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**Knowledge Spillovers Through Human Mobility Across National Borders:
Evidence from Zhongguancun Science Park in China**

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Knowledge Spillovers Through Human Mobility Across National Borders: Evidence from Zhongguancun Science Park in China

Abstract

This paper investigates the impact of returnee entrepreneurs and their knowledge spillovers on innovation in high-tech firms in China. Using panel data for 1,318 high-tech firms in Beijing Zhongguancun Science Park (ZSP) we find that returnee entrepreneurs create a significant spillover effect that promotes innovation in other local high-tech firms. The extent of this spillover effect is positively moderated by the non-returnee firm's absorptive capacity approximated by the skill level of employees. Multinational enterprises' R&D activities positively affect the innovation intensity of non-returnee firms only when these local firms possess the sufficient level of absorptive capacity. Our findings have important policy and managerial implications for policy-makers and practitioners.

Keywords

Returnee entrepreneurs; knowledge spillovers; skill intensity; MNEs' R&D activities; innovation

Knowledge Spillovers Through Human Mobility Across National Borders: Evidence from Zhongguancun Science Park in China

1 INTRODUCTION

It is increasingly recognized that technology-based firms in emerging economies are important drivers of innovation and growth (Bruton, Ahlstrom and Oblój, 2008), but emerging economies typically lack the entrepreneurial expertise, knowledge and resources to develop innovation activities (Peng, 2001). Previous research has suggested that this “skills gap” can be closed by trade-related and foreign direct investment (FDI)-related knowledge spillovers (Buckley, Clegg and Wang, 2007; Monteiro, Arvidsson and Birkinshaw, 2008; Schulz, 2003; Wei and Liu, 2006). In addition to capital and trade movements, some studies have focused on intra-firm and inter-firm human mobility as a channel of knowledge transfer within a country (Almeida and Phene, 2004; Almeida and Kogut 1999, Saxenian 1994). More specifically, a new feature of human mobility, returnee entrepreneurs, has recently gained significance as having the potential to be another important driver of knowledge transfer and innovation (Saxenian, 2006). We define returnee entrepreneurs as scientists and engineers returning to start up a new venture in their native countries, after several years of business experience and/or education in OECD countries. Despite growing awareness of the importance of returnee entrepreneurs for their home economies (Saxenian, 2004; 2006), limited research has been conducted on how human mobility across national borders may affect innovation through their spillover effect in emerging economies, such as China.

The mobility of highly-skilled entrepreneurs across national borders challenges the traditional dominance of existing studies on international knowledge spillovers which assume immobile labour. Returnee entrepreneurs may be central in stimulating innovation in technology-

based firms in China which has attracted a large number of highly skilled returnees. They may be able to affect the innovative activities of other non-returnee firms through knowledge spillovers that help to enhance the technological capabilities of local firms.

Immigrant entrepreneurs, the ethnic diaspora and their role in technological development has been an active research topic for some time, particularly in relation to the contribution of Chinese and Indian entrepreneurs to the development of Silicon Valley in California (Saxenian, 1994). The possible spillover effect of such human mobility on innovation in local firms upon returning back home has attracted limited academic attention. For example, more than 275,000 overseas Chinese scientists and students had returned to China by 2006. Among these, 5,000 returnees have set up 2,000 new high-tech firms in Zhongguancun Science Park (ZSP), China's Silicon Valley (People's Daily, 2007). Clearly, the economic impact of this "brain circulation" is quite significant and governments in emerging economies are becoming increasingly aware of its importance to national economic development. However, limited studies have investigated the spillover effect of cross-border human mobility (Oettl and Agrawal, 2008; Song, Almeida, Wu, 2003). There is relatively limited empirical evidence with regard to the extent to which cross-border human mobility affects the diffusion of technological and scientific knowledge in emerging economies.

To address these issues, we use a unique panel dataset based on the compulsory annual reports of 1,318 firms over the period 2000-2003 operating in the ZSP in Beijing, the largest science park in the People's Republic of China (for detailed descriptions see Cai et al., 2007; Tan, 2006). The Park is an important laboratory to study our hypotheses since it provides the same location for different types of firms, there is a large presence of MNCs and it is an attractive destination for returnees. We also use interview evidence and some illustrative

examples from secondary sources to provide direct links between the existence of returnee firms and knowledge spillovers, thus complementing our hypothesis development based on the literature. This combination enables us to obtain new insights.

This paper offers a number of contributions to this research stream. By focusing on high-tech SMEs in China, it extends previous research on knowledge spillovers and provides a good understanding of human mobility across national borders as a new channel for knowledge spillovers and helps to advance knowledge spillover research on innovation. In particular, the paper highlights and empirically tests the key role of human mobility as a conduit of knowledge spillovers and innovation. Our analysis of returnee entrepreneurs as conveyors of knowledge which is vital for the development of innovation activities provides a novel contribution to the existing literature on knowledge spillovers. By combining resource and knowledge-based views of the firm, we argue that the latest technology, patents and valuable networks that were developed and brought back by returnee entrepreneurs may benefit other non-returnee firms in the same high-tech industry through knowledge spillovers. By possessing advanced technology and having access to global networks, returnees may act as ‘knowledge brokers’ who facilitate international knowledge flows and transfers. Hence, their impact is not limited to their own firms. They can affect the technological base of high-tech industries in their home country and generate positive technology spillovers to other local firms in the same sector, especially those which are within a close geographical proximity.

In addition, we also consider how MNEs’ R&D activities affect local firms’ innovation, given that MNEs, returnee firms and non-returnee firms all locate in ZSP which provides an ideal setting to examine knowledge diffusion within a large industrial cluster. Co-location implies interaction between different types of firms, and knowledge spillovers are more readily

acquired due to close geographical proximity (Jaffe et al. 1993; Almeida et al. 2003). In particular, incorporating MNEs R&D activities enables us to obtain new insights into the change in MNEs' global R&D strategies which have recently set up R&D centres in large emerging economies such as China and India (China Daily, 2004). Finally, building on research by Szulanski, Capetta and Lensen (2004) that focuses on possible moderators of knowledge spillovers we consider moderating effects of non-returnee firms' absorptive capacity on the interrelationship between returnee spillovers, MNEs' R&D activities and the innovation performance of other non-returnee firms.

2 THEORY AND HYPOTHESES

It is widely recognised that external knowledge is an increasingly important source of firm innovation, and acquiring external knowledge is regarded as a critical and necessary condition for organisations to sustain competitive advantage (Matusik and Heeley, 2002; Schmidt and Sofka, 2009; Tzabbar, 2009). Building on KBV, Zahra et al. (2000) suggest that high-tech ventures' short organizational life, small size, resource constraints, and the pressure to learn quickly to survive are likely to persuade their managers to fully leverage learning from their experiences in order to build capabilities. The knowledge needed for innovation may be obtained from a variety of internal and external sources. Few firms, however, possess all the elements required for successful and continuous technological development (Mansfield, 1988). External knowledge spillovers exist due to the non-rival nature of knowledge. However, knowledge is not universally accessible (Arrow, 1962) and is also partially excludable which gives private firms an incentive to invest in R&D in order to obtain higher profits based on market demand (Romer, 1994). It is recognized that much knowledge in organizations is tacit (Nonaka and Takeuchi,

1995) and socially complex. The tacit and complex nature of valuable knowledge makes knowledge acquisition very difficult (Kogut and Zander, 1992) as it embodies in organizational members, tools, tasks and networks. This kind of knowledge can be transferred more effectively through human mobility (Kaj et al. 2003; Song et al., 2003) and hands-on experience (Almeida and Kogut, 1999; Teece, 1982; Zucker et al., 1998). Hence, human mobility, such as returnee entrepreneurs, enables firms to overcome barriers in knowledge transfer and facilitate knowledge diffusion.

We develop these arguments further by suggesting that firms established by local entrepreneurs may benefit from the presence of returnee entrepreneurs in their industry. Returnee-founders who have obtained advanced technology and established networks abroad are able to enhance the overall level of innovation capability in high-tech industries. As a result, non-returnee firms are able to benefit from such knowledge spillovers.

Besides the examination of human mobility-related knowledge spillovers, we also investigate the impact of localised knowledge spillovers through MNEs' R&D activities on local innovation within an industrial cluster. Hence, our study considers various external sources of innovation. However, external knowledge spillovers through human mobility and MNEs' R&D activities may represent necessary but not sufficient conditions for innovation as internal knowledge creation plays an important role in generating sustainable competitive advantages based on unique technologies and knowledge and materializing external knowledge spillovers (Zahra et al., 2000; Zander and Kogut, 1995; Cohen and Levinthal (1990). The resource based view and capabilities perspectives (Barney, 1991; Helfat, 1997) suggest that R&D-related staff is key factors that underpin innovation activities of the firm and enable firms to absorb external knowledge. We build on previous studies that are focused on possible moderators of inter-

organizational knowledge transfer (e.g., Szulanski et al., 2004) and suggest that these spillover effects may differ across local firms, and their extent will be positively moderated by the local firm's absorptive capacity (Cohen and Levinthal, 1990; Lane, Koka and Pathak, 2006). Firms with higher absorptive capacity, such as those with large numbers of research-related staff, are more likely to take advantage of returnee spillovers and use this knowledge transfer to generate new patents, products and processes. The following sections develop these arguments further and suggest a number of research hypotheses.

2.1 Returnee entrepreneurs, MNEs' R&D activities and skill intensity

Firms do not often possess the knowledge needed for innovation. They need to seek external sources of knowledge in order to enhance their innovation (Mansfield, 1988). This is particularly the case in emerging economies where firms typically lack sufficient resources and ideas for innovation. Returnee entrepreneurs represent a new feature of human mobility that has recently gained significance and may act as a new channel for knowledge spillovers from OECD countries to China (Saxenian, 2006).

Returnee entrepreneurs possess a number of important characteristics that differentiate them from local entrepreneurs in terms of possible spillover effects on innovation. First, returnee entrepreneurs may have specific human capital that relates to a spectrum of skills and knowledge with varying degrees of transferability (Castanias and Helfat, 1992). Individuals with broader pools of human capital resources should be associated with superior innovation and productivity 'outputs' (Becker, 1975; Davidsson and Honig, 2003). Human capital of entrepreneurs that is based on past experience may be an important factor underpinning SME innovation and performance (Westhead, Wright and Ucbasaran, 2001). Returnee entrepreneurs may have

acquired academic knowledge in the form of general education and scientific and technical training. They may also have acquired practical business human capital from either working in a commercial environment or through having started a business. For example, LHWT Microelectronics Inc., a high-tech company, was set up in 2001 by Dr Guoliang Shou, a returnee who received his PhD from Tokyo University which forms the basis for over 100 patents that underpin the company's focus on software R&D in image identification systems, wireless LAN systems and RFID chips. Baidu, the largest Chinese search engine, was founded in 2000 by Yanhong Li who studied and worked in the US (Zhang and Xia, 2007).

Second, returnees may have specific social capital that involves the relational and structural resources attained through a network of social relationships (Adler and Kwon, 2002; Cooper and Yin, 2005). Such social capital is important to many small firms as it provides access to information and resources not available internally (Davidson and Honig, 2003; Peng and Zhou, 2005). An individual that develops social capital through working abroad may be able to use that social capital to access diverse sources of knowledge when they become a returnee entrepreneur. Agrawal, Cockburn and McHale (2006) have found that social relationships facilitate knowledge spillovers, and the geographic distribution of social capital affects knowledge flows.

Social capital can also be complementary to other resources (Adler and Kwon, 2002). Social capital enables these firms with relatively weak internal resources to access complementary assets within the wider network (Bruton, Ahlstrom and Wan, 2003). Bridging social capital derived through external relations may be especially important for returnee entrepreneurs to obtain advanced technology and ideas externally which may not be available to non-returnee firms.

Since a large part of knowledge is complex, tacit, cumulative and not easily codifiable, it is increasingly difficult to separate knowledge from those who possess it. Tacit knowledge can be acquired only through experience or learning-by-doing and thus can be transferred best through human mobility. When knowledge is difficult to separate from those who produce and possess it, the mobility of returnee entrepreneurs not only provides a one-time technology transfer of information, but also facilitates the transfer of competencies, promoting further knowledge building (Saxenian, 2006). The existence of returnee firms may benefit high-tech ventures established by local entrepreneurs through knowledge spillovers in several ways.

As discussed above, returnees not only bring the latest technology, patents and valuable networks with them when they return home, they also perform functions as “knowledge brokers”. They can build bridges between OECD countries and their home country and become an important source of new ideas. Returnees who studied/worked abroad usually continue to maintain contacts with the Western scientific community. Hence, they may act as a channel for diffusing advanced technology generated by technological leaders in the West. Evidence from our interview data also supports the notion that returnee entrepreneurs act as a bridge between China and the outside world. For example, STARTECH was set up in 2002 by Dr Jichang Guang, a returnee from the US. STARTECH utilizes Dr Guang’s global networks to bring the US market and Chinese talented scientists together. Dr Guang keeps regular contact with the US and other OECD countries through maintaining business links and attending international conferences and events organised by professional associations abroad.

In addition, returnees also affect the technological base of high-tech industries in their home country and may generate positive technology spillovers for other local firms which have a close geographical proximity with returnee firms. For example, Vimicro Corporation was set up

in 1999 by Dr John Deng, a returnee who received his PhD degree in electronics engineering and computer science from the University of California, Berkeley. Building upon this work, Vimicro Corporation is now helping to standardize Chinese internet and mobile multimedia communications through its VXP platform. Vimicro Corporation has become one of the world's largest graphic chip suppliers and has established the industrial standard for PC graphic input applications in China. Vimicro has strategic relationships with China Telecom, China Netcom, China Mobile and China Unicom (Zhang and Xia, 2007).

Previous studies suggest that external knowledge spillovers are one of the most important factors for innovation and economic growth (Almeida and Phene, 2004; Fritsch and Franke, 2004; Laursen and Salter, 2006). In particular, more recent studies (e.g., Audretsch and Lehmann, 2005; Madsen et al., 2003; Saxenian, 2006) suggest that in an increasingly globalized economy, human mobility and the emergence of trans-national scientists and engineers may play an important role in knowledge transfer. Saxenian (1994) argues that human mobility was an important driver of the high level of innovation in computer firms in Silicon Valley due partly to the rapid movement of tacit technical knowledge throughout the region. In the context of emerging economies, Saxenian (2002) provides case study evidence that Indian returnees have significantly contributed to the development of the Indian IT industry.

Previous studies associate the process of inter-firm knowledge transfer with the density of the population of "knowledge" brokers in a particular industry and/or location (Almeida and Phene, 2004; Audretsch and Lehman, 2005; Bernstein and Mohnen, 1998; Fritsch and Franke, 2004). The higher this density, the more likely the focal firm will be engaged in formal or informal interactions with "knowledge brokers" and become a recipient of knowledge spillovers. For example, Venus Info Tech Inc., founded by Dr Jane Yan, a returnee who gained her PhD

degree in Computer Science from the University of Pennsylvania, focuses on three core businesses: security solutions, security services and security products. Venus has made continuous technological innovation and has played a leading role in developing network security in China (Ren and Lai, 2002). Dr Guang, the founder of STARTECH, believes that returnees not only have technological advantage, but also international experiences, visions, and new business ideas. Hence, local non-returnee firms will be able to benefit from returnees through formal and informal contact. It is expected that returnee-related knowledge spillovers are more likely to occur in areas and sectors with a high density of returnee entrepreneurs, we suggest the following hypothesis:

***Hypothesis 1.** Innovation intensity of the non-returnee SME in China is positively associated with the density of returnees in the SME's sector.*

Intensive studies have examined the impact of FDI-related spillovers on productivity and innovation of local firms (Hejazi and Safarian, 1999; Chuang and Hsu, 2004; Branstetter, 2006; Wei and Liu, 2006; Liu and Buck, 2007). These studies have identified a number of ways through which inward FDI may affect local firms' innovation. First, MNEs may demonstrate the feasibility of new technologies through technical assistance and through other channels, such as reverse engineering; the demands of MNEs for local inputs may increase the backward and forward activities of local industries. Local firms can learn about the designs of the new products and technology through the interaction with foreign firms. Second, the demonstration effect through inward FDI can stimulate local firms' innovative activities through learning by doing or by analysing and observing the outputs of MNEs' R&D projects. As a result, local firms become more effective in conducting their own innovative activity. As we aim to examine localised

knowledge spillovers within an industrial cluster, ZSP, we also focus on MNEs' R&D activities. In particular, we consider the change in some MNEs' R&D global strategies which have shifted their R&D centres from headquarters to host countries. For example, 400 out of 500 world top MNEs have established R&D centres in China recently (China Daily, 2004). Foreign R&D activities may generate a positive impact on local innovative capacity. For example, a recent study by Cai et al. (2007) using the same dataset as ours has examined how MNEs' R&D activities affect the entry of local firms in ZSP. They find that MNEs' R&D activities promote entry of domestic firms into the same industry and enhance R&D activities of newly established domestic firms. Complementing their study, we examine whether there are knowledge spillovers from MNEs' R&D activities to local firms in the same location. Hence, we propose:

Hypothesis 2. Innovation intensity of the non-returnee SME in China is positively associated with the local R&D activities of MNEs in the SME's sector.

The above hypotheses highlight the importance of external knowledge spillovers in the innovation performance of local firms. However, external knowledge spillovers only represent a necessary, but not a sufficient condition for local innovation. Internal knowledge creation is also crucial to innovation. In particular, skill intensity or number of research-related personnel has been recognized as an important driver of innovation (Marvel and Lumpkin, 2007; Reagans and Zuckerman, 2001; Shane, 2000). Human capital theory suggests that individuals with higher human capital will generate greater outcomes (Becker, 1975). Employees with more human capital in terms of experience and education enable firms to implement new technologies more effectively (Siegel, Waldman and Youngdahl, 1997). Human capital can encourage the

generation of creative ideas, leading to innovative opportunities (Shane, 2000; Shepherd and DeTienne, 2005). An individual's stock of human capital can be increased through education. Higher level degrees, especially PhDs may provide the scientific training and knowledge that facilitates the identification of innovative opportunities (Baum, Locke and Smith, 2001; Gimeno, Folta, Cooper and Woo, 1997). More specific technological knowledge, perhaps from working in a particular technological context, may be particularly important for innovation (Ardichvili, Cardozo and Ray, 2003). This technological knowledge may be combined with other types of knowledge, such as knowledge of customers and markets, to identify innovative opportunities. Human capital embodied in the technological knowledge of entrepreneurs may enhance the absorptive capacity of SMEs since it facilitates faster and more effective processing of new information to identify novel innovative opportunities (Lord and Maher, 1990). Supporting these arguments, Marvel and Lumpkin (2007) find for a sample of firms in university-based incubators that formal education and prior knowledge of technology were the most important factors associated with the innovativeness of products and services developed by technology-based new ventures. These arguments suggest that the firm's skill intensity measured as the ratio of scientists and engineers to the total number of employees is an important driving force of innovation. Hence:

***Hypothesis 3.** Innovation intensity of high-tech SMEs in China is positively associated with skill intensity.*

2.2 The moderating effect of firms' absorptive capacity on knowledge spillovers through returnee entrepreneurs and MNEs' R&D activities

Previous research on R&D spillovers mainly focuses on voluntary leakage of knowledge which is classified as a type of ‘public goods’ (Grossman and Helpman, 1991). These studies implicitly assume that knowledge, once it has been generated, spills over more or less automatically to other firms. However, organizational learning theorists have associated knowledge-related capabilities with the notion of “absorptive capacity”, or the ability to value, assimilate, and exploit knowledge (Cohen and Levinthal, 1990). Some researchers argue that the effectiveness of knowledge transfer may be affected by a number of moderating factors such as trust and causal ambiguity (Szulanski et al., 2004). In addition, the KBV suggests that the extent of technology spillover from knowledge generators to knowledge recipients may depend on recipients’ absorptive capacity (Keller, 1996; Zander and Kogut, 1995). Cohen and Levinthal (1990) argue that absorptive capacity underpins the firm’s ability to develop and improve its new products through the adaptation of the external technology stock. It also includes the ability to internalize technology created by others and modify it to fit its own specific applications, processes and routines (Narula, 2002). Greater absorptive capacity enables firms to better interpret and assess knowledge from outside the company. These abilities also allow firms to better communicate and transfer knowledge that they are able to interpret and assess within the company. The absorptive capacity of local firms may, therefore, moderate their ability to absorb the potentially available spillovers from returnees and MNEs. Firms with higher absorptive capacity are more likely to benefit from returnee firms and MNEs’ R&D activities in terms of promoting their innovation activities. We associate the firm’s absorptive capacity with its skills intensities which are able to enhance the learning capacity of an organization and allow the firm to scan and screen the external technology and increase the absorptive capacity of their firm to

integrate external technology with their own innovative projects (Veugelers and Cassiman, 2004). Therefore, the above arguments suggest two linked hypotheses:

***Hypothesis 4a.** The relationship between innovation intensity of the non-returnee SME in China and the density of returnee entrepreneurs in the SME's sector is positively moderated by skill intensity.*

***Hypothesis 4b.** The relationship between innovation intensity of the non-returnee SME in China and MNEs' R&D activities in the SME's sector is positively moderated by skills intensity.*

3 METHODS

3.1 Data

Our empirical analysis is based on data for high-tech firms in Beijing Zhongguancun Science Park (ZSP) which was officially established in 1988 and has remained the largest science park in China since its establishment (Cai et al., 2007). Entrepreneurship and R&D activities have been developed in ZSP from the very beginning of China's economic reforms (see Tan, 2006). Starting from the mid-1990s, all firms identified as high-tech must report their annual financial statements to the Management Committee of the ZSP¹. This annual report provides detailed information on operations, performance, human resources, and R&D activities of high-tech firms. A notable feature of this data is that information disclosure by firms was compulsory, leading to 100% response rates. This is the most detailed data on high-tech firms in ZSP currently available.

¹ In order to qualify as high-tech firms should invest more than 5% of total sales in R&D annually, over 30% of employees should have a university degree and 10% of employees should be R&D personnel. Sales from new products should account for at least 60% of total income.

In this paper, we use data from this source for the period 2000-2003 as detailed information on R&D personnel and R&D investment was not available before 2000. Our sample consists of high-tech SMEs which are defined as a firm with fewer than 300 employees and a total value of sales below 5 million RMB (ZSP Development Report, 2006). We identify firms in the four years with all the necessary information needed for our analysis, and our final sample consists of 1,318 firms, of which 222 are foreign-owned, 128 are founded by returnees, and 968 non-returnee firms.

The data contains detailed technological characteristics of the firms, such as R&D expenditure, R&D personnel as well as expenditure on importing foreign technology. The constructed panel data allow us to control for various firm-level characteristics and to take account of the dynamic effects of external sources and firms' internal factors on innovation. The location of firms in the same science park provides an excellent opportunity to test the impact of returnee spillovers on non-returnee firms' innovation due to close geographical proximity (Zhou and Xin, 2003).

3.2 Variables

Dependent variables. We used the number of patents (granted by Chinese Patent Bureau) per employee of the firm to proxy innovation performance. The Chinese patent system classifies all patents into three categories according to their innovativeness: invention, utility model and exterior design. Our dependent variable, the number of patents, only included invention patents. Hence this measure represents technologically sophisticated innovative outputs. Invention patents are directly related to inventiveness and are granted only for 'non-obvious' improvements, or solutions with discernible utility. They also represent an externally validated

measure of technological novelty and they confer property rights upon the assignee and therefore have economic significance. However, the use of patents as a measure of innovation performance also has limitations. For example, some inventions are not patentable; others are not patented; and the inventions that are patented differ greatly in their commercial value (Ahuja and Katila, 2001).

Independent variables.

The *Skill intensity* variable was calculated as the ratio of scientists and engineers to the total number of employees in the firm. We adopt the definition of returnees specified by the Chinese government which views a returnee as a Chinese native with at least a few years of commercial and/or educational experience in an OECD country (ZSP Development Report, 2006). We use the item in the dataset ‘returnees are legal representatives’ to identify the firms that are returnee related, then we excluded state-owned firms using the item ‘firms with state owned holdings. We proxied returnee spillovers using the *Returnee density* variable which was measured by the ratio of the total number of returnees in a specific industry (excluding returnees in the focal firm) to the total number of employees in the same industry (excluding employees in the focal firm). Since all firms in our sample are in the same location, we did not use other proxies such as geographical proximity (Hu, 2007). *MNEs’ R&D activities* were calculated as the R&D expenditure of foreign firms in an industry weighted by the total number of employees in the industry (Aitken and Harrison, 1999; Liu et al., 2009).

Control variables. As the firms in our sample belong to different segments of the high-tech sector, we controlled for industry-specific effects by introducing dummy variables for firms from electronics and information technology, bio-engineering and new medical technology, and the new materials sectors, using the rest of our sample as a control. We controlled for firm *Age* in

terms of years since founding, and firm *Size* (log value of total assets). Total asset values were deflated using appropriate price indices. Some firms in ZSP are privately owned whereas others retain some public ownership after being established as spin-offs from public institutions (e.g. local authorities or universities) or state-owned enterprises (see Cai et al., 2007, for a discussion). Therefore, we included *Ownership* as a dummy variable with privately-owned firms taking the value 1 (zero otherwise).

Previous studies have identified R&D investment as an important input into the process of innovation. From the resource-based perspective (Barney, 1991; Peteraf, 1993; Wernerfelt, 1984), R&D activity may develop new capabilities that the firm can use to develop new products, processes, patents and know-how. Investment in R&D may help small firms develop their capabilities to sell mainly innovative, self-developed, technology-based products (Acs, Morck, Shaver and Yeung, 1997). Hence, we control for in-house R&D which was measured as R&D expenditure per employee.

Since our focus was on organizational outcomes associated with knowledge spillovers, we controlled for other sources of knowledge spillovers not related to returnee spillovers and MNEs' R&D activities. Specifically we controlled for possible spillover effects of exports and imports as well as industry R&D. Internationalization enables firms to leverage their existing capabilities and knowledge across countries and create scale economies otherwise unavailable domestically. It provides new market opportunities in which the firm can sell product innovations, as well as connections with important constituencies in diverse markets, allowing them to obtain key resources economically (Zahra et al., 2000). Gabrielsson and Kirpalani (2004) also suggest that being exposed to overseas markets helps the firm to acquire new knowledge that can be used to build new value-creating skills and augment existing capabilities. This

learning-by-exporting can facilitate technology diffusion and transfer, for example through obtaining technical assistance from foreign buyers, or buyers specifying high quality products. Bearing this in mind, we controlled for *Export intensity* measured as the ratio of export sales to total sales.

In addition, the innovation activities of local firms may be enhanced by importing technologies from abroad. This channel enables domestic researchers to access the ideas and technology developed by their foreign counterparts. In particular, local firms may ‘reverse engineer’ the products of their foreign rivals. Thus, importing foreign technology and know-how can boost domestic innovative capacity. To control for this potential effect we introduced the *Imported technology* variable calculated as the firm’s expenditure on purchasing foreign technology and equipment per employee. We also control for local R&D spillovers in the same industry which were measured as the ratio of the total R&D expenditure in a specific industry (excluding R&D expenditure in the focal firm) to the total number of employees in the same industry (excluding employees in the focal firm) (Aitken and Harrison,1999; Liu et al., 2009)². Detailed measures for the variables used in the study are provided in the Appendix.

3.3 Empirical methods

Following Section 2, the innovation intensity of local Chinese firms is considered as a function of external sources of technological spillovers and internal skill intensity. To test our hypotheses we focus on the sample of non-returnee SMEs only. Our dependent variable, *innovation intensity*, was measured by the number of patents per employee. The independent variables were skill intensity, returnee density, MNEs’ R&D activities and the interactions between returnee density, MNEs’ R&D activities and the focal firm’s skill intensity. Control variables include

² We would like to thank an anonymous reviewer for this suggestion.

other sources of knowledge transfer, such as import of technology, exports and industry R&D spillovers. Firm size, firm age and ownership were also controlled for. As the firms in our sample all belong to high-tech industries they mainly fall into the following segments of the high-tech sector: Medical and Pharmaceutical Products, Chemical Materials and Products, Electric Equipment and Machinery, Telecommunications Equipment, Electronic Apparatus, Computer Applications, Medical Equipment and Instruments, Meters and Office Equipment. We use sets of industry and time dummies to control the effects of sectoral variations within high-tech industries and time variations in the estimation.

From a theoretical point of view, there may be reverse causation running from innovation to returnees and MNEs' R&D activities, which implies that returnees and foreign firms only enter an industry with strong innovative capability. If such endogeneity exists between innovation and industry selection by returnees and MNEs, the estimation of a single equation for innovation intensity using OLS regression will lead to inconsistent results.

One way to deal with this endogeneity problem is to use the generalized method of moments (GMM) analysis, as this method is sufficiently flexible to control for the unobserved heterogeneity and endogeneity. In particular, Blundell and Bond (1998) suggest that system GMM estimation is an appropriate approach to short dynamic panel data as it allows for a large set of instruments of both lagged levels and first differences and, therefore, exploits fully all of the available moment conditions. This yields better predictions for the endogenous explanatory variables in the finite sample. We adopt this approach for our estimations.

4 RESULTS

Table 1 reports the descriptive statistics for the variables used in the analysis and the matrix of correlation coefficients. It shows that the average age of the sample firms is 7.73 years with average total assets of 57 million RMB. On average, firms possess one patent. Over 65 percent of total sales are associated with new products. Scientists and engineers accounted for 11% of total employees in our ZSP sample.

Insert Table 1 near here

The results of formal tests of the hypotheses are provided in Table 2. The consistency of the GMM estimator depends on the validity of the instruments used in the regression. We address this issue by considering the Sargan test for over-identifying restrictions, which tests the overall validity of the instruments by analyzing the moment conditions in the estimation process. Failure to reject the null hypothesis gives support to the model. The Sargan test did not reject the null hypothesis that the instruments are uncorrelated with the error term. Therefore, the instruments used in the system GMM are valid.

Table 2 provides results for regressions that estimate the impact of explanatory variables on the innovation intensity of non-returnee firms. First, we estimated how returnee density and MNEs' R&D activities affect the innovation intensity of non-returnee SMEs. Second, we explored the effect of interactions of returnee density, MNEs' R&D intensity and skill intensity of non-returnee SMEs. The results show that there is a positive and significant association between the main independent variables and the proxy for innovation intensity. The variable measuring returnee density is statistically significant. The result may suggest that returnees with advanced technological knowledge have helped to enhance the technological base of Chinese

high-tech industries and have a positive effect on the innovation performance of non-returnee SMEs. Hence, we have obtained evidence that non-returnee SMEs in the same high-tech industry which have benefited from returnees, have generated high innovation performance, in line with Hypothesis 1 which postulates a positive association between returnee density and innovation performance of non-returnee firms. The results support the notion of knowledge diffusion through human mobility across national borders (Saxenian, 2006).

The MNEs' R&D variable is insignificant in affecting the innovation intensity of non-returnee firms. Thus the result is inconsistent with Hypothesis 2 which proposes a positive relationship between MNEs' R&D activities and local firms' innovation. Our result contrasts with that of Cai et al. (2007) who found a positive spillover effect from MNEs' R&D activities on new entry of local firms in ZSP. The possible reason is that materialising MNEs' R&D spillovers may require local firms to have a sufficient level of absorptive capacity. The variable for skill intensity is statistically significant and positively contributes to innovation intensity, supporting Hypothesis 3 which highlights the important role of skill intensity in innovation.

In terms of control variables, the variable for export intensity is positively significant at 1% level. This result supports the argument that learning through exporting enhances firms' ability to innovate, as proposed in the existing literature (Liu and Buck, 2007), but the results only partially support that there is a positive spillover effect from imports. The variable for industry R&D intensity is significant in affecting patents, showing positive industry R&D spillover effects within local firms.

The results show that in-house R&D efforts enhance innovative capability. Firm size negatively affects innovation output, implying that small firms possess more patents or they have a high level of research productivity. There is a negative relationship between age and patents,

showing that younger firms perform better and learn more from returnees in terms of generating more patents. The dummy variable for privately-owned firms is positively significant and demonstrates strong evidence that private non-returnee SMEs are more innovative and are able to extract more knowledge spillovers from returnees and other external sources of innovation.

We obtained a number of important results with regard to the complementary effect between returnee density, MNEs' R&D activities and the absorptive capacity of non-returnee SMEs which was proxied by firms' skill intensity. The interaction between returnee density and skill intensity is significant at the 1% level, providing strong evidence that supports Hypothesis 4a which assumes skill intensity positively moderates the spillover effect of returnees. The interaction term between MNEs' R&D activities and skill intensity is also significant, thus supporting Hypothesis 4b which proposes the positive moderating effect of skill intensity on MNE spillovers. It should be noted that MNEs' R&D activities are only significant when the interaction between this variable and skill intensity is taken into account. These results suggest that human capital-related aspects of the absorptive capacity (e.g., the skill intensity variable) of non-returnee SMEs are an important factor affecting the effectiveness of the technology spillover from returnees and MNEs to non-returnee SMEs. We return to this result in the discussion section.

Robustness test

As noted above, using patents as an indicator of innovation performance has some limitations as some inventions are not patentable; others are not patented; and the inventions that are patented differ greatly in their commercial value (Ahuja and Katila, 2001). Bearing this in mind, we used another measure of innovation intensity calculated as the proportion of sales from new products

in the total sales of the firm to conduct a robustness test. The definition of new products adopted by China Statistic Bureau is the same as in other countries (Veugelers and Cassiman, 1999; Larsen and Salter, 2006). Specifically, a new product is defined as either a completed new product or an existing product which has been significantly improved through the adoption of a new structure, new materials or a new manufacturing technique. In other words, a new product must contain “novelty” and/or innovative elements. We obtained similar results for our hypothesised independent variables with new product sales intensity being used as the dependent variable in Table 2. The returnee density variable is significant, in line with Hypothesis 1. The variable for MNEs’ R&D activities is insignificant. Hence, Hypothesis 2 is not supported. We find evidence that there is a positive association between skill intensity and new product sales, thus supporting Hypothesis 3. The interaction terms between the returnee density, MNEs’ R&D activities and skill intensity variables are positive and significant, supporting Hypothesis 4a and Hypothesis 4b. The imported technology variable is insignificant in this model specification. The ownership variable is positive, but only weakly significant at the 10% level. Interestingly we obtained different results in terms of firm size and age in the robustness test. The variables for firm size and age positively affect new product sales. The results suggest that large and well-established firms are capable of commercialising their innovation and achieving high new product sales. Hence, they tend to perform better in terms of new product sales.

5 DISCUSSION

This study takes a first step toward examining the role of returnee entrepreneurs in knowledge spillovers in ZSP in China that was initially concerned about the outflow of talent abroad. The results show that returnee density and internal skill intensity are significantly

associated with innovation. The results in relation to returnee density are central to our study. We have found that returnee entrepreneurs are an important source of external knowledge spillovers, and that returnee presence facilitates knowledge spillovers to non-returnee SMEs.

We have found that skill intensity is an important factor affecting the innovation performance of local Chinese firms. High levels of R&D related staff enable local firms to be more innovative. Our findings are also in line with the existing literature which suggests that external technology spillover channels and internal absorptive capacity are important determinants of innovation (Keller, 1996). These findings indicate that non-returnee SMEs with strong absorptive capacity are able to capture more benefits from returnees. Our results suggest that human capital or skill intensity is playing an important role in facilitating knowledge spillovers. In rapidly changing global markets, which typifies the high-tech sector, this emphasizes the importance of individual expertise in identifying and exploiting innovative opportunities, rather than simply relying on the amount of R&D expenditure.

Our results show that MNEs' R&D activities in isolation do not affect the innovation performance of non-returnee firms. The result contradicts the findings obtained in some previous studies which have found that foreign presence has a positive impact on the total factor productivity of indigenous Chinese firms (Buckley et al., 2002; Liu and Wang, 2003). Cai et al. (2007) have found that MNEs' R&D activities stimulate the new entry of local firms in ZSP. However, we extend their analysis by showing that MNEs' R&D activities positively affect the innovation intensity of non-returnee firms only when these firms possess a sufficient level of skill intensity or absorptive capability. This implies that higher levels of foreign R&D intensity alone do not constitute technology spillovers from MNEs to local Chinese firms automatically. Foreign R&D activities are an effective spillover channel of innovation only when local firms

have sufficient number of scientists and technicians who actively learn from foreign firms. Our finding is in line with the existing literature which suggests that external technology spillover channels and internal absorptive capacity are important determinants of innovation. The absorptive capacity of local firms may be a pre-condition for MNEs' R&D activities to generate positive knowledge spillovers.

Our empirical findings show the positive effect of exports on local innovation. Export spillover channels, proxied by export intensity, are statistically significant, implying that the extent of exposure of Chinese firms to international markets enhances the innovative capacity through learning-by-exporting. This result indicates that entering international markets enables firms to foster external learning and to augment innovative capacity through interaction with buyers and also to respond to intensive competition in export markets. All these factors seem to have generated positive spillovers which affect the innovative capacity of export-oriented firms.

Our study contributes to extending the existing literature in a number of ways. First, our analysis represents the concept of returnees as two-way human capital and knowledge flows between China and OECD countries. Hence, the analysis of returnees involves interactions between China and OECD countries. It adds to the limited empirical studies on the spillover effect of returnee entrepreneurs in the context of an emerging economy, providing evidence that emphasizes the need to consider a new feature of globalized economy, i.e. frequent movement of highly skilled human capital across national borders.

Second, both scholars and policy-makers have paid much attention to the impact of rapid globalization in the form of FDI and international trade. In particular, the impact of FDI and trade on international knowledge transfer in emerging economies has been the focus of attention. However, the growing mobility of scientists and entrepreneurs represents a new

channel for international knowledge transfer, parallel with FDI and international trade. Therefore, the study develops previous research by emphasising the important role of cross-border international entrepreneurs in international knowledge spillovers.

Our study also has important managerial implications. For local firms, a combined “making” and “learning” innovation strategy may be adopted to enhance domestic innovation. Local firms may maximize the benefits from building linkages with returnees and developing their innovative capabilities. At the same time, local firms should conduct their own in-house R&D. As shown in our research, without sufficient R&D investment and sufficient numbers of scientists and engineers, it is unlikely that domestic firms will be able to benefit from returnees. The combined strategy may enable local firms to develop their innovative capabilities effectively.

As Cai et al. (2007), who study the same science park as ourselves, the findings contribute to the development of FDI policy that may benefit local entrepreneurs in China and elsewhere. We extend their insights beyond MNEs to encourage returnee entrepreneurs. Our evidence of the positive impact from returnees obtained in our study suggests that government policies should aim at attracting returnees. Our evidence suggests that this policy may not only attract returnee entrepreneurs but also stimulate a spillover effect from returnees to local firms. To facilitate such movements, governments may need to consider the development of incentives to encourage returnees but the specifics of such policies are beyond the scope of this paper. Our findings suggest that other some emerging economies may find it helpful to adopt a broader view regarding the encouragement of FDI R&D to benefit local firms that extends beyond MNEs to include returnee entrepreneurs. However, our study has drawn evidence from only one large science park in China involving the clustering of large numbers of firms and universities and

developed over a long period. Further contextualized analysis may therefore be required in other emerging economies to ensure that more fine-grained policy support is adapted to local circumstances. For example, governments may need to consider whether they need to accompany encouragement of returnees with complementary policies regarding science parks or other industrial clusters.

6 LIMITATIONS

By focusing on the impact of returning entrepreneurs and their knowledge spillovers, our study provides a better understanding of patterns of knowledge flows via different channels. However, we acknowledge that the paper has limitations which provide opportunities for further research. First, the study was limited to a single science park in the Chinese context. Further research might extend to returnee entrepreneurs in science parks within and outside China such as India and Russia where these economies have also experienced a large number of inflows of returnees who may be crucial to the building of national innovation capability. This extension would enable us to examine whether the effectiveness of returnees as a channel for internal knowledge spillovers is constrained by local institutions and economic environments. Second, we have focused on density of returnees as a new channel for knowledge spillovers due to the data availability. However, our finding of the importance of an interaction between skill intensity and returnees relates to the process of transfer. Further questionnaire and case research is needed to reveal the process of knowledge transfer between returnees and locals and the conditions which affect such knowledge transfer. Third, we are unable to measure the impact of the diversity of skills on innovation due to data limitations, and future studies should examine not only the quality, but also the diversity of R&D related personnel. Fourth, although we used both

patents and new product sales as measures of innovation we are restricted in what we can conclude about how the type of innovation may affect the link between firm size and innovation. As we are using secondary data, we are unable to identify disruptive or sustaining innovation. Similarly, we are unable to distinguish whether new product sales involve new products developed by the firms themselves or whether they are acting as sales agents for other firms' products in order to generate cash-flow to support their own R&D. It may also be the case that some returnee entrepreneurs engage in a two step process of returning to China to work for MNEs before they then establish their businesses. Further survey based research may be able to shed light on these issues.

7 CONCLUSION

Emerging economies typically lack the entrepreneurial expertise, knowledge and resources to develop innovation activities. While it has traditionally been argued that this skills gap can be closed by trade-related and FDI-related knowledge spillovers (Javorcik, 2004), these options may be particularly problematical in emerging economies where uncertainty in the legal and economic environment prevails. In this paper we have examined the role of returnee entrepreneurs as an alternative mechanism in resolving the deficit of entrepreneurship and in stimulating innovation in technology-based firms in emerging economies. Using a unique panel dataset, we have found that the presence of returnees facilitates technology spillovers to non-returnee SMEs. Our results provide new empirical evidence which indicate that these "new Argonauts" (Saxenian, 2006) act as a new channel for international technology transfer.

Our findings emphasize the important role of human mobility in facilitating international knowledge flows from technological leaders (OECD) to followers (emerging economies). We suggest that our findings indicate that in the new global economy, scientific and technical

human capital has become more mobile and more easily able to cross national borders. The impact of mobile, internationally skilled entrepreneurs and scientists on knowledge spillovers has become more important, adding a new dimension to the knowledge spillover literature. If trade and foreign firms were the key mobile factors driving economic development and technology spillovers in the past, it seems that human mobility across national borders is likely to play a central role in today's globalized world economy. We suggest that this opens up an important new research agenda that needs to consider the comparative efficacy of the knowledge brought by returnee entrepreneurs versus the resources and knowledge of multinational enterprises in stimulating the development of emerging economies.

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Table 1: Descriptive Statistics and Correlation Matrix

	Mean	St. Dev.	1	2	3	4	5	6	7	8	9	10	11	12
1 Patents per employee	0.012	0.050	1.000											
2 New product sales/total sales	0.663	0.418	0.037	1.000										
3 Skill intensity	0.112	0.235	0.046	0.072	1.000									
4 Returnee density	0.005	0.008	0.005	0.018	0.142	1.000								
5 MNE R&D	0.704	1.338	0.003	0.067	0.209	0.137	1.000							
6 Export intensity	0.017	0.105	0.016	-0.016	0.001	0.018	0.010	1.000						
7 Imported technology	0.322	7.155	-0.005	0.009	-0.014	-0.012	-0.004	-0.004	1.000					
8 In-house R&D	2.334	9.629	0.023	0.087	0.119	0.048	0.079	0.046	0.008	1.000				
9 Industry R&D intensity	4.577	2.820	0.002	0.004	-0.038	-0.019	-0.028	-0.019	0.030	-0.033	1.000			
10 Size	8.306	1.862	-0.053	-0.002	0.019	0.034	0.035	0.092	0.053	0.137	-0.015	1.000		
11 Age	7.738	4.842	-0.046	-0.015	-0.005	-0.021	-0.027	-0.012	-0.004	-0.045	0.028	0.101	1.000	
12 Ownership	0.178	0.382	0.054	0.044	-0.004	-0.001	0.030	-0.006	-0.018	0.012	-0.007	-0.148	-0.249	1.000

Notes: All correlation coefficients with an absolute value greater than 0.12 are significant at the 5% level or higher.

Table2: GMM Estimations of the Effects of Knowledge Spillovers from Returnees on the Innovation Intensity of non-returnee Firms

Independent Variables	Patents per employee			New product sales/total sales		
Skill intensity	0.008 (0.001)***	0.008 (0.001)***	0.008 (0.001)***	0.002 (0.035)*	0.102 (0.070)*	0.097 (0.007)**
Returnee density	0.066 (0.021)**	0.073 (0.013)***	0.066 (0.024)**	4.236 (0.238)***	0.474 (1.305) †	4.012 (0.424)***
MNE R&D	7.03E-05 (0.0002)	0.0001 (7.85E-05)	0.0004 (0.0003)	0.001 (0.007)	0.016 (0.018)	0.002 (0.003)
Returnee density × Skill intensity		0.360 (0.037)***			5.627 (2.849)**	
MNE R&D× Skill intensity			0.002 (0.001)**			0.078 (0.008)**
Export intensity	0.008 (0.003)**	0.007 (0.003)*	0.004 (0.0004)**	0.032 (0.015)*	0.150 (0.084)†	0.024 (0.020)
Imported technology	9.96E-06 (5.54E-05)	0.0003 (4.56E-05)*	0.0002 (3.07E-05)†	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
In-house R&D	7.87E-05 (3.82E-06)**	4.06E-05 (2.19E-05)†	3.91E-05 (2.35E-05)†	0.002 (0.001)*	0.004 (0.001)*	0.002 (0.001)*
Industry R&D intensity	0.001 (0.0002)**	0.011 (0.004)**	0.001 (0.001)*	0.186 (0.195)	0.192 (0.098)*	0.220 (0.194)
Firm size	-0.002 (0.0002)**	-0.002 (5.95E-05)**	-0.001 (0.0002)**	0.019 (0.003)**	0.012 (0.003)**	0.019 (0.003)**
Age	-0.0001 (0.0001)	-0.0002 (7.53E-05)*	-0.0002 (0.0001)*	0.003 (0.002)†	0.005 (0.002) †	0.003 (0.002)†
Ownership	0.006 (0.001)**	0.007 (8.18E-05)**	0.007 (0.001)***	0.062 (0.036)†	0.026 (0.021)	0.061 (0.036)†
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R ²	0.146	0.157	0.211	0.151	0.209	0.114
Observations	3872	3872	3872	3872	3872	3872
Sargan test	0.161	0.272	0.119	0.292	0.129	0.224

Notes: standard errors are in parentheses. ***, **, *, †: significant at the 0.1%, 1%, 5% and 10% levels respectively.

Appendix: Detailed measures for the variables used in estimations

Dependent Variables:

Innovation intensity: the number of patents granted by Chinese Patent Bureau per employee of the firm.

Innovation intensity: the proportion of sales from new products in the total sales of the firm.

Independent Variables:

Skill Intensity: the ratio of scientists and engineers to the total number of employees in the firm.

Returnee Spillovers (Returnee Density): the ratio of the total number of returnees in a specific industry (excluding returnees in the focal firm) to the total number of employees in the same industry (excluding employees in the focal firm).

MNEs' R&D activities: the R&D expenditure of foreign firms in an industry weighted by the total number of employees in the industry.

Control Variables

In-house R&D: R&D expenditure per employee of the firm.

Firm Age: years since founding.

Firm Size: log value of total assets.

Ownership: a dummy variable for privately-owned firms having the value of 1 (zero otherwise).

Export Intensity: the ratio of export sales to total sales of the firm.

Imported Technology: the firm's expenditure on purchasing foreign technology and equipment per employee.

Industry R&D intensity: the ratio of the total R&D expenditure in a specific industry (excluding R&D expenditure in the focal firm) to the total number of employees in the same industry (excluding employees in the focal firm).