R&D Partnerships and Capability of Innovation of Small and Medium-sized Firms in Zhongguancun, Beijing: The Power of Proximity

Nobuaki Hamaguchi,
Research Institute for Economics& Business Administration,
Kobe University
and
Yoshihiro Kameyama,
The International Centre for the Study of East Asian Development

Working Paper Series Vol. 2008-20
July 2008

The International Centre for the Study of East Asian Development, Kitakyushu

R&D Partnerships and Capability of Innovation of Small and Medium-sized Firms in Zhongguancun, Beijing: The Power of Proximity

Nobuaki Hamaguchi† **and Yoshihiro Kameyama**††

†Research Institute for Economics & Business Administration, Kobe University
††The International Centre for the Study of East Asian Development (ICSEAD)

Abstract

We examine the impact of research partnerships on a firm's own R&D capability along with the context of the importance of geographical proximity using original survey data obtained from small and medium-sized firms in Zhongguancun Science Park (ZSP). This study develops an analytical framework related to the impact of research partnerships on a firm's R&D capability. Results show that research cooperation with universities and research institutes and small and medium-sized firms enhances the R&D capability of individual firms when the partners are located nearby, although distance has no significant effect on cooperation with large firms.

JEL classification: O32, R12, R39

Keywords: research cooperation, spillovers, R&D capability

† 2-1 Rokkodai Nada-ku, Kobe, 657-8501, Japan. E-mail: hamaguchi@rieb.kobe-u.ac.jp
†† Comments are welcome. Send your comments to kameyama@icsead.or.jp . Address: 11-4 Otemachi, Kokurakita-ku, Kitakyushu, 803-0814, Japan. TEL: +81-93-583-6202; FAX: +81-93-583-4602.

1. Introduction

As Cohen and Levinthal (1989) showed, research and development (R&D) has two faces, cooperation in R&D also has impacts not only on increasing knowledge creation but also on strengthening the innovative capability of individual firms. Research cooperation can be undertaken with partners of various types in different locations. For partners of some types, such impacts are felt more strongly if partners are located nearby because communication is convenient and frequent. The present study specifically analyzes the impact of research partnerships on a firm's own R&D capability, devoting particular attention to partner types and their geographical proximity. This empirical study uses firm-level data from a questionnaire survey on small and medium-sized firms in Zhongguancun Science Park (ZSP), a scientific-knowledge-based industrial cluster in Beijing. Because innovative capability is a scarce asset, especially for a newly industrializing country such as China, results of detailed empirical studies might contribute to the debate related to technological and regional policies.

It has been asserted that ZSP will become the leader of Chinese high-tech industrial development in the 21st century, following Shenzhen in Guangdong as the symbol of economic opening and reform in the 1980s, and Pudong in Shanghai as the icon of China's entry into the globalization era in the 1990s. Although the expanse of ZSP's urban landscape might be interpreted by some as simply an 'electronics shopping town', its remarkable development has created the buzz of a 'Silicon Valley model'. The agglomeration of high-tech firms is not the only engine of economic growth of Beijing, but it is viewed as a key piece of future Chinese development aimed at a higher intensity of innovation.

The central role played by ZSP in the national innovation system is underscored by the following figures. Based on data provided by *2006 Annual Report of the Beijing Technical Market* (http://www.cbtm.net.cn/jytj/2006tjgb.htm), Beijing's organizations produced 51,575 technology contracts worth 69.7 billion yuan. While Beijing imported 6,106 technology contracts from other provinces, technology contracts with other provinces generated a 32.7 billion yuan surplus, corresponding to 4.7 percent of the gross regional product for the Beijing economy. In fact, ZSP accounts for 58 percent of all contracts, or 69 percent in value terms. Indeed, 82 percent of Beijing's technology sellers are in ZSP. Within the ZSP, about 85 percent of ZSP technology contracts and 75 percent of the contracted value originate in Haidian-qu.

Furthermore, it is remarkable that 48 percent of technology contracts concluded in Beijing are made with customers in the same city, underscoring the strong localization there. Nonetheless, the technological flows are not restricted to local exchange: 50 percent of technology contracts are made with other Chinese provinces. The remaining only 2 percent are with foreign countries.

The contribution of this paper is threefold. First, it presents a statistical analysis of a firm's own R&D and research partnerships for small and medium-sized firms in ZSP using our unique firm-level data. Despite strong attention attributed to ZSP, it has rarely been studied empirically using firm-level data. Second, it develops an analytical framework which relates the impact of research partnerships on a firm's own R&D capability. In most previous studies, the relation between research partnerships and a firm's own R&D has been examined from different perspectives such as whether research partnerships' increase the productivity of individual R&D; and whether a firm's own stronger R&D capability increases the likelihood of engaging in research cooperation. Third, using this framework, we seek evidence of the relevance of geographical proximity of some types of research partners such as universities and research institutes and small and medium-sized firms on the effectiveness of promoting individual firms' R&D capability.

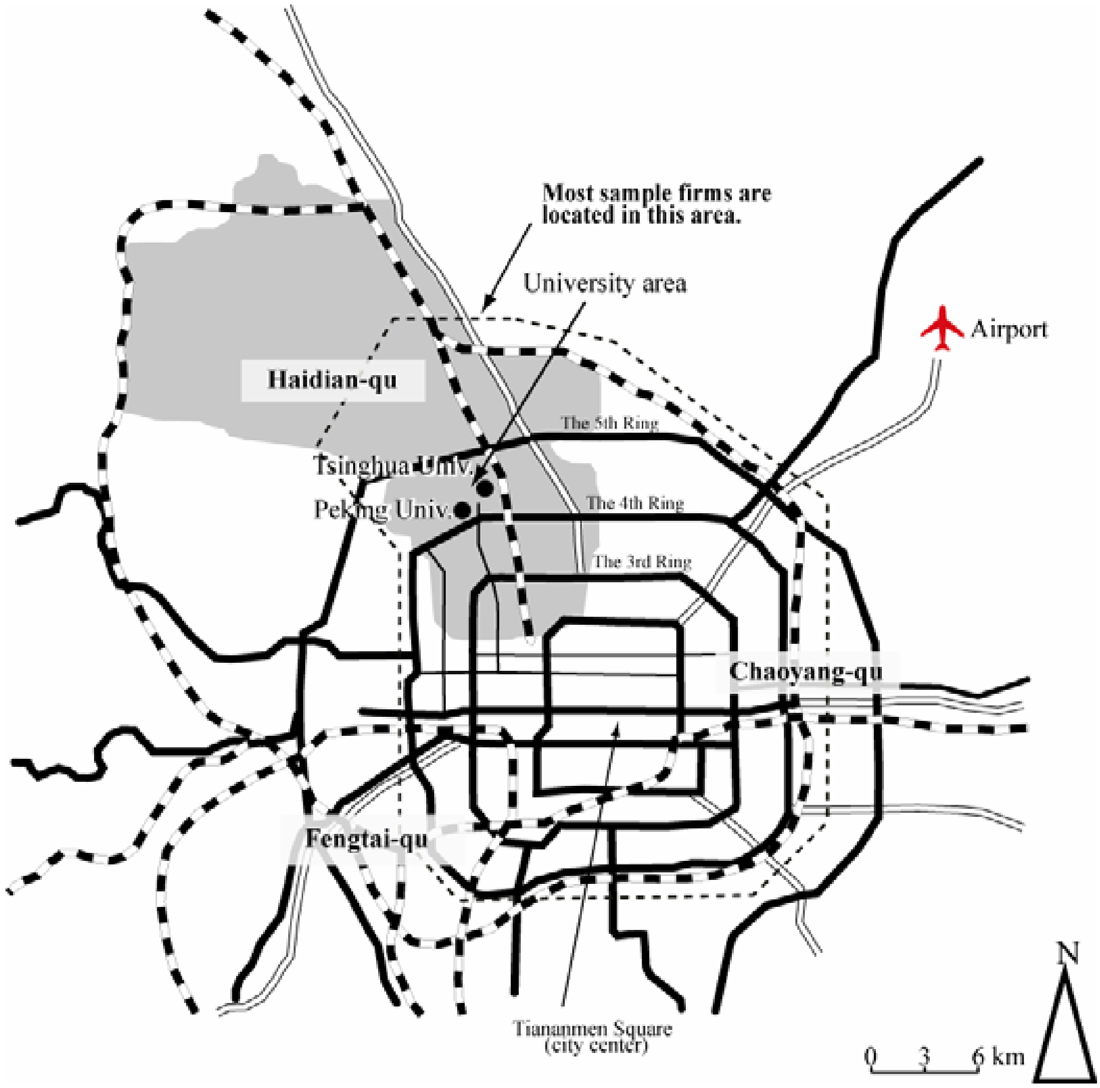
This paper is organized into four sections. Following this introduction, Section 2 provides some basic information related to ZSP and summary statistics of the surveyed data. In Section 3, after discussion of theoretical background of our analytical framework, we describe the empirical model and present main results. Section 4 summarizes and concludes the discussion.

2. Setting the Scene: Zhongguancun Science Park and Sample Data

2.1. Basic Features of Zhongguancun Science Park (ZSP)

To set the scene, it is necessary to provide some basic information related to our sample survey region. The current structure of ZSP, consisting of 10 sub-parks covering 232 km^2, was established under the centralized management of the ZSP Management Committee by the merger of five science parks in Beijing in 1999. The core of ZSP is Haidian-qu, located in the northwestern part of the central districts of Beijing, covering about 100 km^2 (see Figure 1). The district is represented by academic activities at China's elite universities such as Tsinghua University and Peking University, in addition to numerous national level research laboratories operated under the auspices of the Chinese Academy of Sciences. By the early 1980s, computer-related private businesses (retail, parts and components, maintenance) had come to flourish in a small area near the university zone, then known as Zhongguancun. In 1988, this area was designated by the Beijing municipal government as China's first science park.

Figure 1: Map of Beijing and location of the ZSP core area



As of the end of 2007[1], ZSP became home to more than 20,000 high-technology firms with strong emphasis on electronics and information-communication technology (ICT), generating employment for 954,000 technological workers. In 2007, the total value-added production in ZSP came to represent 18 percent of the gross regional product of Beijing, generating tax revenues of 31.9 billion yuan out of 859.6 billion yuan gross sales revenue. This region also attracts leading companies of the world to establish their R&D branches.

The progress of ZSP as a knowledge creation center is supported by the following factors. First, the remarkably rich R&D human resource environment of ZSP offers invaluable conditions for the development of the high tech industrial cluster. Based on Beijing Statistical Yearbook 2007, we can roughly calculate that universities in Beijing annually produce about one-fourth of all national graduates with doctoral degrees, and about 15 percent of those with master's degrees. Furthermore, notably, the ZSP Management Committee (2006) reports that among 67 higher education institutions in Beijing offering at least full-time undergraduate level courses, 42 percent are situated in the ZSP vicinity.

Secondly, the ZSP area is well supported by local infrastructure and supportive policies. Some narrow streets have been reconstructed into broad multi-lane avenues with convenient access to the ring roads (loop highways), along which new high-rise office buildings equipped with high-speed internet access stand in a row. The area is also served by the subway network. In the science park, projects authorized by the Beijing municipal government as high-tech[2] are benefited by supportive programs including simplification of procedures to establish a company, income tax reduction, subsidized credit, admittance to buildings equipped with high-quality infrastructure, and granting resident registration of Beijing (which is only slightly obtainable because migration is controlled in China). These benefits are targeted to those who have earned doctorate degrees at foreign universities and hope to return to use their knowledge and experience in China. In addition, and quite importantly in a country where governmental control is strong, more opportunities, both formal and informal, are available in the nation's capital for scientists to obtain information related to future technological standards set by the central government.

The third factor is the local innovation networks among firms, universities, and local and central government. Nevertheless, this is much less obvious than the two factors described above because the intangible nature of knowledge transfers and its effectiveness have been questioned in previous studies, casting some doubt on the sustainability of ZSP as a center of innovation. Reasons for such skepticism include the following: strong hierarchical restraints from the state-owned institutions or firms on local networking and local firms' direct global linkages with multinationals (Wang and Wang, 1998); high start-up costs and dominance by large firms, which discourages an entrepreneurial culture (Tan, 2006); changing characteristics from an indigenous innovation region to a satellite marketing platform for multinational companies (Zhou and Xin, 2003); and the excessive market orientation of universities and research institutes, which might skew their decision-making to short-term commercial success in neglect of basic research and education (Chen and Kenny, 2007).

Despite such concerns, empirical studies of ZSP firms at the microeconomic level remain limited. Liefner et al. (2006) is a major exception to analyses ZSP firms' behavior on R&D cooperation using original company survey data. They found that both foreign companies and public research organizations and higher education institutions (PROHEIs) are sources of new knowledge for ZSP firms, but the two knowledge flows are geographically distinctive. Locations of foreign companies are international, whereas the majority of cooperating PROHEIs are located in Beijing. Companies with higher knowledge-absorptive capacity tend to cooperate more with foreign companies, whereas local companies rely on knowledge dissemination through PROHEI-led networks. The results of their study showed that cooperation with foreign firms is not a substitute for that with PROHEIs because their cooperation with PROHEIs is fundamental for building their knowledge-absorptive capacity.

2.2. Data Description

Our data for empirical analysis come from a questionnaire survey of ICT-related small and medium-sized firms in ZSP carried out in March 2005[3]. Sample firms were selected from the Tsinghua Science Park directory; it is a subsidiary of Tsinghua University that develops high-tech industrial estates in ZSP and provides support to tenant firms. The survey was conducted either on direct visits or by telephone to a person in a top management position of each firm[4]. We obtained effective replies from 207 firms, of which 204 firms are located in Beijing city. The most common activities of our sampled ICT-related firms are *electronic parts and devices, package software and information processing*.

Table 1 presents the spatial distribution of sample firms. Most firms are located in the area highlighted in Figure 1, consisting of seven districts which incorporate science parks of ZSP: Dongcheng-qu, Xicheng-qu, Chongwen-qu, Xuanwu-qu, Chaoyang-qu, Fengtai-qu, and Haidian-qu. In this paper, we define the seven districts covering only eight percent of the land area of Beijing city as the central districts and the remainder of Beijing and other provinces as the outer area. Notably, about 85 percent of the survey sample firms are located in Haidian-qu. Although this heavy concentration might seem odd, it represents reality reasonably well: 64 percent of 3,526 high tech firms registered in the firm directory of ZSP Management Committee in 2004 are actually located in Haidian-qu. Recently, many new firms have been established in the outer area, especially in Changping-qu in the northwestern vicinity of Haidian-qu and Daxing-qu, which incorporates Beijing Economic-Technological Development Area. However, the two districts are not covered in our survey.

Table 1: Locations of high-tech firms in Beijing

		Number of Establishments				Land Area (km^2)[2]	
		Survey data		Actually registered [1]			
			(%)		(%)		(%)
Central districts[3]		204	98.6	3,117	88.4	1,284.01	7.8
	Haidian-qu	176	85.0	2,265	64.2	430.73	2.6
	Chaoyang-qu	14	6.8	320	9.1	455.08	2.8
	Dongcheng-qu	4	1.9	71	2.0	25.34	0.2
	Xicheng-qu	6	2.9	91	2.6	31.63	0.2
	Fengtai-qu	4	1.9	335	9.5	305.80	1.9
Outer area	Changping-qu	0	0.0	246	7.0	1,343.54	8.2
	Others	3	1.4	163 [4]	4.6	13,782.99	84.0
Total		207	100.0	3,526	100.0	16,410.54	100.0

Note: 1) Zhongguancun Science Park Management Committee and Beijing Statistics Bureau (2004)
2) Total 16,410 km^2 (*Beijing Statistical Yearbook 2006*)
3) Including Chongwen-qu and Xuanwu-qu.
3) This includes those which do not report an address.

For the remainder of the analysis, we drop firms with more than 300 employees from the dataset to retain consistency with the Chinese official statistical definition of small and medium sized firms. This reduces the sample size to 193. Table 2 shows summary statistics of that sample. The average age of firms is about five and a half years. Their average number of employees is 44. These firms show strong R&D intensity: about 39 percent of all employees are employed in R&D; 26 percent of the total sales are invested in R&D. Therefore, we can paint a picture of an average ZSP firm as R&D-intensive, young, and small.

Our questionnaire included questions related to firms' partnerships in R&D. We distinguished partners into three types: large firms (LFs), small and medium-sized firms (SMFs), and universities and research institutes (URIs). Both LFs and SMFs can be either suppliers or customers. Geographically, each partner is differentiated between those located nearby (i.e. within the central districts) and those which are distant (i.e. the outer area). Table 3 depicts the result. We obtained replies from 65 firms that have partnerships in R&D with LFs, 77 firms with SMFs, 66 firms with URIs, and 17 firms with none. A glance at the table shows that most partnerships with other firms, both LFs and SMFs, are with those in distant locations, which is surprising in the sense that we can expect denser inter-firm R&D cooperation within ZSP. Nevertheless, our finding is consistent with those of a study by Liefner et al. (2006), which found Chinese firms with which ZSP firms exchange technological information are mostly located outside Beijing. On the other hand, our result reveals a strong tendency of localization with respect to partnerships with URIs.

Table 2: Summary statistics of sample firms

(N = 193)

	Unit	Mean	Standard deviation	Coefficient of variation	Maxi-mum	Mini-mum
Firm Age[1)]	Year	6.54	8.67	1.33	53.00	0.00
Number of Employees (A)	Person	43.75	58.24	1.33	300.00	2.00
Number of Research Staff (B)	Person	16.13	29.56	1.83	260.00	0.00
Research Staff' Intensity (B)/(A)	%	39.22	31.88	0.81	100.00	0.00
R&D Expenditure [2)]	US$1, 000[3)]	325.54	1,110.64	34.12	9,661.84	0.00
R&D Expenditure Share in Sales [2)]	%	26.41	28.73	1.09	160.00	0.00

Note: Some firms answered these figures not by single-unit establishment level but at the all-business establishment level. Those figures of sample firms were not included in this table.
1) Since the year of establishment; 2) Annual figures in 2004. Other figures are as of the time of the survey; 3) Converted with 8.28 yuan /dollar (fixed exchange rate at the time of the survey).

Table 3: R&D cooperation partners and distance

(%)

	Large firms (65 firms)	Small and medium-sized firms (77 firms)	Universities and research institutes (66 firms)
Nearby area	6.1	7.8	60.7
Distant area	93.9	92.2	39.3
Total	100.00	100.0	100.0

Note: Total number of answers is 119, allowing multiple answers. In all, 102 firms replied that they have at least one partnership; 17 firms declared that they have none.

3. Empirical Analysis

3.1. Theoretical background

The influence of knowledge spillovers on innovation has been widely studied in economics. Given high sensitiveness to distance of knowledge exchange, knowledge spillovers have been associated with regional economies since Marshall (1890). Using US small business data, Audretsch and Feldman (1996) found that, even after controlling for the degree of geographical concentration of production, innovation is geographically concentrated, and influenced by regional factors such as higher industry R&D/sales ratios, availability of skilled labor, and higher intensity of university research. Numerous case studies have credited universities with relevant contributions to innovation of local industries (Mansfield, 1995; Varga, 1998; Anselin et al., 2000; Adams, 2002).

Specifically examining the influence of distance, Adams (2002) asserted that academic spillovers are more localized than industrial spillovers, arguing that local university research has characteristics of open science that is reasonably current and not proprietary, although industrial joint researches are based on contractual arrangements. Under such conditions, university research will be stunted by a distance; industrial joint research can be done over longer distances in so far as it is appropriate. If a contract is incomplete and the risk of information leakage is higher, industrial spillover can be also localized. This might be the case of cooperation between small and medium-sized firms. In a general setting, as explained by De Bondt (1996), knowledge spillovers might discourage innovation because of limited appropriability. If so, why can firms be encouraged to undertake cooperative research? Cohen and Levinthal (1989) introduced a theoretical model in which R&D not only creates new knowledge; it also enhances a firm’s absorptive capacity for learning. Recognition of the latter effect lends support to knowledge spillover’s role of enhancing innovation when firms have strong absorptive capacity that is accumulated through a firm's own R&D. Partial evidence was uncovered by Roper et al. (2000) which analyzed the U.K. plant-level survey data and concluded that plants not having R&D departments derive less benefit from positive innovation effects of being in a region with a large fraction of employment in R&D intensive industries.

The alternative view can be presented such that local research cooperation also has another face to enhance firms' capability of innovation. Using Japanese firm-level survey data, Motohashi (2005) found that young firms that began to participate in university-industry cooperation in the recent period primarily lacked their own R&D, implying that universities are expected to help local new technology-based firms to build up their own internal R&D resources. However, working with plant-level data from the U.K. and Germany, Love and Roper (2001) found no empirical support for the influence of regional variables (e.g., population density, GDP per capita, percentage of plants undertaking R&D, and college graduates' share of the regional labor force) on plants' innovation intensity (i.e. R&D employees' share of total employment in each plant).

This study extends the analytical perspective of relating local conditions to firms' capacity of innovation. Specifically, we argue that a firm's capacity for innovation is enhanced by inter-organizational cooperation, especially when partners of the cooperation are located in nearby. It therefore follows that individual research workers are more valuable because local cooperation boosts R&D activities. Consequently, we intend to analyze the effect of local knowledge spillovers on R&D at both the firm level and the individual level.

3.2. Specification of the empirical model

For an empirical analysis of the argument presented above, we first consider the following reduced-form model:

$$\ln RES = \alpha_0 + \alpha_1 \ln EMP + \alpha_2 \ln R\&D + \alpha_3 \ln AGE + \beta_1 DM_1 + \beta_2 DM_2 + \beta_3 DM_3 + \mu \qquad (1)$$

The dependent variable RES represents the number of research staff employed by a firm representing its capacity of innovation. As explanatory variables, the right-hand-side includes three firm-characteristics variables: EMP, representing the total employment which stands for a firm size; $R\&D$, the R&D expenditure encapsulating efforts of innovation; and AGE, years in operation since establishment, which represents business experience. The last term μ is an error variable. Because our sample comprises firms in technology-intensive industries, growth in firm size and innovative efforts naturally call for expansion of the firm's own R&D capability. Consequently, we expect that both EMP and $R\&D$ have positive coefficients. The effect of AGE is not so obvious: some might expect that more experienced firms tend to be more innovative; others would claim that start-up firms are more ambitious in technological differentiation and more standardized in later stages.

We also introduce three R&D partnership dummies— DM_1, DM_2, DM_3—where the subscript corresponds to each partner such that 1= large firms (LFs), 2= small and medium-sized firms (SMFs), and 3= universities and research institutes (URIs). The LFs and SMFs can be either their customers or suppliers of sample firms. We assign 1 to each dummy variable if a firm would have R&D partnerships with a counterpart and 0 otherwise. This arrangement implies that the firms that have no R&D partnerships and rely solely on their own R&D signify the benchmark case. Assuming that such cooperation affects enlargement of the firm-level capacity of innovation, we expect a positive sign for β_1, β_2,and β_3 in equation (1).

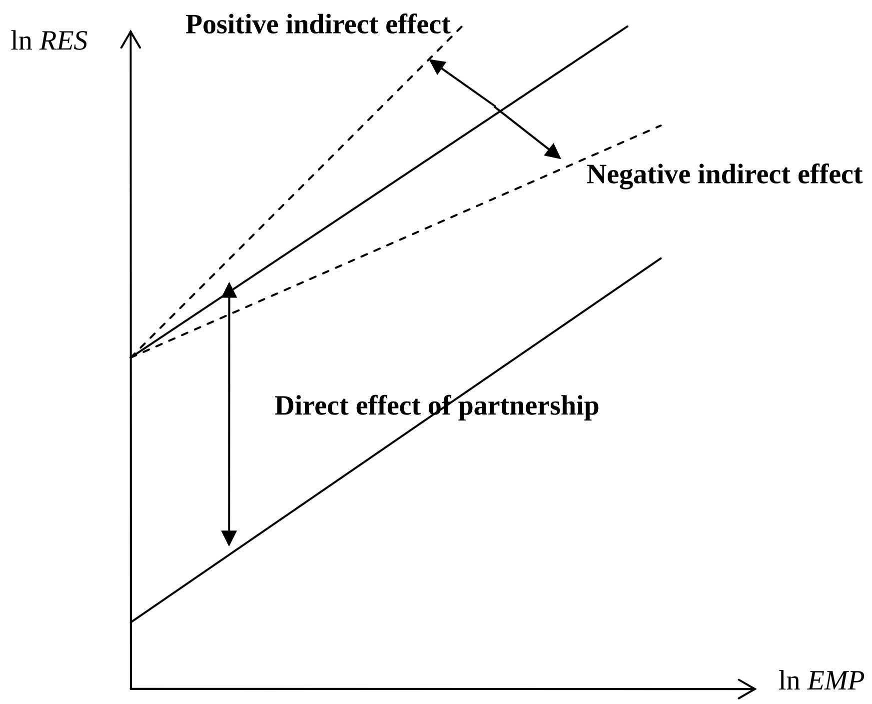
This model resembles the knowledge production function used by Audretsch and Feldman (1996), Love and Roper (2001) and Acs (2002), which also included firm-level characteristics and regional characteristics as explanatory variables. Nevertheless, it differs from their models in two ways. First, our model introduces the firm-level capacity of innovation instead of R&D outcomes as the independent variable, which are not mutually equivalent because of the high degree of uncertainty in R&D successes and failures. Second, although the regional characteristics variables in previous studies merely portray the regional macro-environment, such as the numbers of scholars, universities, and research laboratories of private firms, the dummy variables of our model capture the micro-behavior of firms in relation to local interaction.

Based on equation (1), we extend the model to incorporate the interaction terms of the R&D expenditure and the R&D partner dummies. This model is given as the following.

$$\begin{aligned} \ln RES = {} & \alpha_0 + \alpha_1 \ln EMP + \alpha_2 \ln R\&D + \alpha_3 \ln AGE + \beta_1 DM_1 + \beta_2 DM_2 + \beta_3 DM_3 \\ & + \beta_1 (DM_1 \times \ln R\&D) + \beta_2 (DM_2 \times \ln R\&D) + \beta_3 (DM_3 \times \ln R\&D) + \mu \qquad (2) \end{aligned}$$

In this specification, R&D partnership dummies have both direct and indirect effects on firms' capacity of innovation. The interaction terms capture the indirect effect of R&D partnerships through R&D expenditure on R&D employment. As depicted in Figure 2, the positive coefficient of these terms suggests that R&D partnerships increase a firm's R&D expenditure's propensity to be related to the firm's capacity. If the coefficient is negative, the partnership would reduce the same propensity, implying that R&D expenditure per R&D worker will be higher. In the latter case, partnerships make individual R&D workers more valuable because they handle greater research funds on average. It is presumably in such regions where knowledgeable workers would like to seek jobs.

Figure 2: Effects of business partnership on firm innovation capabilities



We then apply the model to consider the influence of the geographical proximity of R&D partners whose distribution is presented in Table 3. As described in Section 2, the notion of "nearby" is defined such that R&D partners are within the seven central districts of Beijing, whereas "distant" refers to the outer area including other cities and provinces. We redefine R&D partnership dummies assigning 1 if a firm has R&D partnerships with each counterpart located nearby and 0 otherwise. These dummies are expressed using the superscript *N*. Similarly, we introduce dummy variables indicating distant R&D partners located far off the central districts with the superscript *F*. Using equations (1) and (2), we obtain the following equations for testing the influence of geographical proximity.

$$\ln RES = \alpha_0 + \alpha_1 \ln EMP + \alpha_2 \ln R\&D + \alpha_3 \ln AGE + \beta_1^N DM_1^N + \beta_2^N DM_2^N + \beta_3^N DM_3^N + \mu \quad (3)$$

$$\begin{aligned} \ln RES = \alpha_0 + \alpha_1 \ln EMP + \alpha_2 \ln R\&D + \alpha_3 \ln AGE + \beta_1^N DM_1^N + \beta_2^N DM_2^N + \beta_3^N DM_3^N \\ + \beta_1^N (DM_1^N \times \ln R\&D) + \beta_2^N (DM_2^N \times \ln R\&D) + \beta_3^N (DM_3^N \times \ln R\&D) + \mu \quad (4) \end{aligned}$$

$$\ln RES = \alpha_0 + \alpha_1 \ln EMP + \alpha_2 \ln R\&D + \alpha_3 \ln AGE + \beta_1^F DM_1^F + \beta_2^F DM_2^F + \beta_3^F DM_3^F + \mu \quad (5)$$

$$\begin{aligned} \ln RES = \alpha_0 + \alpha_1 \ln EMP + \alpha_2 \ln R\&D + \alpha_3 \ln AGE + \beta_1^F DM_1^F + \beta_2^F DM_2^F + \beta_3^F DM_3^F \\ + \beta_1^F (DM_1^F \times \ln R\&D) + \beta_2^F (DM_2^F \times \ln R\&D) + \beta_3^F (DM_3^F \times \ln R\&D) + \mu \quad (6) \end{aligned}$$

We then estimate equations (1)–(6) using OLS estimations with robust standard errors in view of possible heteroskedasticity in the error term.

3.3. Results

Table 4 presents results of the first test of the effects of R&D cooperation partners. As we expect in equation (1), the firm size and R&D expenditure have a positive influence on the R&D capacity. We found no statistically significant effects of firm age, perhaps because our sample firms are uniformly young. These results are consistent throughout the remainder of the analysis. Still working on equation (1), none of the three dummy variables representing frequent contacts with R&D partners has a statistically significant impact.

Adding the terms of interaction between the R&D partnership dummies and R&D expenditure, equation (2) reflects that the direct impact of contact with URIs (DM_3) is positive, although its indirect effect through R&D expenditure appears to be negative. Consequently, interacting with URIs, firms are employing less R&D labor for a given level of R&D expenditure, which indicates that cooperation with universities stimulates the R&D capability at the firm level through a direct effect and allows an increase in the average R&D expenditure for each R&D worker, suggesting higher R&D capability at the individual worker level. The direct effect of partnerships with LFs (DM_1) is irrelevant, although the indirect effect is found to be positive but only at a weak level of statistical significance, suggesting that R&D partnerships with LFs might increase R&D

employment through stimulation of R&D expenditure. Interaction with SMFs (DM_2) exhibits neither direct nor indirect effects on the R&D capacity of firms.

Table 4: Effect of R&D cooperation partners

	Equation (1)			Equation (2)		
	Coefficient	*t*-statistic	*p*-value	Coefficient	*t*-statistic	*p*-value
ln *EMP*	0.579***	(6.280)	(0.000)	0.593***	(7.270)	(0.000)
ln *R&D*	0.175***	(2.380)	(0.019)	0.130*	(1.690)	(0.094)
ln *AGE*	-0.024	(0.170)	(0.867)	-0.062	(0.460)	(0.647)
DM_1 (LFs)	0.101	(0.740)	(0.458)	-0.443	(1.210)	(0.229)
DM_2 (SMFs)	0.029	(0.200)	(0.839)	-0.181	(0.520)	(0.607)
DM_3 (URIs)	-0.025	(0.180)	(0.856)	0.661**	(2.290)	(0.024)
DM_1*ln *R&D*				0.132*	(1.690)	(0.095)
DM_2*ln *R&D*				0.048	(0.640)	(0.522)
DM_3*ln *R&D*				-0.155**	(2.340)	(0.021)
Constant	-0.311	(1.010)	(0.313)	-0.102	(0.250)	(0.806)
Adj. R^2	0.712			0.732		
Probability > *F*-statistic	0.000			0.000		
Number of observations	119			119		

Note: * Significant at the 10% level; ** 5% level; *** 1% level.

The results in relation to partnerships with LFs and SMFs are altered substantially if we differentiate the partners by location. Table 5 reports the results of a test which takes into consideration a geographical proximity of R&D partners. The analysis uses dummy variables referring to cooperation with nearby agents in panel (a), and cooperation with distant partners in panel (b). In contrast to Table 4, we can identify positive direct and negative indirect effects of cooperation with nearby SMFs, which suggests that synergy in R&D among SMFs in ZSP takes advantage of geographical proximity, although such instances are limited, as presented in Table 3. In contrast, cooperation with distant SMFs showed an effect on R&D capability that was not statistically significant; moreover, the estimated coefficient has an unexpectedly negative sign. Consequently, the impact of partnerships with distant SMFs on R&D capability is irrelevant.

Table 5: Effects of partners and their location

(a) Nearby partners

	Equation (3)			Equation (4)		
	Coefficient	*t*-statistic	*p*-value	Coefficient	*t*-statistic	*p*-value
ln *EMP*	0.591***	(6.760)	(0.000)	0.623***	(7.560)	(0.000)
ln *R&D*	0.179***	(2.650)	(0.009)	0.212***	(2.990)	(0.003)
ln *AGE*	-0.006	(0.040)	(0.966)	-0.059	(0.390)	(0.694)
DM_1^N (LFs)	0.163	(1.170)	(0.243)	0.077	(0.240)	(0.814)
DM_2^N (SMFs)	0.519***	(4.190)	(0.000)	1.191***	(4.760)	(0.000)
DM_3^N (URIs)	0.015	(0.110)	(0.914)	1.145***	(3.260)	(0.001)
DM_1^N *ln *R&D*				0.036	(0.520)	(0.601)
DM_2^N *ln *R&D*				-0.247***	(2.450)	(0.016)
DM_3^N *ln *R&D*				-0.243***	(3.370)	(0.001)
Constant	-0.377	(1.520)	(0.130)	-0.537**	(2.140)	(0.035)
Adj. R^2	0.718			0.736		
Probability > *F*-statistic	0.000			0.000		
Number of observations	119			119		

(b) Far-off partners

	Eq. (5)			Eq. (6)		
	Coefficient	*t*-statistic	*p*-value	Coefficient	*t*-statistic	*p*-value
ln *EMP*	0.574***	(7.070)	(0.000)	0.581***	(7.230)	(0.000)
ln *R&D*	0.169***	(2.660)	(0.009)	0.095	(1.380)	(0.170)
ln *AGE*	-0.036	(0.260)	(0.792)	-0.064	(0.500)	(0.619)
DM_1^F (LFs)	0.346***	(2.700)	(0.008)	-0.199	(0.610)	(0.543)
DM_2^F (SMFs)	-0.070	(0.570)	(0.571)	-0.552	(1.670)	(0.098)
DM_3^F (URIs)	-0.177	(1.180)	(0.242)	-0.059	(0.180)	(0.855)
DM_1^F *ln *R&D*				0.118	(1.570)	(0.119)
DM_2^F *ln *R&D*				0.111	(1.390)	(0.166)
DM_3^F *ln *R&D*				-0.049	(0.660)	(0.509)
Constant	-0.251	(1.010)	(0.314)	0.117	(0.410)	(0.684)
Adj. R^2	0.712			0.740		
Probability > *F*-statistic	0.000			0.000		
Number of observations	119			119		

Note: * Significant at the 10% level; ** 5% level; *** 1% level.

Examining the effect of R&D partnerships with LFs, we found a statistically significant and positive influence only for distant partners; the impact from partnerships with nearby LFs was also positive but not statistically significant. We suspect that the latter effect is supported only weakly because of the small number of instances, as presented in Table 3. Consequently, it might be surmised that the influence of distance is irrelevant in relation to the impact of cooperation with LFs on R&D capability of ZSP firms. This observation matches the fact that ZSP firms play a central role in generating Beijing's outstanding surplus in technological contract transactions with the remainder of China, as described in Section 2.

Finally, direct and indirect effects from cooperation with universities and research institutes, which are found in equation (2), are detected only for the case of nearby partners, although these effects are not at all apparent in panel (b). Therefore, we can conclude that any stimulus from research partnerships with universities and research institutes is localized. This observation is consistent with Adams (2002), as described above.

4. Concluding remarks

The empirical results presented above demonstrate that R&D partnerships with local universities and research institutes and those with local small and medium-sized firms in ZSP have effects of enhancing R&D capability at the firm level. They also increase the R&D capability of research workers at an individual level. In these respects, locating within ZSP has a positive impact on boosting the innovative capability of firms and workers. Presumably, it is to such a location that technology intensive firms can be attracted, leading to self-reinforcing agglomeration. These results are evidence that localized research cooperation with universities and research institutes and that with small and medium-sized firms promotes R&D capability of small and medium-sized firms in ZSP[5]. Access to external knowledge through local cooperation is attractive to young and small firms such as those in our survey data which cannot sufficiently afford their own R&D, corroborating the finding of Motohashi (2005) from Japanese data.

In contrast, although we can offer only weak evidence, our result shows that distance is not a major factor affecting the influence of cooperation with a large firms on R&D capability, which concurs with conclusions reached by Liefner et al. (2006): the vast majority of ZSP firms' cooperating firms are located outside Beijing. Our results further suggest that not only are they cooperating, the cooperation enhances the R&D capability of ZSP firms. We can speculate that R&D cooperation with larger firms has effects over a longer distance because of more complete contract, which protect appropriability. This speculation remains as an interest to be addressed in future research.

Our findings suggest that support for firms' own R&D in cooperation with local URIs will strengthen the innovative capability of ZSP firms. The support is expected to be of particular importance for young and small firms, which have no sufficient allowance to undertake systematic cooperation with academic scientists. Cooperation with local SMFs is actually much less common, although a relevant effect is apparent on innovative capability. As the industrial organization literature points out, the issue of appropriability tends to prevent cooperation among firms. Further investigation is necessary to design a local-level scheme to encourage firms' interactions.

Although it is beyond the perspectives of the analysis of this paper, our results hint that a complementary relation pertains between a firm's own R&D capability and research cooperation, and also between research cooperation with local partners such as URIs and SMFs and that with similar large firms. This is not a trivial question because it is also likely that such relations are mutual substitutes. Investigation in this direction can engender richer implications for regional policy.

---

[1] ZSP Management Committee website http://www.zgc.gov.cn/yqxw/35337.htm, viewed 05/08/2008.

[2] According to Liefner et al. (2006), the requirements to be considered as high tech firms by the Beijing municipal government are the following. (1) R&D must specifically address designated technological categories such as IT and biotechnology; (2) At least 30% of all employees must have at least an undergraduate degree; (3) R&D investment must be more than 3% of the total revenues; (4) More than 50% of the total revenues must be generated by sales of high-tech products.

[3] The survey was a part of a research project of the International Centre for the Study of East Asian Development (ICSEAD) on urban agglomeration in East Asia.

[4] The selection was not random: the sampling was made by contacting firm managers one by one until the number who agreed to participate was sufficient.

[5] Regarding the measure of distance designated as geographical proximity, numerous previous studies have regarded a considerably wide range of space such as 50 miles, 100 miles, and 200 miles as nearby areas (see Acs, 2002; Adams, 2002). Compared to those studies, this paper reveals that the range of space is sufficiently small to allow knowledge spillovers. This is the other contribution of this paper. These survey data enable us to examine the innovative capability of firms and workers in the context of the importance of geographical proximity because the survey was designed to capture the concrete linkages of each actor.

References:

Acs, Zoltan J. (2002), *Innovation and the Growth of Cities*, Edward Elgar Publishing.

Adams, James D. (2002), "Comparative Localization of Academic and Industrial Spillovers," *Journal of Economic Geography*, 2, 253-278.

Anselin, Luc., Attila Varga, and Zoltan Acs J. (2000), "Geographic and Sectoral Characteristics of Academic Knowledge Externalities," *Papers in Regional Science*, 79, 435-443.

Audretsch, David B. and Maryann Feldman. (1996), "R&D Spillovers and the Geography of Innovation and Production," *American Economic Review*, 86 (3), 630-640.

Chen, Kun and Martin Kenney. (2007), "University / Research Institutes and Regional Innovation Systems: The Case of Beijing and Shenzhen," *World Development*, 35 (6), 1056-74.

Cohen, Wesley M. and Daniel Levinthal A. (1989), "Innovation and Learning: The Two Faces of R & D," *The Economic Journal*, 99, 569-596.

De Bondt, Raymond. (1996), "Spillovers and Innovative Activities," *International Journal of Industrial Organization*, 15, 1-28.

Liefner, Ingo, Stefan Hennemann, and Lu Xin. (2006), "Cooperation in the Innovation Process in Developing Countries: Empirical Evidence from Zhongguancun, Beijing," *Environment and Planning A*, 38, 111-130.

Love, James H. and Stephen, Roper. (2001), "Location and Network Effects on Innovation Success: Evidence for UK, Germany and Irish Manufacturing Plants," *Research Policy*, 30, 643-661.

Mansfield, Edwin. (1995), "Academic Research Underlying Industrial Innovations: Sources, Characteristics, and Financing," *Review of Economics and Statistics*, 77, 55-65.

Marshall, Alfred. (1890), *Principles of Economics*, London: Macmillan (8th ed. Published in 1920).

Motohashi, Kazuyuki. (2005), "University-industry Collaborations in Japan: The Role of New Technology-based Firms in Transforming the National Innovation System," *Research Policy*, 34, 583-594.

Penrose, Edith T. (1959), *The Theory of the Growth of the Firm*, John Wiley: New York.

Roper, Stephen, James H. Love, Brian Ashcroft, and Stewart Dunlop. (2000), "Industry and Location Effects on UK Plants' Innovation Propensity," *Annals of Regional Science*, 34, 489-502.

Tan, Justin. (2006), "Growth of Industry Clusters and Innovation: Lessons from Beijing

Zhongguancun Science Park," *Journal of Business Venturing*, 21, 827-850.

Varga, Attila. (1998), *University Research and Regional Innovation: A Spatial Econometric Analysis of Academic Technology Transfers*, Kluwer Academic Publishers, Boston.

Wang, Jici and Jisian Wang. (1998), "An analysis of New-Tech Agglomeration in Beijing: A New Industrial District in Making?" *Environment and Planning A*, 30, 681-701.

Zhongguancun Science Park Management Committee. (2006), *Zhongguancun Industrial Development Report 2006*, (in Chinese, http://www.zgc.gov.cn/document/20070919155100562615.doc)

Zhongguancun Science Park Management Committee and Beijing Statistics Bureau. (2004), *Business Guidebook of the Zhongguancun Science Park 2004* (in Chinese), Beijing, Zhongguo Shangye Chubanshe.