COOPERATION PATTERNS OF HIGH-TECH COMPANIES IN SHANGHAI AND BEIJING: ACCESSING EXTERNAL KNOWLEDGE SOURCES FOR INNOVATION PROCESSES

Ingo Liefner and Gang Zeng

With 1 figure and 5 tables

Received 17 July 2008 · Accepted 16 September 2008

Summary: The endowment of cities with sources of new knowledge, e.g. universities and innovative enterprises, creates opportunities for cooperation in innovation processes. This article analyzes to what extent the regional availability of such knowledge sources influences the cooperation patterns of enterprises in Shanghai and Beijing. The article contributes to the broader discussion of how technological progress in China's leading metropolitan regions is influenced by economic and institutional changes. The empirical analyzes are based on statistically representative survey data. Thus, this article complements a number of related publications that are based on case study material. The analyses show that the availability of local knowledge providers explains the relative importance of knowledge sources but not the absolute frequency of contacts.

Zusammenfassung: Das Spektrum der Kooperationsmöglichkeiten für Unternehmen im Innovationsprozess wird von den vor Ort erreichbaren potenziellen Kooperationspartnern beeinflusst. Dieser Artikel untersucht, in welchem Maß das lokale Vorhandensein bestimmter Kooperationspartner mit den Kooperationsmustern von Hightech-Firmen in Shanghai und Beijing korrespondiert. Damit möchte der Artikel einen Beitrag zur Diskussion um die Einflussfaktoren des technologischen Wandels in Metropolregionen von Schwellenländern leisten. Die empirische Analyse basiert auf repräsentativen Befragungsdaten. Die Ergebnisse zeigen, dass das lokale Vorhandensein potentieller Kooperationspartner die relative Bedeutung einzelner Wissensquellen für Innovationen beeinflusst, nicht aber die absolute Kooperationshäufigkeit.

Keywords: Regional innovation systems, knowledge transfer, cooperation partners, high tech, China

1 Introduction

China puts more and more emphasis on developing a high-tech industry as part of the country's goal to establish a knowledge-intensive economy: Government-funded programs support basic research and development (R&D), help to increase business spending on R&D and facilitate technology dissemination (Schwaag Serger and Breidne 2007; Hennemann and Kroll 2008). Building a knowledge-based economy is a major challenge for China: the country has to complete the transition of its science sector from a planned system led by government directives to one that is prepared to serve companies in a market-oriented economy (Sun 2002, 484-485). Moreover, China needs to improve the technological capabilities of its enterprises. This will allow the firms to gradually move from low-cost and labor-intensive production to gaining competitiveness in high-tech and innovation. Technological upgrading of Chinese firms, however, has already made definite progress during the first two decades of reform (Ho 1997; Sun 2002): During the 1980s technological upgrading was mainly driven by importing embodied technology. In the 1990s knowledge transfer by multinational companies became more and more important making technology imports more efficient. In recent years Chinese companies' indigenous technological efforts begin to emerge.

An individual company's success in technological upgrading, innovation, or producing technology-intensive goods depends on two factors: its internal capabilities and its external environment (Bell and Pavitt 1997). A firm's internal technological capabilities are predominantly determined by its internal R&D efforts and the qualification of its employees. R&D activities both generate new ideas and help to absorb knowledge from outside

DOI: 10.3112/erdkunde.2008.03.05 ISSN 0014-0015 http://www.giub.uni-bonn.de/erdkunde

(Cohen and Levinthal 1989). The qualification of employees – a company's human capital – is the basis for R&D and any other form of entrepreneurial behavior. Other factors that are related to internal capabilities are size, age, and form of ownership (Katrak 1997). The external environment affects a company's efforts of technological upgrading in two ways: One, the legal framework and informal institutions form the basis for decisions on the way of technological upgrading. For example, the effectiveness of the protection of intellectual property rights is crucial for the decision, whether upgrading is better achieved by R&D and own innovation or by copying and reverse engineering. Two, technological upgrading requires continuous information and knowledge exchange with partners.

The latter aspect deserves particular interest from an economic geography viewpoint for two reasons: one, there is little comprehensive knowledge about the quality and the quantity of innovative linkages of (high-tech) firms in China though the topic has been addressed implicitly and explicitly. In general, innovative linkages are seen to be weak and insufficient for generating a strong inflow of new ideas into Chinese firms (Wang and Lin 2008; Sun 2002, 488; Wang 1999, 222). However, there are regional and sectoral examples for the evolution of strong and productive linkages (Zhou 2005, 1126; Wei and Leung 2005, 34; Chen 2006; Liefner et al. 2006). Two, the exchange of tacit knowledge requires direct communication between people and is, thus, much easier to facilitate through local interaction. Therefore, the set of cooperation partners that is available locally determines a company's potential for intensive cooperation. For example, regions that are endowed with a broad spectrum of industries offer wider opportunities for cooperation than regions with a narrow spectrum of industries.

The analysis in this paper concentrates on Beijing and Shanghai, two of China's leading cities with respect to knowledge and technology-driven economic development, and their respective hinterlands (Hu and Xiong 2003, 28; Chen 2006, 68). In many respects, Shanghai and Beijing are comparable to each other: Both cities were opened late to the world market. They are comparable in size and have served as industry bases in communist times. Both cities shall function as economic engines for the high-tech development of their surrounding regions, the Yangtze Delta and the Bohai Region (Zhang 2000; Liu et al. 1997). Their future developments, however, may look very different: Beijing is the city of politics, science, and culture, whereas Shanghai is a city of trade, finance, and industry. Shanghai has been attributed the role of an open city and Beijing the role of a science city. These roles reflect existing strengths and weaknesses of both cities and their surrounding regions: foreign direct investment (FDI) inflow, the presence of foreign-invested enterprises (FIE), and trade relations with foreign enterprises (FE) vary as much as the quantity and quality of local universities and public R&D institutes (URI).

This paper hypothesizes that these regional differences affect the cooperation patterns of high-tech companies, taking up arguments recently made by Sun (2003, 378, 387) and Chen (2006, 75, 95). Specifically it will focus on the following two research questions:

1) Do the interaction patterns of high-tech companies in Shanghai and the Yangtze Delta, and in Beijing and the Bohai Region correspond with the accessibility of potential cooperation partners, i.e. FIE, FE and URI?

2) Does the availability of local cooperation partners sufficiently explain cooperation patterns?

The purpose of this paper is twofold: First, it aims at giving statistically significant proof for Chen's and Sun's argument, in that it goes beyond the stage of collecting evidence from case studies only. Secondly, in contrast to many other studies that provide detailed descriptions of individual cities' innovation systems it aims at comparing two regions with a consistent method. Thus, the analysis is restricted to a few comparable aspects and leaves out a discussion of both cities' individual characteristics.

The analysis is based on representative data from surveys among high-tech companies in Beijing and Shanghai. It concentrates on these firms' linkages with FIE, FE and URI. Answers to the research questions will help to assess China's policy of a regionalized high-tech development strategy based on policy tools like selective opening of cities, concentrated funding for universities, establishment of high-tech parks, etc. They will contribute to the discussion of regional characteristics and variation within the coastal zone. Moreover, the results will be useful for understanding some of the major forces behind the evolution of urban high-tech industries in newly industrializing countries.

The article takes up ideas and concepts that have been discussed in various articles published in this journal, e.g. Koch 2005; Mossig 2004; Bathelt and Depner 2003.

2 Theoretical background: cooperation in regional innovation systems

Successful technological upgrading of companies is determined by internal and external factors. The above-mentioned internal factors are incorporated in the registration criteria for high-tech firms in China. For example, high-tech firms in Beijing's Zhongguancun Science Park have to prove certain levels of personnel qualifications, internal R&D activities, and business activity in designated high-technology fields (see section 4). This paper only deals with high-tech companies and, thus, the existence of internal determinants for technological upgrading can be taken as given.

Various theoretical concepts have been proposed to explain the relevance of cooperation for innovation. An overview of the main approaches and arguments is given by Moulaert and Sekia (2003), Moulaert et al. (2005) and Breschi and Lissoni (2001). The concept of regional innovation systems (RIS) helps to capture the systemic nature of external determinants for technological upgrading. This concept is based on interactive models of innovation that stress the importance of cooperation between innovating firms and partnering organizations (Kline and Rosenberg 1986). Close interaction allows companies to acquire knowledge from their partners and to utilize it in the innovation process (e.g. Leydesdorff and Meyer 2003, 196). Important actors in RIS are firms carrying out R&D as both knowledge providers and knowledge absorbers, universities and public research organizations as knowledge providers, and many other actors like banks, insurance companies, business service companies and governments. A related approach that focuses on knowledge absorption in developing countries is the concept of learning regions (Viotti 2002; Mathews 2001). Asheim and Vang (2006) point out that the RIS of metropolitan regions in developing countries offer stimulating conditions for innovation and learning: The universities and research institutes in such cities are usually among their nations' top institutes. Human capital concentrates there as well as the respective countries' technologically most advanced companies, and foreign companies that seek cheap but skilled personnel. These general statements can be linked to various conceptual and empirical studies on China (e.g. Su 2000; Chang and Shih 2004; Liu and White 2001; Sun 2002; Zeng and Wen 2004).

Cooperation is essential in the concept of RIS. It signals that knowledge is actively disseminated – transferred and absorbed – by the actors in the system. Knowledge providers, e.g. FIE and URI, supply new knowledge and (local) cooperating firms receive knowledge. Thus, cooperation in innovation can be used as an indicator for the pattern of local knowledge flows and the possibilities for learning and upgrading. However, Malecki (2002, 933) argues that links to outside the regional network are most crucial for a local innovation system and should be established and maintained. Thus, firms should engage in cooperation with local firms and actors as well as in global networks.

With respect to the use of cooperation as an indicator for the pattern of knowledge flows in Shanghai and Beijing in section 5 two aspects are important: First, one can expect FIE, FE and URI to function as sources of new, yet different types of knowledge: As the overall aims and capabilities of FIE, FE and URI differ substantially their contribution to technological upgrading will differ, too. FIE and FE can be expected to cooperate primarily in the fields of marketing and market information as well as product adaptation and design (Shi 2001; Zhou and Tong 2003). URI aim at generating extra money either from contract research or from the long-term benefits of being involved with spin-off and other high-tech companies (Baark 2001). Hence, their contacts and the possible knowledge transfer arising from that should focus more on the core fields of technological cooperation, i.e., research and development. Secondly, a basic assumption of the RIS concept is that spatial proximity between the actors facilitates cooperation and helps to generate spillover effects (Salter and Martin 2001, 518). This assumption holds true for those types of knowledge that cannot be codified in form of texts, formula, or blueprints: implicit or tacit knowledge. Other types of knowledge, e.g. publications, can be transferred over large distances at little or no cost. Only tacit knowledge that is obtained by and attached to people is also sticky to places (Anselin et al. 1997; cp. Leydesdorff and Zeng 2001). Many studies in this field underline the importance of spatial proximity between the actors in innovation processes (e.g. Döring and Schnellenbach 2006).

However, spatial proximity alone is not a sufficient precondition for cooperation: Close interaction requires some common understanding of how to communicate and work together. Companies' attitudes towards cooperation vary with company size, age, industry, national background, its employees' individual characteristics, etc. The cooperation behavior of URI is affected by its sources and amounts of funding and by its organizational structure (cp.

Figure 1: Knowledge intensive regions in China

Liefner and Schiller 2008). Thus, establishing linkages between firms and URI takes time, as barriers resulting from differences in organizational behavior need to be overcome. Moreover, culture affects cooperation behavior as well. A lot of theoretical and empirical work has been devoted to the differences between Chinese and Western business culture and their implications for company interaction (e.g. Buckley et al. 2004; Bennett et al. 2001).

Walcott (2002, 350-352) argues that cooperation in Chinese high-technology districts evolves and changes over time. Initially, FIE dominate and local firms only function in relation to FIE. In a later stage, a separate network evolves around URI in which some local firms engage in high-technology production depending on knowledge and capital from universities. In a final development stage these two networks eventually merge into one system in which FIE and URI serve as knowledge-providers and local high-tech firms function as entrepreneurs, high-technology producers, suppliers, and customers. The literature on cooperation in China's business context provides ample evidence for the relation between the regional economic structure and local firms' cooperation behavior (e.g. Wang 1999; Hong 2003; Zhou and Tong 2003; Zhou 2007).

For the purpose of comparing cooperation patterns in Shanghai and Beijing, neither the sequence of the development stages nor the time frame of this development is important. But this article takes up the argument that local firms' linkages are to a large extend focused on the key cooperation partners that are available as well as on local business cultures (cp. Sun 2003, 378).

3 Literature review: knowledge bases and linkages in Shanghai and Beijing

The two regions under investigation can be characterized as the most knowledge intensive regions in China (Wang and Zhang 2003, 388; Hu and Xiong 2003, 28; Dahlman and Aubert 2001, 43ff.), but they differ significantly in the industrial activity, the sources of knowledge and the network building capabilities. Figure 1 shows the location of both regions in China, and the third knowledge intensive region, the Pearl River Delta. The latter region, however, will be excluded from this article's analysis due to its strong focus on low-tech manufacturing and very limited reliance on innovative linkages (cp. Wang and Lin 2008).

Shanghai is a leading economic center of China, Beijing is the country's political center. Shanghai's rise to become a metropolis of industry, trade and commerce, and other services had begun in colonial times. During the period of Maoist autarky policy the city's role had been reduced to one of a major industrial region. But within the fifteen years after 1990, Shanghai managed to regain the status of a nationally and internationally important industry and service location, symbolized in the development of Pudong (Zhang 2003, 1552). Beijing has some importance as an industry center, too, but the city's role is determined by its political, scientific, and cultural functions (Liu et al. 1997, 123). As the seat of the central government, Beijing leads the political hierarchy of China's cities. The two most prestigious universities of Beijing – Beijing University and Tsinghua University – are at the same time the two leading universities of the country. The same holds true for Beijing's institutes of the Chinese Academy of Sciences. According to Jacobs (1997, 163) these differences explain why Shanghai appears to be an open, internationally oriented city whereas Beijing is much more oriented towards fulfilling its functions for the nation.

Table 1 summarizes basic economic indicators and figures that underline differences in the internationalization of both metropolitan economies. The figures show considerable differences in both cities' integration into the world market for goods and capital. As these differences have been a constant feature of the last decade, it is obvious that the location of Shanghai offers much more possibilities for linking up with foreign-funded enterprises or trade partners.

Table 2 illustrates Beijing's lead in higher education, science and technology (S&T). In quantitative terms, the city's endowment with teachers and researchers is much higher than Shanghai's, and unmatched by any other city in China. Nearly 11% of China's scientists in higher education institutions and more than 20% of the country's scientists at other public R&D organizations work in Beijing (NBS 2005). Moreover, Beijing's top universities and R&D institutes are often ranked first and second in national university league tables but also in independent sources like the Science Citation Index (CERNET).

Table 1: Key economic indicators

	GDP p.c.[1)]	Exports[2)]	Exports p.c.[3)]	FDI[4)]	FDI p.c.[5)]
Shanghai	57,115	113,589	6,258	85,430	4,805
Beijing	49,780	37,954	2,401	23,830	1,549

1) Yuan RMB
2) Mio. US $
3) US $
4) cumulated, Mio. US $
5) cumulated, US $

Source: NBSC 2007

The clear differences in the relative strengths of Shanghai and Beijing – openness to trade and investment vs. science – did not affect the past growth of the two cities' high-tech sectors that have been growing by around 20% (Shanghai) and 18% (Beijing) annually since 1998 (NBS 2005, own calculation). However, these relative strengths go hand in hand with specific opportunities for cooperation and the accessibility of different types of new knowledge. This may affect directions and outcomes of innovation processes in the long run. So far, many authors claim that China's high-tech firms are only loosely linked to potential cooperation partners (Wang and Lin 2008, 179; Sun 2002, 488; Wang 1999). But recent studies reveal that Shanghai and Beijing offer specific opportunities for accessing knowledge for innovation. Moreover, they show that firms start making use of these options. For example, Hong (2003) and Chen (2006) show that Shanghai's innovation system is predominantly company-driven. Horizontal linkages between firms evolve as important channels for knowledge exchange. Case studies reveal that successful knowledge transfer and subsequent learning is an emerging feature of linkages with suppliers or customers. Beijing's innovation system, in contrast, is dominated by the influence of research universities, public research institutions, and the cooperation potential arising from them. For example, Zhou (2007, 2005), Su (2000), and Wang (1999) describe the dynamics

Table 2: Indicators of the science base

	University Graduates	S&T personnel in universities	S&T personnel in universities[1)]	Employees of R&D institutes[2)]	Employees of R&D institutes[1), 2)]
Shanghai	88,645	26,111	193	33,438	247
Beijing	97,424	45,872	394	108,508	933

1) per 100,000 inhabitants
2) non-university and non-business R&D, e.g. Chinese Academy of Sciences

Source: SMSB 2005; BMBS 2005; NBS 2005 of research-driven systemic changes in Beijing. In using case studies of companies or universities, Lu (2001), Gu (1996), Wen and Kobayashi (2001), and others show that vertical linkages and knowledge transfers have led to successful commercialization of new knowledge. The empirical section of this article compares cooperation frequencies in both regions. Due to the limitations of quantitative analysis, however, this article will neither discuss why firms seek cooperation with specific partners, nor the effects of cooperation.

4 Data source

The data used in this article were obtained in surveys of high-tech enterprises in Shanghai and Beijing. The surveys were part of two consecutive research projects on technological change, regional economic development, and cluster formation. They were sponsored by the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) and carried out jointly by the Departments of Economic Geography of the University of Hannover, Germany, the East China Normal University, Shanghai, and the Chinese Academy of Sciences, Beijing. In a first step, the "Shanghai Innovation Survey" and the "Beijing Innovation Survey," quantitative data were obtained in 2003 and 2004 by means of a standardized questionnaire. In a second step, quantitative information was verified and complemented by qualitative information from oral interviews. These interviews were carried out with a sub-sample of those companies that had previously responded to the questionnaire. The interviews were held in 2004, 2005, and 2006. Within Beijing the Zhongguancun Science Park (ZGC) and within Shanghai the Pudong New Area including the Zhangjiang High-tech Park (ZJHTP) were selected as survey sites. In both regions, a quantitative, completely standardized survey of high-tech companies was combined with in-depth interviews of CEOs. The results were discussed in detail among the researchers involved to avoid a misinterpretation that could arise from cultural differences and background experience.

According to the official regulations of the Beijing Municipal Science and Technology Commission on the confirmation of the new-technology enterprises, new-technology or high-technology enterprises must meet the following requirements (BMSTC 1998):

Research, development, production, and business management must focus on at least one of a specified range of product categories and technologies (e.g., microelectronics, IT, bio-technologies, new material technologies, photo-electron mechanics technologies, new energies).

At least 30% of all employees must have at least an undergraduate degree.

Share of R&D investments must account for more than 3% of the total income.

More than 50% of the total income has to be generated by sales of high-/new-technology products.

Regulations for the registration of high-tech enterprises in Pudong are similar (Shanghai ZJHTP). Thus, a relatively high level of internal technological capabilities is given.

In Beijing, a sample was drawn from the population of all companies registered as high-tech companies in ZGC in 2003. At the time of the first survey, the total number of registered high-tech enterprises was 7,104 (ZGC-AC 2003). These companies met the above criteria or had at least completed the registration process. Altogether, 500 companies were randomly sampled from the total, using a stratified sample on size and industry type. The sample covered all areas of ZGC with the bulk of companies located in ZGC core area and "Shangdi Park." In Pudong, all high-tech companies registered until 2003 (378) were surveyed. The questionnaires were delivered personally to the contact person, who was either the CEO or the head of R&D, and were collected one week later.

Support from local authorities ensured a rather high response rate of around 46% for Beijing (n=234) and around 66% for Shanghai (n=254). This is a high figure compared to many other surveys carried out in China, which were more or less designed as qualitative surveys (cf. Lau et al. 2002; Lu 2000; Zhou and Tong 2003). The high absolute number of returns gives statistically representative proof of the statements made in this article. The accuracy of the quantitative results was underlined by the results of the second survey phase.

In this article the terms cooperation, interaction, and linkage are used synonymously. The focus is on interaction between technology-receiving companies and possible donors (FIE and URI). Each act of cooperation is counted as one link to another entity. This method has the advantage that cooperation can be related to distinct phases of the innovation process.

The questionnaire contained separate questions on whether or not the company cooperates with other actors and in which phases of the innovation process they cooperate. It differentiated between the five stages of the innovation process: exchange of information, development of ideas, prototype development, pilot application, and market entry (cp. Fischer et al. 2001). In the tables 3, 4, and 5, cooperation partners are subsumed into two groups: FIE+FE and URI. The group of FIE+FE includes all foreign-invested firms in China and all cooperating firms located abroad. These are foreign and foreign-invested suppliers, foreign customers, parent companies and other affiliated firms abroad, foreign business and technical service providers, and other foreign companies. The group of URI includes universities and other research institutes (Chinese Academy of Science (CAS), Chinese Academy of Social Sciences (CASS), others).

5 Empirical results: relative and absolute frequencies of cooperation

The guiding questions for the empirical analyses were posed in the introductory section: 1) Do the interaction patterns of high-tech companies in these cities correspond with the accessibility of potential partners (FIE+FE, URI) that varies locally? 2) Does the accessibility of cooperation partners sufficiently explain cooperation behavior or do we have to take other factors into account? These questions will be addressed focusing, first, on linkages during the innovation process, secondly, on the share of companies cooperating with certain partners, and, thirdly, on the cooperation behavior of Chinese-owned companies.

5.1 Linkages during the innovation process

Table 3 summarizes the innovative linkages reported by high-tech companies in both locations in the stages of the innovation process.

In Beijing, cooperation with URI is more frequent (n=258) than cooperation with FIE+FE (n=218). In Shanghai, high-tech firms cooperate more frequently with FIE+FE (n=504) and less with URI (n=410). Thus, the relative endowments of both regions with FIE+FE and URI go hand in hand with the major directions of linkages. Although this finding is merely statistical, a causal relation can be assumed to exist: the quantities and qualities of foreign investment and academic organizations in both regions determine cooperation patterns.

Moreover, the percentage figures reveal that FIE+FE and URI fulfill different roles in the cooperating firms' innovation processes: the relative importance of contacts to FIE+FE and URI varies over the stages of the innovation process. In both regions, cooperation with foreign-invested firms or foreign firms is mainly done in the early and the very late stages of the innovation process whereas cooperation with URI tends to concentrate in the central stages (cp. Liefner and Hennemann 2008). The latter result, which reveals the different types of knowledge FIE+FE and URI can offer, however, is not in the focus of this article.

Table 4 displays the shares of Chinese high-tech firms reporting linkages with FIE+FE and URI during their innovation processes, thus eliminating the impact of the slightly different populations in Shanghai and Beijing. In addition, information on cooperation with the most important sub-groups of FEI+FE and URI is included.

The table switches from the perspective of linkages to the perspective of firms. It shows important results concerning the original research questions. The frequency of intensive contacts to FIE+FE and URI is generally low, in particular in the case of Beijing. There, over the different stages of the

Table 3: Absolute number of linkages during the stages of the innovation process

a) Beijing

Partners	N (linkages)	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
FIE+FE	218 (100%)	43 (20%)	58 (27%)	37 (17%)	27 (12%)	53 (24%)
URI	258 (100%)	60 (23%)	89 (34%)	54 (21%)	29 (11%)	26 (10%)

b) Shanghai

Partners	N (linkages)	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
FIE+FE	504 (100%)	110 (22%)	128 (25%)	110 (22%)	54 (11%)	102 (20%)
URI	410 (100%)	109 (27%)	131 (32%)	107 (26%)	45 (11%)	18 (4%)

Stage 1: Exchange of information
Stage 2: Development of ideas
Stage 3: Prototype development
Stage 4: Pilot application
Stage 5: Market introduction

Source: Shanghai Innovation Survey, Beijing Innovation Survey

Table 4: Cooperation of all high-tech firms with selected partners (Percentage-shares of firms reporting links with selected partners)

a) Beijing

Partners	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
FIE+FE	*16%*	*22%*	*12%*	*9%*	*18%*
Suppliers	13%	17%	7%	5%	12%
Customers	3%	5%	4%	3%	6%
Parent company, affiliate	2%	2%	4%	3%	3%
URI	*18%*	*27%*	*20%*	*11%*	*9%*
Universities	13%	20%	13%	7%	6%
Research institutes[1]	12%	18%	10%	6%	5%

b) Shanghai

Partners	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
FIE+FE	*33%*	*40%*	*37%*	*18%*	*32%*
Suppliers	19%	24%	21%	7%	12%
Customers	7%	10%	8%	5%	13%
Parent company, affiliate	10%	12%	13%	9%	13%
URI	*31%*	*38%*	*31%*	*14%*	*5%*
Universities	21%	23%	16%	6%	3%
Research institutes[1]	22%	29%	25%	12%	4%

c) Difference in relative cooperation frequency (Shanghai – Beijing)

p-value (chi-square)	0.013	0.000	0.033	0.152	0.000

Stages 1-5: see Table 3
[1] figure includes links with institutes of the CAS, the CASS, and all other non-university public research institutes

Source: Shanghai Innovation Survey, Beijing Innovation Survey

innovation process only between 9% and 22% of the high-tech firms surveyed have cooperation with FIE+FE, the figure for cooperation with URI is only marginally higher. On the other hand, the fact that more than one quarter of the firms in Beijing are linked to URI in the stage of development of ideas underlines that some knowledge transfer from URI to local companies is going on. The important aspect to notice, however, is that high-tech firms in Shanghai cooperate much more frequently in general. Not only maintains an average of about one third of companies contacts to FIE+FE over the stages of the innovation process, even cooperation with URI occurs more frequently than in Beijing: High-tech firms in Shanghai cooperate more frequently with any of the two types of partners in most of the five stages of the innovation process.

The relative frequencies of contacts with the selected partners differ significantly between both locations. The chi-square test underlines the initial hypothesis that innovative linkages are a matter of opportunity, i.e. the accessibility of partners. The p-values were computed after figures had been adjusted for differences in absolute cooperation frequencies. Thus, they were not affected by the higher overall cooperation frequency of firms in Shanghai. The highly significant results for stages 1 to 3 and stage 5 are mainly driven by the differences in cooperation with customers and parent companies in Shanghai and Beijing.

Thus, two important empirical findings from tables 4 and 3 stand out: one, the relative strengths of the two knowledge sources in the two regions is reflected in the cooperation frequencies of high-tech firms, and, two, Shanghai firms have more linkages than Beijing firms on average.

5.2 Chinese-owned companies' linkages

In tables 3 and 4 linkages reported by all companies were treated equally: the ownership backgrounds of the companies surveyed were not taken into account. Shanghai has a much higher inflow of FDI compared to Beijing and, thus, a much higher share of international joint ventures and wholly foreign-owned subsidiaries in the sample. The fact that these Shanghai-based FIE have a higher propensity to cooperate with other FIE and enterprises located abroad is somewhat tautological – and, indeed, an integral part of the success story of Shanghai's economy – and it strongly affects the data. Table 5 presents data on the linkages of Chinese-owned companies exclusively, in order to avoid the possibility that FIE-to-FIE+FE cooperation dominates the analyses.

Three observations from table 5 stand out: First, cooperation patterns of firms in Beijing meet the expectations: URI are the more frequent cooperation partner with the exemption of stage 5. Secondly, cooperation patterns of Chinese-owned firms in Shanghai do not fully meet the expectations: the firms do still cooperate rather often with FIE+FE but they seek cooperation with universities or the academies even more frequently. Thirdly, only in stages 3 and 4 relative cooperation frequencies differ significantly between both locations. Hence, Chinese-owned firms show similar cooperation patterns regardless of the region investigated. P-values in stages 3 and 4 are not driven by differences in cooperation frequency with FIE+FE and URI. Instead, they derive from differences in cooperation frequencies with universities and public research institutes: Beijing's high-tech companies tend to focus on universities whereas Shanghai's firms cooperate more often with public research institutes. Fourthly, the Chinese-owned high-tech firms in Shanghai are generally more likely to cooperate than Chinese-owned firms in Beijing. This holds true for all four categories of partners included here, foreign suppliers, foreign customers, universities, and research institutes. Thus, the key results from table 4 cannot be attributed to the effects of the FIE among the sample in Shanghai.

It can be summarized from the empirical section that the inflow of FDI into the two regions and the strengths of URI in both regions predict cooperation patterns, as long as all high-tech firms registered in both locations are taken into account. Thus, the answer to research question 1 is "yes". If the analysis is restricted to Chinese-owned companies, the favored partner of cooperation is URI in both regions. Chinese-owned firms in Shanghai make much less use of opportunities to absorb knowledge from abroad than Shanghai-based FIEs. And, above all, firms in Shanghai cooperate much more frequently than firms in Beijing. Hence, the answer to research question 2 is "no", the accessibility of FIE and URI does not sufficiently explain cooperation behavior.

Table 5: Cooperation of Chinese-owned firms with selected partners (Percentage-shares of firms reporting links with selected partners)

a) Beijing

Partners	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
FIE+FE	*16%*	*21%*	*10%*	*9%*	*17%*
Suppliers	14%	16%	6%	5%	12%
Customers	2%	5%	3%	3%	5%
URI	*20%*	*28%*	*21%*	*10%*	*10%*
Universities	14%	22%	13%	6%	6%
Research Institutes[1)]	14%	18%	10%	5%	5%

b) Shanghai

Partners	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
FIE+FE	*24%*	*35%*	*27%*	*9%*	*27%*
Suppliers	18%	26%	20%	5%	14%
Customers	5%	5%	5%	4%	11%
URI	*34%*	*52%*	*43%*	*20%*	*8%*
Universities	24%	33%	23%	7%	3%
Research Institutes[1)]	22%	37%	35%	18%	8%

c) Difference in relative cooperation frequency (Shanghai – Beijing)

p-value (chi-square)	0.570	0.338	0.031	0.005	0.083

Stages 1-5: see Table 3
[1)] figure includes links with institutes of the CAS, the CASS, and all other non-university public research institutes

Source: Shanghai Innovation Survey, Beijing Innovation Survey

6 Discussion: additional factors affecting cooperation

The latter result from the empirical section functions as the starting point for the following discussion that brings together ideas and thoughts about factors that possibly explain differences in absolute cooperation frequencies between both cities. The section starts with a discussion of factors that emerge from the quantitative survey. It shows that internal company characteristics have no significant influence on the results. Then, additional factors are discussed that relate to the fields of policy and culture. These thoughts provide starting points for future research in this field.

6.1 Company characteristics

With Beijing and Shanghai this article is comparing two major cities that are similar in many ways (see above). The company populations in both survey locations share many common features, too, as all companies went through similar registration processes and had to fulfill similar requirements with respect to the qualifications of the personnel, R&D activities, and the fields of business. However, apart from the already discussed share of FIE, there are some differences in the enterprise populations that could theoretically affect cooperation behavior. These differences are size, age, and human capital base (cp. Katrak 1997).

With respect to size and age, the companies surveyed in Beijing differ significantly from those surveyed in Shanghai: the average high-tech firm in Pudong has been established five years prior to the survey whereas the average firm in Beijing is much younger. As it takes time to establish an intensive cooperation this age difference could cause differences in the number of linkages. However, there is no valid statistical relation between firm age and the number of its linkages in the data. Average firm size also differs with Shanghai's firms twice as big as Beijing's firms. But again, there is no significant statistical relation between these differences and cooperation. The factor that is theoretically most relevant is a company's human capital and internal R&D capabilities. In both Shanghai and Beijing, a strong statistical relation was found between the share of employees with a university degree, i.e. a firm's human capital, and the number of its intensive linkages. The share of a firm's revenue that goes into R&D is also positively correlated with cooperation. However, firms in Beijing do slightly better in both indicators than firms in Shanghai do, so that the effect of internal R&D is not the cause for the differences observed.

Hence, company characteristics cannot explain differences in absolute cooperation frequency.

6.2 Local vs. inter-regional contacts

Whenever cooperation is used to exchange tacit knowledge spatial proximity between the partners is necessary. But not all knowledge that can be transferred in cooperation is necessarily tacit. For example, Salter and Martin (2001, 528) argue that some universities may absorb academic knowledge on a worldwide scale and disseminate it into a national or regional innovation system. In such a case, also partners that are not located in close proximity to such a university may seek cooperation and try to use forms of contact that do not require frequent personal interaction.

In the case of China, the dominant academic institutions are the leading universities in Beijing and the leading institutes of the Academy of Sciences, also in Beijing. The data indicate that these institutions indeed fulfill their role as knowledge absorbers and knowledge providers not only for firms within Beijing but also for firms in Shanghai. Among the many companies in Pudong that reportedly cooperate with URI more than 70% have at least one URI-partner in Beijing. The reverse case, a firm in Beijing reporting to have a URI-partner in Shanghai, is much less common. Thus, part of the surprisingly high number of linkages of firms in Shanghai with URI can be attributed to the nationwide outreach of Beijing's URI. However, public research organizations in Shanghai and neighboring Jiangsu province function as knowledge providers for Shanghai's high-tech firms, too.

6.3 Policy influence

In China, the role of policy can be both beneficial and hampering to the technological upgrading of individual firms: On the one hand, the government provides funding for R&D, on the other hand, government regulations and bureaucracy can be a constraint for entrepreneurial action. The political influence, however, varies from province to province and from municipality to municipality, and generally decreases with the distance from the capital (cp. Kroll and Liefner 2008). While the central government keeps a relatively close look at Beijing, distant regions – e.g. the Pearl River Delta – enjoy more freedom and flexibility in experimenting with new economic policies (Lin 1997, 59, 65). But on the other hand, the availability of government funding for firms' in-house R&D is much better in Beijing than at other places (Hong 2003).

The companies in the survey were asked to state whether they regarded government influence and bureaucracy as a major constraint for their business. The answers show clear differences between Beijing and Shanghai: 40% of Chinese-owned firms in Beijing and 57% of FIE in Beijing view government action as a constraint for their business. The respective figures for Shanghai are 27% (Chinese-owned firms) and 20% (FIE). These results indicate that state intervention and directives are negatively affecting many firms in Beijing (cp. Wang 1999; Zhou 2005, 1125). In Shanghai, government influence is reportedly less direct and strong and seems to follow a more liberal approach (cp. Chen 2006, 76). However, compared with RIS in Western countries, government influence in China is generally very strong and deserves attention in future research.

6.4 Regional cultures

Regional business culture affects the strengths and functions of relations between firms and other actors. In this context, Beijing is said to exemplify the business culture of North China. This culture attaches high value to stability, laws and regulations, collectivity, and gives priority to the development of the nation. On the other hand, the "South China" business culture exemplified by Shanghai is said to lean towards flexibility, creativity, individual success, and an international orientation (cp. Lin 1997, 63-64).

These cultures may explain differences in cooperation (Zhou 2005, 1127-1131; Chen 2006, 78, 81). In the context of the more flexible southern business culture, it may be easier to establish horizontal linkages between firms or between firms and FIE, URI. In addition to that one can expect horizontal links to evolve from the initiatives of one or both of the partners. Establishing these links does not require government initiative. In Beijing, in contrast, the government still often acts as a mediator in establishing horizontal linkages (cp. Liu and Jiang 2001, 180). Hence, these linkages have a vertical component that may slow down the process of establishing links, reduce the flexibility of the cooperation arrangement and lower the intensity of contacts.

7. Conclusion

High-tech firms in Beijing cooperate more frequently with URI whereas high-tech firms in Shanghai cooperate more frequently with FIE and FE, reflecting the strengths of both cities. But the fact that companies in Shanghai have a higher overall number of linkages could not be expected from the RIS concept explained in the theory section. In the discussion three different approaches were offered to explain the latter finding: first, the spatial scale of cooperation has to be taken into regard: the leading URI in Beijing also cooperate with firms in Shanghai. Secondly, government action affects the firms' cooperation patterns. Thirdly, both cities represent different business cultures that may have a profound impact on cooperation patterns.

Returning to the starting point of this paper, it is clear that the regionally varying accessibility of FIE, FE and URI has an impact on high-tech companies' cooperation behavior. The emerging, regionally varying cooperation patterns in both cities will in turn shape future developments (cp. Wang and Zhang 2003, 392): one can expect the high-tech location Beijing to build up strengths in fields that require interaction with public research, e.g. bio-tech. The high-tech location Shanghai will most probably develop strength in fields that benefit from international exchange and competition. Thus, existing regional profiles will be reinforced by internal dynamics of cooperation and innovation. But as long as the Beijing companies' overall efforts to cooperate remain far below the levels reached in Shanghai, the innovative potential of Beijing will not be fully exploited.

The last aspect, obvious differences in the overall cooperation efforts, deserves particular attention in future research projects. This would contribute to a better understanding of the causes of different development patterns in leading technical and economic regions and allow for a more detailed prediction of the evolution of regional specializations and growth patterns.

Acknowledgements

The authors wish to thank Prof. Dr. Jie Fan (CAS Beijing) and his team for carrying out the Beijing survey, and the reviewers for helpful comments.

References

ANSELIN, L.; VARGA, A. and ACS, Z. (1997): Local geographic spillovers between university research and high technology innovations. In: Journal of Urban Economics 42, 422–448.

ASHEIM, B. and VANG, J. (2006): Regions, absorptive capacity and strategic coupling with high-tech TNCs: lessons from India and China. In: Science, Technology & Society 11, 39–55.

BAARK, E. (2001): Technology and entrepreneurship in China: commercialization reforms in the science and technology sector. In: Policy Studies Review 18, 112–129.

BATHELT, H. and DEPNER, H. (2003): Innovation, Institution und Region: zur Diskussion über nationale und regionale Innovationssysteme. In: Erdkunde 57, 126–143.

BELL, M. and PAVITT, K. (1997): Technological accumulation and industrial growth: contrasts between developed and developing countries. In: ARCHIBUGI, D. and MICHIE, J. (eds.): Technology, globalisation and economic performance. New York, 83–137.

BENNETT, D.; LIU, X. M.; PARKER, D.; STEWARD, F. and VAIDYA, K. (2001): Technology transfer to China: a study of strategy in 20 EU industrial companies. In: International Journal of Technology Management 21, 151–182.

BMBS (BEIJING MUNICIPAL BUREAU OF STATISTICS) (2005): Beijing Statistical Yearbook 2005. Beijing.

BMSTC (BEIJING MUNICIPAL SCIENCE AND TECHNOLOGY COMMISSION) (1998): The regulations of Beijing municipality on the conforming of the new-technology enterprises. http://www.zgc.gov.cn (26.03.2004).

BRESCHI, S. and LISSONI, F. (2001): Knowledge spillover and local innovation systems: a critical survey. In: Industrial and Corporate Change 10, 975–1005.

BUCKLEY, P. J.; CLEGG, J. and TAN, H. (2004): Knowledge transfer to China: policy lessons from foreign affiliates. In: Transnational Corporations 13, 31–72.

CERNET (CHINA EDUCATION RESEARCH NETWORK). http://www.edu.cn.

CHANG, P. L. and SHIH, H. Y. (2004): The innovation systems of Taiwan and China: a comparative analysis. In: Technovation 24, 529–539.

CHEN, Y. C. (2006): Changing the Shanghai innovation systems: the role of multinational corporations' R&D Centres. In: Science, Technology & Society 11, 67–107.

COHEN, W. M. and LEVINTHAL, D. A. (1989): Innovation and learning: the two faces of R&D. In: The Economic Journal 99, 569–596.

DAHLMAN, C. J. and AUBERT, J.-E. (2001): China and the knowledge economy. Seizing the 21st Century. Washington.

DÖRING, T. and SCHNELLENBACH, J. (2006): What do we know about geographical knowledge spillovers and regional growth? A survey of the literature. In: Regional Studies 40, 375–395.

FISCHER, M. M.; REVILLA DIEZ, J. and SNICKARS, F. (2001): Metropolitan innovation systems. Theory and evidence from three metropolitan regions in Europe. Berlin.

GU, S. L. (1996): The emergence of new technology enterprises in China: a study of endogenous capability building via restructuring. In: The Journal of Development Studies 32, 475–505.

HENNEMANN, S. and KROLL, H. (2008): Die Wissensmacht China. In: Geographische Rundschau 60, 12–19.

HO, S. P. S. (1997): Technology transfer to China during the 1980s – how effective? Some evidence from Jiangsu. In: Pacific Affairs 70, 85–106.

HONG, W. (2003): An assessment of the business environment for high-tech industrial development in Shanghai. In: Environment and Planning C 21, 107–137.

HU, A. G. and XIONG, Y. Z. (2003): The strategy of knowledge-based development: China's long-run future. In: Social Sciences in China 24, 24–35.

JACOBS, J. B. (1997): Shanghai: an alternative centre? In: GOODMAN, D. G. S. (ed.): China's provinces in reform. Class, community and political culture. London, 163–193.

KATRAK, H. (1997): Developing countries' imports of technology, in-house technological capabilities and efforts: an analysis of the Indian experience. In: Journal of Development Economics 53, 67–83.

KLINE, S. J. and ROSENBERG, N. (1986): An overview of innovation. In: LANDAU, R. and ROSENBERG, N. (eds.): The positive sum strategy: harnessing technology for economic growth. Washington, 275–305.

KOCH, A. (2005): Unternehmensgründungen, Innovation und Regionalentwicklung: Spin-off-Gründungen aus Unternehmen. In: Erdkunde 59, 22–33.

KROLL, H. and LIEFNER, I. (2008): Spin-off enterprises as a means of technology commercialisation in a transforming economy. Evidence from three universities in China. In: Technovation 28, 298–313.

LAU, C. M.; LU, Y.; MAKINO, S.; CHEN, X. H. and YEH, R. S. (2002): Knowledge management of high-tech firms. In: TSUI, A. S. and LAU, C. M. (eds.): The management of enterprises in the People's Republic of China. Boston, 183–210.

LEYDESDORFF, L. and MEYER, M. (2003): The Triple Helix of university-industry-government relations. In: Scientometrics 58, 191–203.

LEYDESDORFF, L. and ZENG, G. P. (2001): University-industry-government relations in China. An emergent national system of innovation. In: Industry & Higher Education 15, 179–182.

LIEFNER, I. and HENNEMANN, S. (2008): Cooperation in Chinese innovation systems. In: ROWEN, H. S.; HANCOCK, M. G. and MILLER, W. F. (eds.): Greater China's quest for innovation. Stanford Project on Regions of Innovation and Entrepreneurship (SPRIE) publications. Charlotte (in print).

LIEFNER, I. and SCHILLER, D. (2008): Academic capabilities in developing countries. A conceptual framework with empirical illustrations from Thailand. In: Research Policy 37, 276–293.

LIEFNER, I.; HENNEMANN, S. and LU, X. (2006): Cooperation in the innovation process in developing countries: empirical evidence from Beijing Zhongguancun. In: Environment and Planning A 38, 111–130.

LIN, G. C. S. (1997): Red capitalism in South China. Growth and development of the Pearl River Delta. Vancouver.

LIU, H. and JIANG, Y. Z. (2001): Technology transfer from higher education institutions to industry in China: nature and implications. In: Technovation 21, 175–188.

LIU, X. L. and WHITE, S. (2001): Comparing innovation systems: a framework and application to China's transitional context. In: Research Policy 30, 1091–1114.

LIU, Y.; ZHANG, L. and LINGE, G. (1997): The Bohai Sea rim: some development issues. In: LINGE, G. (ed.): China's new spatial economy. Heading towards 2020. New York, 123–143.

LU, Q. (2000): China's leap into the information age. Innovation and organization in the computer industry. New York.

LU, Q. W. (2001): Learning and innovation in a transitional economy: the rise of science and technology enterprises in the Chinese information technology industry. In: International Journal of Technology Management 21, 76–92.

MALECKI, E. J. (2002): Hard and Soft Networks for Urban Competitiveness. In: Urban Studies 39, 929–945.

MATHEWS, J. A. (2001): National systems of economic learning: The case of technology diffusion management in East Asia. In: International Journal of Technology Management 22, 455–479.

MOSSIG, I. (2004): Steuerung lokalisierter Projektnetzwerke am Beispiel der Produktion von TV-Sendungen in den Medienclustern München und Köln. In: Erdkunde 58, 252–268.

MOULAERT, F.; MARTINELLI, F.; SWYNGEDOUW, E. and GONZALEZ, S. (2005): Towards alternative model(s) of local innovation. In: Urban Studies, 42 (11), 1969–1990.

MOULAERT, F. and SEKIA, F. (2003): Territorial innovation models: a critical survey. In: Regional Studies, 37 (3), 289–302.

NBS (NATIONAL BUREAU OF STATISTICS OF CHINA) (2005): China statistical yearbook on science and technology 2005. Beijing.

– (2007): China Statistical Yearbook 2007. Beijing.

SALTER, A. J. and MARTIN, B. R. (2001): The economic benefits of publicly funded basic research: a critical review. In: Research Policy 30, 509–532.

SCHWAAG SERGER, S. and BREIDNE, M. (2007): China's fifteen-year plan for science and technology: an assessment. In: Asia Policy 4, 135–164.

SHANGHAI ZJHTP (SHANGHAI ZHANGJIANG HI-TECH PARK): Investment Guidebook. Shanghai.

SHI, Y. Z. (2001): Technological capabilities and international production strategy of firms: the case of foreign direct investment in China. In: Journal of World Business 36, 184–204.

SMSB (SHANGHAI MUNICIPAL STATISTICS BUREAU) (2005): Shanghai Statistical Yearbook 2005. Shanghai.

SU, J. (2000): The comparative study of regional innovation systems of Japan and China. NISTEP Study Material 74. Tokyo.

SUN, Y. F. (2002): China's national innovation system in transition. In: Eurasian Geography and Economics 43, 476–494.

– (2003): Geographic patterns of industrial innovation in China during the 1990s. In: TESG 94, 376–389.

VIOTTI, E. B. (2002): National learning systems. A new approach on technical change in late industrializing economies and evidences from the cases of Brazil and South Korea. In: Technological Forecasting & Social Change 69, 653–680.

WALCOTT, S. M. (2002): Chinese industrial and science parks: bridging the gap. In: The Professional Geographer 54, 349–364.

– (2003): Chinese science and technology industrial parks. Aldershot.

WANG, C. C. and LIN, G. C. S. (2008): The growth and spatial distribution of China's ICT industry: new geography of clustering and innovation. In: Issues & Studies 44, 145–192.

WANG, D. G. and ZHANG, L. (2003): Knowledge disparity and regional inequality in post-reform China. In: Post-Communist Economies 15, 383–399.

WANG, J. C. (1999): In search of innovativeness: the case of Zhong'guancun. In: MALECKI, E. J. and OINAS, P. (eds.): Making connections. Technological learning and regional economic change. Aldershot, 205–230.

WEI, Y. H. D. and LEUNG, C. K. (2005): Development zones, foreign investment, and global city formation in Shanghai. In: Growth and Change 36, 16–40.

WEN, J. and KOBAYASHI, S. (2001): Technology diffusion in China: some new evidence in computer-aided design. In: Science and Public Policy 28, 41–47.

ZENG, G. and WEN, H. (2004): A study on the IT cluster in Pudong of Shanghai. In: Acta Geographica Sinica 59, 59–66.

ZGC-AC (ZGC ADMINISTRATIVE COMMITTEE) (2003): New-technology enterprises in Zhongguancun Science Park. Unpublished document.

ZHANG, L. Y. (2003): Economic development in Shanghai and the role of the state. In: Urban Studies 40, 1549–1572.

ZHANG, W. B. (2000): Shanghai: a gateway to China's economic modernization, In: ANDERSSON, A. A. and ANDERSSON, D. (eds.): Gateways to the global economy. Cheltenham, 254–268.

ZHOU, Y. (2005): The making of an innovative region from a centrally planned economy: institutional evolution in Zhongguancun Science Park in Beijing. In: Environment and Planning A 37, 1113–1134.

– (2007): The inside story of China's high-tech industry. Making Silicon Valley in Beijing. Lanham.

ZHOU, Y. and TONG, X. (2003): An innovative region in China: interaction between multinational corporations and local firms in a high-tech cluster in Beijing. In: Economic Geography 79, 129–152.

Authors

Prof. Dr. Ingo Liefner
Justus Liebig University Giessen
Department of Geography
Senckenbergstr. 1
35390 Giessen, Germany
ingo.liefner@geogr.uni-giessen.de

Prof. Dr. Gang Zeng
East China Normal University
Institute of Spatial Planning and Regional Economy
3663 North Zhongshan Rd.
Shanghai 200062, PR China
gzeng@re.ecnu.edu.cn