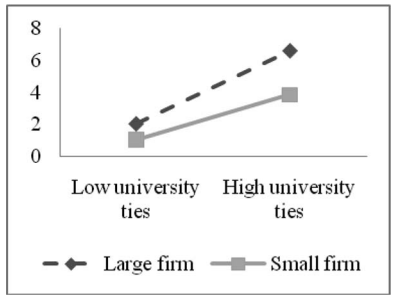

Fig. 3. Interactive effect of university ties and R&D capacity (FDI firms).

We also use the across regression equation t test to compare the above effects between FDI firms and local firms. The results further confirm our arguments that firm characteristics, such as R&D capacity and firm size, play an important role on the relationship between university ties and firm innovation for FDI firms more than that for local firms. Moreover, university ties are equally important for both FDI firms and local firms on their innovation outcomes.

While prior research suggests that managerial ties are important for firm innovation, who can cultivate university ties more in China? Our study concludes that it depends. Although university ties will positively influence innovation for both FDI firms and local firms, its effect depends on firm characteristic (i.e., firm size and R&D capacity) and ownership type (i.e., local or FDI firms). FDI with larger size and higher internal R&D capacity can better cultivate university ties for firm innovation, whereas local firms regard university ties as a substitute for internal R&D capacity.

To investigate the moderating effect of the model in this research, Figs. 1–4 provide the further explanations. Figs. 1 and 2 show that for FDI firms, higher level of university ties with the

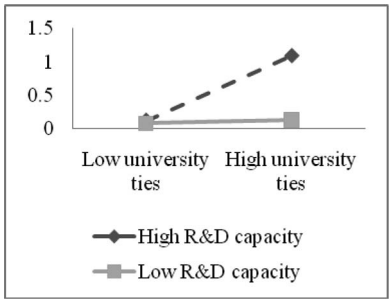

Fig. 4. Interactive effect of university ties and firm size (FDI firms).

larger size of the firm or the higher level of R&D capacity can enhance a firm's innovation. For local firms, Fig. 3 shows that higher level of university ties with the larger size can enhance a firm's innovation. On the contrary, Fig. 4 shows that higher level of university ties with the lower level of R&D capacity can enhance a firm's innovation. The aforementioned results also support our argument that internal R&D capacity and external university ties are substitutes for local firms but complementary for FDI firms.

Our results are relevant for practicing managers because they show that acquiring the knowledge in universities is contingent on firm characteristics as well as ownership types. Managers should consider the resources and R&D capacity before they establish university ties with professors, scientists, and engineers. For FDI firms, abundant resources and higher R&D capacity complement with university ties to improve innovation. For instance, IBM, Microsoft, or Motorola established their research centers in the university-intensified area in Beijing. They all build intimate cooperation relationships with well-known universities in China. However, for Chinese local firms, because of the resource limitation, it is viable for them to take advantage of university ties and allocate their valuable resources to other functions instead of R&D activities.

VI. Conclusion

Although prior university–industry studies mostly investigate the process of knowledge transfer in the collaborations, the effect of interpersonal relationships among members between universities and firms on firm innovation has not received great attention. Our research, by introducing the concept of university ties, has significant implications for the increasing studies on university–industry collaborations. In examining 226 Chinese sample firms, we find that the contribution of university ties on a firm's innovation will be influenced by firm characteristics such as size and R&D capacity. The major contribution of this study is to fill the research gap that few prior studies compare the effect of university ties on firm innovation between FDI firms and local firms. Our results suggest that both FDI firms and local firms do cultivate universities ties but in different ways. Local firms cultivate university ties as a substitute for internal R&D capacity whereas FDI firms cultivate university ties as a means of entry strategy to complement their internal R&D capacity.

There are a number of limitations in this research. First, our study did not differentiate among the three types of patents: invention, utility, and design. The future studies, which compare the effect of universities on different types of innovation are promising. Second, the difference of industries may affect how R&D capacity and firm size relate to firm innovation. Although we try to rule out the effect of industries by including industry types as control variables in our study, the future studies in different industries, especially the comparison between high-technology industries and traditional industries, are very helpful to explore to a more insightful understanding of this topic. Third, there is a possibility of the endogeneity between university ties and innovation level. Are firms more innovative because of the university ties or do the firms set up university ties because they are already heavily innovation oriented? Although most prior studies support the argument that firms can be more innovative if they possess closer ties with universities [90], [91], we also agreed that firms set up university ties might be because of their heavily innovation orientation. However, to some extent, a firm's level of innovation orientation determined by its inputs and efforts on innovation and we have controlled it (R&D capacity) in our regression models when examining the relationship between university ties and innovation outputs. Future studies are suggested to further verify the possible relationship between innovation inputs and university ties. Finally, although prior studies have investigated the managerial ties in other emerging economies other than in China [92], the generalizability of university ties in the context of other emerging economies seems to be a promising direction for future research considering the differences of the culture, institution, and language between these emerging countries and guanxi-oriented countries, such as China.

Acknowledgment

The authors would like to acknowledge one of the anonymous reviewers who gave insightful suggestion for this study.

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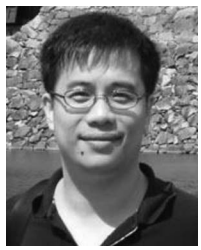

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